ENVIRONMENTAL PROTECTION

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The hottest issues today include pollution and the deteriorated state of the environment that are the result primarily of human activities. The fact that natural conditions not only influence but sometimes modify the processes of pollution into unfavourable direction is less emphasized. After this is discussed, the atlas presents the topic according to environmental elements, however, nature protection and landscape protection are discussed as parts of separate chapters. Waste management as one of the most important fields of environmental protection received special emphasis in this atlas.

Effects of our natural conditions on the state of the environment

Several natural conditions of Hungary can be regarded disadvantageous considering environmental protection. Air pollution for example is significantly influenced by the fact that the Alföld (Great Hungarian Plain) is located at the bottom of the Carpathian Basin, therefore inversion frequently appears in the atmosphere in the winter period. When layers in the atmosphere with inverse temperature distribution do not let the mixing of the rising smoke in higher atmospheric layers or cold air sits near the surface with warm air on top of it and the cold air does not move for days (cold air cushion) then lower air layers become increasingly polluted [1].

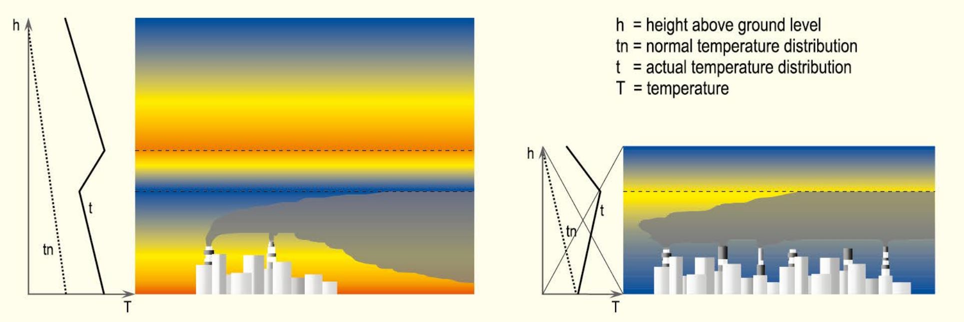
Looking down the Alföld from higher mountains at times like the above, clouds can be seen like a snow cover [1], while those down in the plain live in a grey and increasingly polluted air while smog develops in our larger towns [2].

There are two basic types of smog: *'London type'* (Sulphurous smog) or *reducing smog* appearing mostly in winter and *'Los Angeles type'* (Photochemical smog) or *oxidising smog* typical in summer. In Hungary both types may occur due to the basin character and the climatic conditions (with relatively cold winter and sunny summer) of the country. The development of smog is typical in larger towns where most pollution sources can be found: residential and commercial heating, busy traffic, factories.

Regarding water pollution, the centripetal type water network of Hungary is far from ideal as runoff is from the margins of the basin towards its centre, i.e. pollution from most of the neighbouring countries comes to Hungary via the rivers.

Regarding environmental protection, neither the surface nor the subsurface geological conditions are beneficial. The total area of the Alföld is composed of loose sediments that are mostly (around 80%) porous in which precipitation filtrates relatively easily. Since the groundwater table is found near the surface this landscape is significantly exposed to surface pollutions. Since the Kisalföld (Little Hungarian Plain) has a similar geological composition its sensitivity to pollution is also the same. The karstified limestone and dolomite formations of our karst regions – Transdanubian Range, Bükk Mts., Aggtelek Karst and Mecsek – are extremely vulnerable to the infiltration of various pollutants due to their special petrographic conditions (solubility by water, joint density, cave density). Pollution sensitivity of the Transdanubian Hills and that of Alpokalja (Eastern Alpine Foreland) are more variable. Least sensitive are our volcanic mountains, however, their total area is only a fraction of that of the country.

1 INVERSION AND GROUND INVERSION LAYERING



State and protection of air

Ambient air pollution

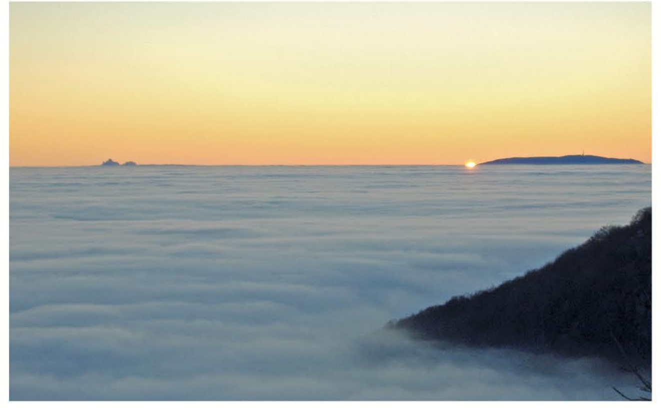
Air pollutants emitted by human activities remain in the atmosphere for different amounts of time depending on their physical and chemical characteristics. Pollutants with long residence time can be dispersed over large distances, even in the whole atmosphere of the Earth. Air pollution of areas at large distances from emission sources is called background air pollution. The effect of local polluting areas (cities, industrial areas, motorways with high traffic) is superimposed on the background level. Background pollution may be transported or formed over long distances (on regional and global scales), thus having significant impacts on the biosphere and the climate. In Hungary, the background air quality monitoring network, operated by the Hungarian Meteorological Service (OMSZ), consists of six stations which are far from inhabited areas and roads. The stations have slightly different monitoring protocols. Hegyhátsál station [3] in the western part of the country focuses on the greenhouse gases with long residence time and thus smaller spatio-temporal variability, while the other stations monitor pollutants (materials causing eutrophication and acidification, tropospheric ozone, aerosols, etc.) with shorter residence time and larger spatial variability, which needs denser monitoring network.

The background air pollution monitoring station at K-puszta (Kecskemét) [4] also has a prominent role in the monitoring activity of OMSZ. These two stations are included in the global and regional monitoring networks of the World Meteorological Organisation (WMO) and the European Evaluation and Monitoring Programme (EMEP) providing background environmental data for Hungary. These networks use standard measuring protocols thus providing globally comparable observations for general conclusions all over the world.

Greenhouse gases

OMSZ has been recording the atmospheric concentration of carbon dioxide since 1981, while the amounts of a few other greenhouse gases (methane, nitrous oxide, sulphur hexafluoride) have been measured since 2006. In the beginning, the measurements were performed at K-puszta station. Since 1994 the measurements have been performed at a higher altitude on the transmitter tower of Antenna Hungária Corporation, far from inhabited areas, offering more extended spatial representativeness of observations. Between 1981 and 2014, the atmospheric concentration of carbon dioxide raised from 346 μmol/mol (346 ppm) to 403 μmol/mol [2], thus it increased by 16%. While in the 1980s the average growth rate was only 1.4 μmol/mol/year, in the 2010s this value reached 2.1 μmol/mol/year in accordance with global observations.

[3] *TV-transmitter station at Hegyhátsál with the monitoring station of OMSZ*



[1] *Stratus clouds of cold air cushion developed above the Alföld as viewed from the Bükk Mts.*

[2] *Smog in Debrecen at the end of November 2016*

[4] *Background air pollution monitoring station at K-puszta (Kecskemét)*

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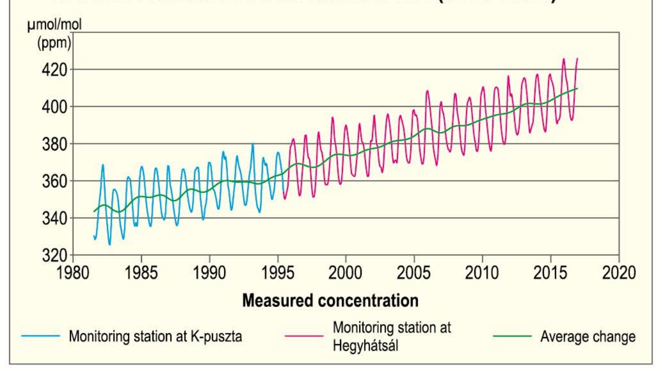
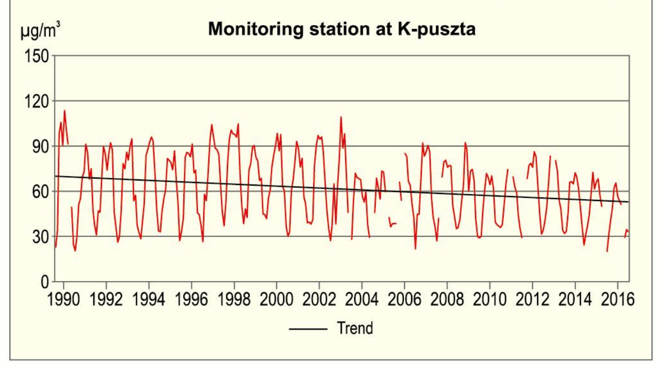
2 LONG-TIME TEMPORAL VARIATION OF ATMOSPHERIC CARBON DIOXIDE CONCENTRATION (1981–2017)



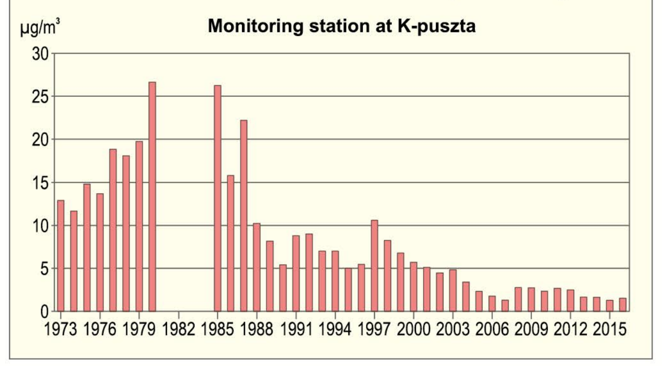
5 LONG-TIME TEMPORAL VARIATION OF THE TROPOSPHERIC OZONE CONCENTRATION (1990–2016)



Sulphur dioxide

Sulphur dioxide is a primary pollutant, which means that it is directly emitted to the atmosphere from natural and anthropogenic sources. This pollutant is one of the main precursors of acid deposition, which damages the biosphere and the built environment. Its natural sources are volcanic activities and the oxidation of reduced sulphur compounds emitted by the biosphere. As a result of fossil fuel burning, almost four times higher amount of sulphur dioxide is released into the air, than through natural processes. It means that human activities have considerably changed atmospheric sulphur circulation. This anthropogenic effect is significant primarily in the Northern Hemisphere in terrestrial areas. The atmospheric concentration of sulphur dioxide has increased until the middle 1980s, from that time, owing to international protocols, it has been continuously decreasing [3].

3 LONG-TIME TEMPORAL VARIATION OF ATMOSPHERIC SULPHUR DIOXIDE CONCENTRATION (1973–2016)



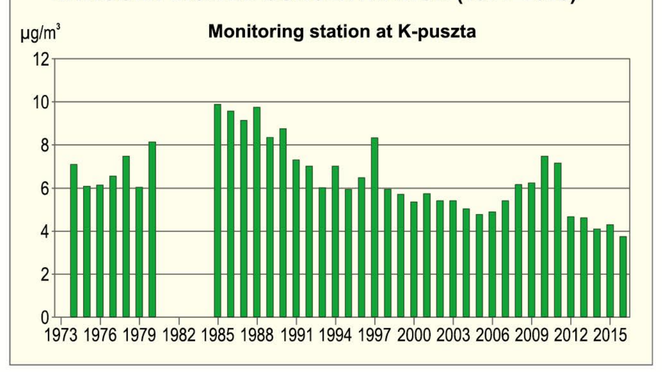
Nitrogen dioxide

Nitrogen dioxide has an important role in regulating the composition of the atmosphere as well as in some environmental effects. It has both natural and anthropogenic sources. Generally it has no primary source, but it is produced by chemical reactions among other nitrous oxides and different atmospheric compounds. The main sources of its predecessors are the burning of fossil fuels and biomass, as well as volcanic activity. From the middle of the 1980s, the atmospheric concentration of nitrogen dioxide has shown a slightly decreasing tendency owing to the international emission reduction protocols [4].

Tropospheric ozone

Tropospheric ozone is one of the most important global air pollutants, which has a great impact on human health, food production and natural environment, and because it is an important greenhouse gas, it effects the climate change as well. Ozone is a secondary pollutant that is not emitted directly into the air at ground level but it forms from its precursor atmospheric compounds. The effectiveness of the chemical reactions of ozone formation is significantly influenced by meteorological conditions and precursor gases. These gases have anthropogenic (e.g. traffic, solvents, fossil fuels) and natural (e.g. forests, wet habitats, soil, lightning) sources. Based on long-term observations at K-puszta, the atmospheric concentration of tropospheric ozone shows a decreasing tendency [5].

4 LONG-TIME TEMPORAL VARIATION OF ATMOSPHERIC NITROGEN DIOXIDE CONCENTRATION (1974–2016)



Emissions of the main air pollutants

Ambient air quality is determined by anthropogenic emissions added to the background state of the air. Most of the emission is composed of gaseous pollutants originated from production and consumption, but nowadays the most studied pollutant is the particulate matter which contains liquid and solid particles and has important effects on human health.

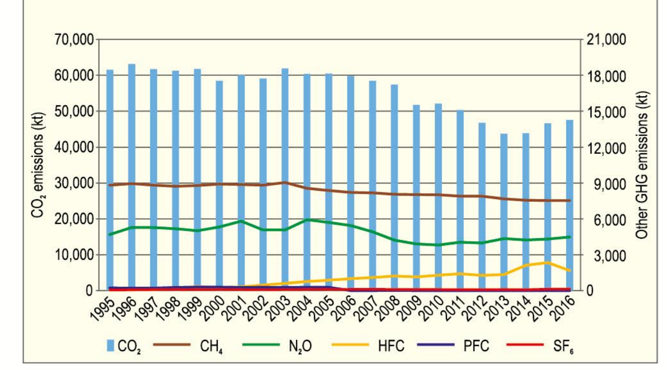
Of the gaseous pollutants, *greenhouse gases* (GHGs), especially *carbon dioxide* emitted from fossil fuel combustion, are followed with worldwide attention. Though several different greenhouse gases are taken into account in the evaluation of climate change [6], carbon dioxide is the determinative one. On the one hand, this gas is produced in the largest amount, on the other hand, carbonaceous gases (CO, CH_4) are transformed to carbon dioxide sooner or later.

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), saturated and unsaturated ('hard' and 'soft') freons (CFCs, HCFCs) and sulphur hexafluoride (SF_6) shown in Table [6] did not occur in the atmosphere before the classic industrial revolution. These pollutants are industrial products of the 20th century, their wide industrial use is illustrated in Table [7]. Their global warming potential is high, exceeding the potential of carbon dioxide by three orders of magnitude, while their atmospheric concentration is smaller by 3–8 orders of magnitude. Many of them have significantly long atmospheric residence time.

The main anthropogenic source of carbon dioxide is the combustion of fossil fuels. The largest emitters include thermal power plants, institutional and household heating and traffic. Cumulative emission remarkably decreased in the years before and after the regime change in the late 1980s, then it barely changed between 1995 and 2008, decreasing again decreased after 2009 [8]. The economic crisis started in 2008 had a major role in the emission decrease because of extremely high fuel prices and moderate residential fuel consumption. Another important decreasing factor is that the economic growth has smaller energy demand recently than it had earlier.

The degree of nitrous oxide emission of mainly agricultural origin is very small and barely changes. The

8 EMISSION OF MAIN GREENHOUSE GASES (1995–2014)



6 MAIN CHARACTERISTICS OF GREENHOUSE GASES PLAYING A DECISIVE ROLE IN THE WARMING OF NEAR-SURFACE AIR

Gas	Formula	GWP*	Atmospheric residence time (year)
Carbon dioxide	CO_2	1	50–200
Methane	CH_4	23	8,4–12
Nitrous oxide	N_2O	314	120
Sulphur hexafluoride	SF_6	22,000	3,200
Hydrofluorocarbons (HFCs)		1,300–12,000	14–260
Perfluorocarbons (PFCs)		6,500–9,200	2,600–50,000
Chlorofluorocarbons (CFCs)		4,600–10,600	45–102
Halons		1,300–6,900	11–65
Hydrochlorofluorocarbons (HCFCs)		1,700–2,400	12–19

*GWP = global warming potential (calculated for 100 years)

7 MAJOR ANTHROPOGENIC SOURCES OF GREENHOUSE GASES

Gas	Formula	Anthropogenic source
Carbon dioxide	CO_2	Fossil fuel combustion, cement production, biomass burning
Methane	CH_4	Mining, landfills and waste, rice agriculture, livestock farming
Nitrous oxide	N_2O	Fossil fuel combustion, biomass burning, fertilizers
Hydrofluorocarbons (HFCs)		Aerosols, foams, refrigeration, air conditioning, fire protection, electricity
Perfluorocarbons (PFCs)		CF_4, C_2F_6: aluminium and semiconductor production, C_6F_{14}: electronics, CFC substitutes
Sulphur hexafluoride	SF_6	Electric insulator, aluminium and semiconductor production, magnesium manufacturing
Chlorofluorocarbons (CFCs)		CFC-11 aerosol, foam production, CFC-12 aerosol, refrigeration
Halons		Fire protection
Hydrochlorofluorocarbons (HCFCs)		CFC substitutes (e.g. HCFC-22 – refrigerant)

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emission of methane is also steady and smaller than that of carbon dioxide by two orders of magnitude. Methane originates mostly from natural gas consumption (fugitive emission), but solid waste landfills and wastewater treatment are also important sources followed by agriculture.

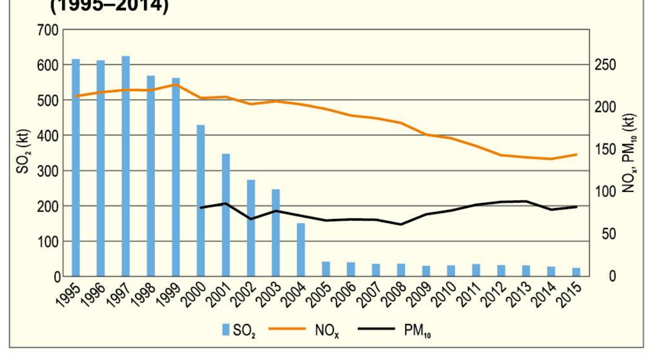
The remarkable increase of HFCs emissions 8 is a rather unfavourable process, since their warming potential is a thousand times higher than that of carbon dioxide. According to the records of the Central Statistical Office (KSH), the application and thus emission of HFCs in the energy production and consumption sector have tremendously increased since 1995, therefore this sector determined their visibly rapid growth. Based on the data of 2014, the global warming potential of HFCs emissions take 3-4% of the total emission. On the other hand, the significant decrease of the perfluorocarbon emissions and the small amount of sulphur hexafluoride are favourable signs.

Another major group of air pollutants is the group of *acidifying gases*. This includes sulphur dioxide and nitrogen oxides which react with the moisture content of the air creating weak acids. Through dry and wet deposition processes (the latter is called acid rain), these acids reach and affect the surface. These effects include the acidification and eutrophication of soils and groundwaters, corrosion of buildings and technical facilities, and through inhalation diseases of the human respiratory system.

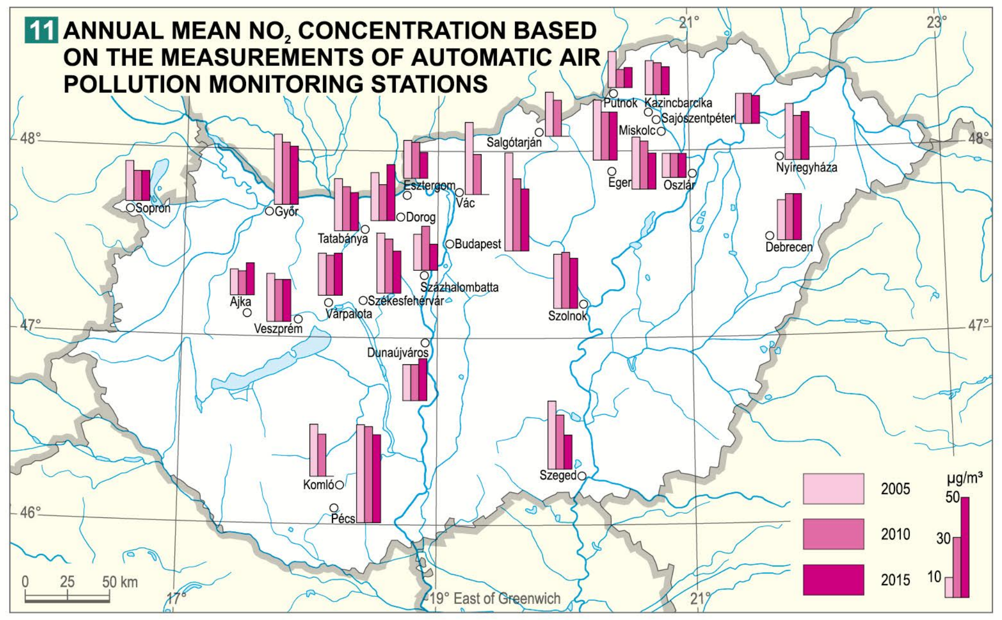
Though there was a remarkable decrease in *sulphur dioxide emission* at the time of the regime change in the former socialist countries, it still stayed at a high level 9. During the gradual transition from coal combustion to oil and natural gas burning the emission also gradually decreased. Owing to flue gas cleaning (sulphur entrainment separator) equipment installed at two thermal power plants (Mátra Power Plant, Vértes Power Plant) between 1998 and 2004, the annual value of national emissions decreased by 230,000 tons. Improving and regulating the quality of petrol and diesel fuels – since 1 January 2005 the sulphur content of fuels can be at most 50 mg/kg – also had an important role in reducing sulphur emissions.

The most significant source of *nitrogen oxides emissions* is the traffic sector, mainly road traffic. Other important sources are energy production and household heating. The slight emission reduction of recent years has been achieved as a result of tightening environmental regulations for vehicles 9 and advanced combustion technologies.

In the last decade, particulate matter emissions received growing attention. This pollutant is a complex mixture of extremely *small solid particles* and liquid droplets which are floating in the atmosphere for a long time thus travelling long distances from their sources. PM_{10} is defined as the fraction of particles with a diameter smaller than 10 μm. The emission of PM_{10} was steady in the last 10 years changing between 40,000 and 49,000 tons/year 9. The major anthropogenic sources of PM_{10} emissions are thermal power plants, residential heating and traffic, but it has significant natural sources as well.



9 CHANGES IN THE EMISSIONS OF SULPHUR DIOXIDE, NITROGEN OXIDES AND PARTICULATE MATTER (1995–2014)



11 ANNUAL MEAN NO_2 CONCENTRATION BASED ON THE MEASUREMENTS OF AUTOMATIC AIR POLLUTION MONITORING STATIONS

Urban air quality

Hundreds of air pollutants – gases, liquid droplets, solid particles – are emitted to the atmosphere by human activities. Most of them are not measured regularly, thus our atlas studies only those pollutants which are regularly observed by the standard air pollution monitoring network. In Hungary, annual average immission concentrations are calculated based on automatic monitoring station data series of 26 cities. The fly in the ointment is that extreme concentration values are hidden by the yearly averaging.

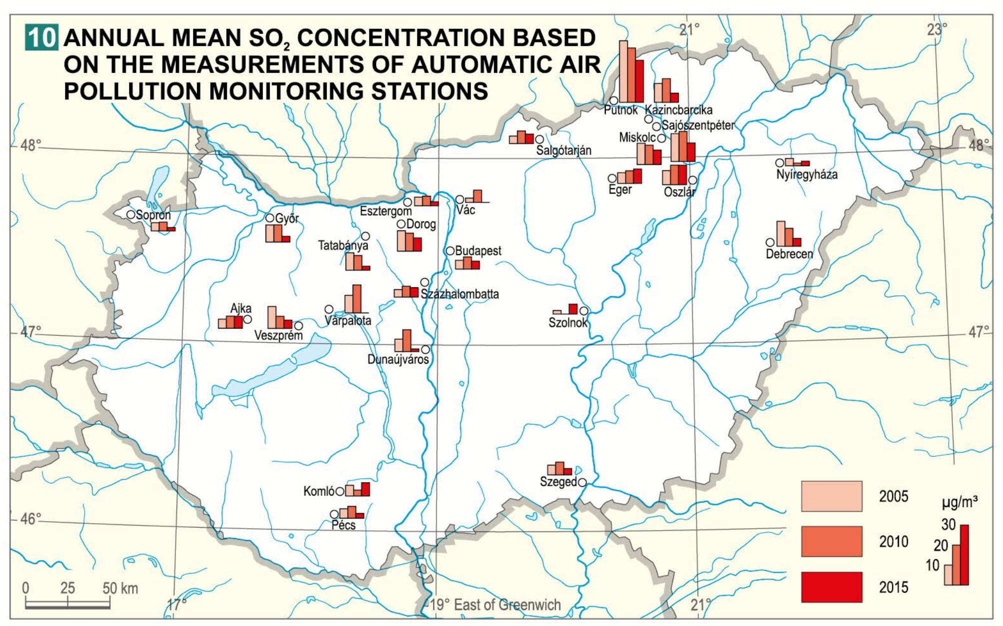
The annual mean *sulphur dioxide concentration* in Hungarian cities and towns is deeply below the limit value for health (50 μg/m³) and it has only slightly changed during the last 10 years 10. Even in Putnok, where the highest concentrations are measured because of coal burning, the annual mean does not reach the half of the limit value for health. Decreasing trends can be observed in the studied urban settlements, there is no health risk concerning this pollutant. This favourable situation can be explained by the changes described above.

Annual mean *nitrogen dioxide concentration* is a bit higher but still stays below the limit value for health (40 μg/m³) 11. The only exception is Pécs, where the mean concentration exceeds the limit (43.9 μg/m³). The mean concentrations are decreasing in almost every city and town, except for Debrecen, Dorog and Dunaújváros, where the trend is slightly rising.

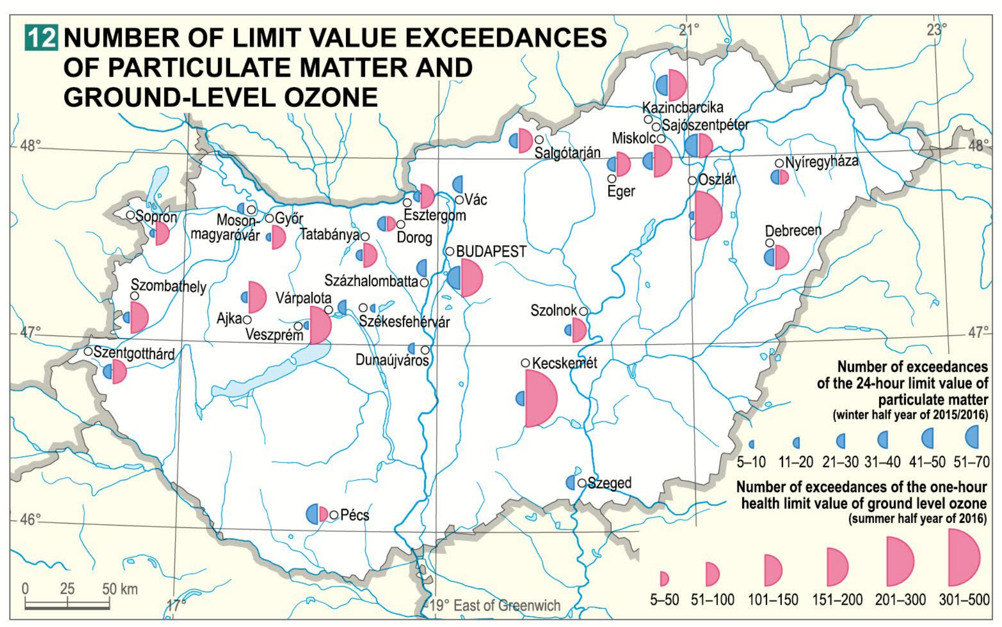
Ground level ozone (O_3) is a typical pollutant of the summer half year, its winter concentration is significantly lower. The ozone, which is an essential compound of the stratosphere in protecting the biosphere, has very harmful effects on the living organisms in the lower troposphere. Long-term exposure to ozone can cause eye irritation and serious diseases of the respiratory system. It is a so-called secondary pollutant, which is formed in the presence of sunlight by photochemical reactions of nitrogen oxides, carbon monoxide and volatile organic compounds emitted by traffic vehicles. Ozone concentration is the highest in urban suburbs, in the inner city it is depleted by nitrogen monoxide emitted by road traffic.

The annual mean ozone concentration is not worth calculating, because the values of the summer and winter half year equalise each other. Therefore, the map shows those settlements 12 where ozone concentration often surpasses the hourly limit value (120 μg/m³) in summer. Not only greater cities fall into this category but smaller settlements (Százhalombatta, Kazincbarcika, Oszlár – 9 km from industrial town, Tiszaújváros) also, where there is heavy traffic or industrial hydrocarbons are emitted.

The annual mean value of *PM_{10} concentration* does not say much about damages to human health either. In 2010, the annual concentration was relatively high in Sajószentpéter (32.7 μg/m³), Budapest (32.7 μg/m³) and Miskolc (31.5 μg/m³), but still stood below the yearly limit value for health. Hungary has a special location in the Carpathian Basin, which causes high pollution episodes in the winter half year, when there are weak winds and the mixing layer is thin. During these episodes PM_{10} concentration can highly exceed the hourly limit value for health for a few days thus increasing the frequency of cardiovascular diseases. Considerable number of 24-hour limit value exceedances were reported in the winter half year of 2015/2016 12 mainly in Budapest and its surroundings, the



10 ANNUAL MEAN SO_2 CONCENTRATION BASED ON THE MEASUREMENTS OF AUTOMATIC AIR POLLUTION MONITORING STATIONS



12 NUMBER OF LIMIT VALUE EXCEEDANCES OF PARTICULATE MATTER AND GROUND-LEVEL OZONE

International protocols on emission reduction

The national air quality policy is basically determined by the regulations of international conventions and EU protocols. In 1979, Hungary was among the first to sign the Geneva Convention on the long-range transboundary air pollution, and then to sign all the related protocols. 2020 target values determined in accordance with this policy are shown in Table 13.

13 2020 TARGETS FOR NATIONAL EMISSIONS OF POLLUTANTS IN ACCORDANCE WITH THE GENEVA CONVENTION

Pollutant	Emissions in 2005 (t)	Target for 2020 (t)	Reduction (%)
Sulphur dioxide	129,000	70,000	46
Nitrogen oxides	203,000	134,000	34
Volatile organic compounds	178,000	124,000	30
Ammonia	80,000	72,000	10

Hungary signed the Vienna Convention and its Montreal Protocol for the protection of the ozone layer thus contracting the stricter requirements for developed countries and the production and consumption of hard and soft freons were discontinued in the country. At the same time – like in other countries – these pollutants were replaced by materials not damaging the ozone layer, but which are strong greenhouse gases (HFCs). In accordance with a 2016 protocol, HFC emissions have to be reduced by 10% globally.

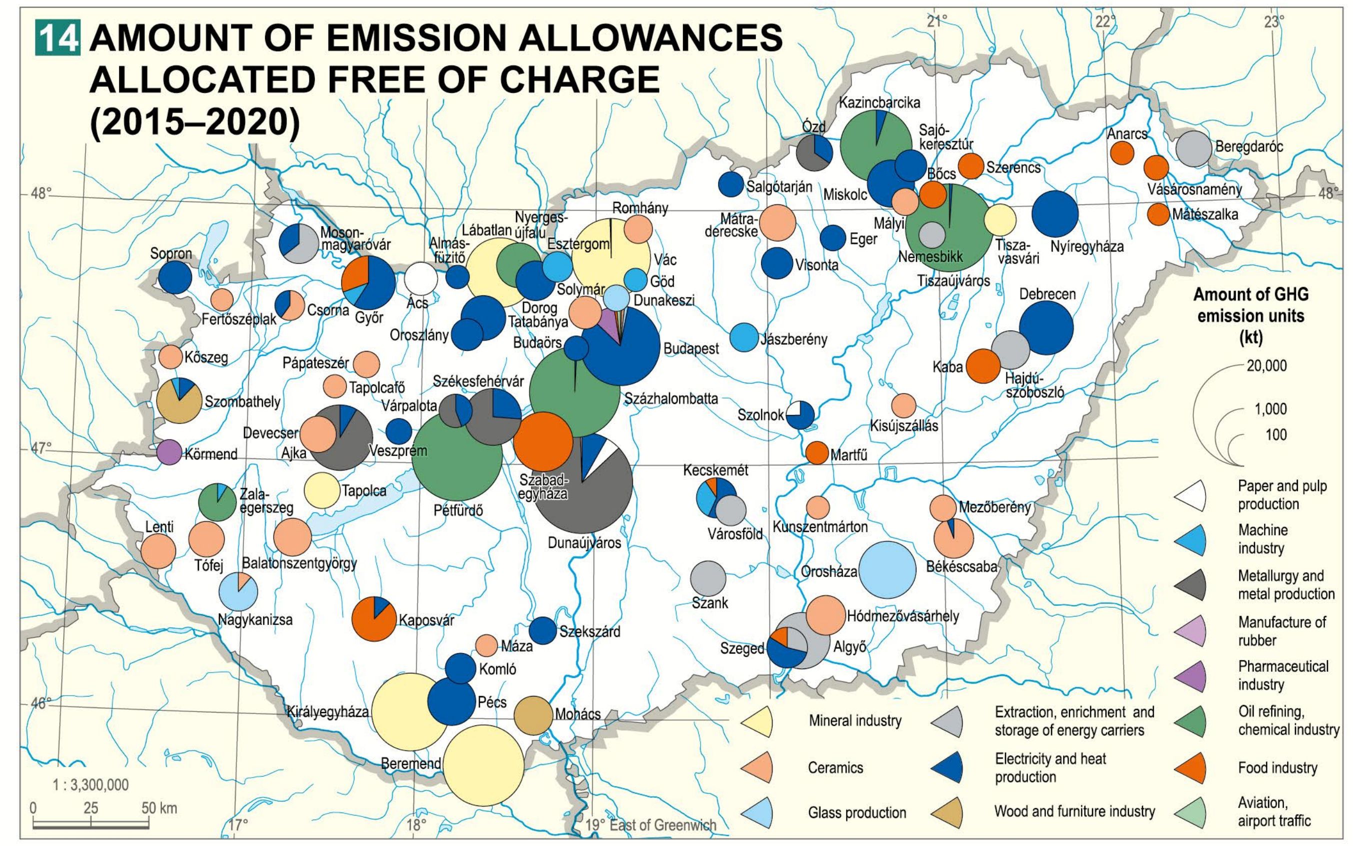
In terms of the fight against climate change, Hungary ratified the UN Convention on Climate Change and the Kyoto Protocol. Average 2008–2011 GHG emissions in Hungary were 40.8% lower than those in the base-year level (the average of the 1985–1987 period), well below the Kyoto target of –6%. Thus Hungary can continuously use the flexible mechanisms at government level by selling its Kyoto units from 2005. The second commitment period of the Protocol (2012–2020) commits the European Union to reduce its greenhouse gas emission by 20% based on the 1990 level. In December of 2015, a new convention was born, the Paris Agreement dealing with greenhouse gas emissions mitigation, adaptation and finance starting in the year 2020. The Agreement aims to further reduce the GHG emissions to reach zero emission by 2100. Each country determines, plans and regularly reports its own contribution. Hungary was among the first to ratify the Agreement.

Sajó Valley, Debrecen and Pécs, but the map shows that many other cities had few-day-long episodes.

One of the most cost-efficient, market-based mechanisms of GHG emissions reduction is emissions trading. In Hungary, in accordance with the EU legislation, the *Kyoto certified European emission reduction units* (the commonly known CO_2 quotes) were (and recently are) on the market in three trading periods – in the periods of 2005–2007, 2008–2012 and recently 2013–2020.

Under the cap and trade principle, a maximum (cap) is set on the total amount of greenhouse gases that can be emitted by all participating installations. Allowances for emissions are then auctioned off or allocated for free, and can subsequently be traded. If emission exceeds what is permitted by its allowances, an installation must purchase allowances from others. Conversely, if an installation has performed well at reducing its emissions, it can sell its leftover credits. This allows the system to find the most cost-effective ways of reducing emissions without significant government intervention. The amount of emission allowances allocated free of charge is decreasing year by year, thus the number of credits in 2020 will be 21% less than in 2005, and it will run out by 2027. Meanwhile the number of installations is increasing, therefore the quotes will be replaced via stock exchange. Map 14 shows the total amount of emission allowances allocated free of charge for the 8-year-trading period of 2012–2020 according to the geographic location and the activities of the installations.

Installations subject to GHG emission authorization are operated in 85 Hungarian cities. Of these installations, 171 received free emission allowances in the recent trading period. Considering their number, most of them are power plants, however the biggest number of allowances (one-third part) were allocated to oil refineries and to the chemical industry, followed by metallurgy and metal production (24%) and cement and lime production (20%). The number of free emission allowances decreased by 90% in the energetics sector in the recent trading period compared to 2005, while other sectors have half of their previous quotes, meanwhile new members of the trade system appeared among the applicants. 60% of the national GHG emissions can be related to installations in five settlements. In addition to their energy production, Dunaújváros has steel and iron metallurgy, Százhalombatta and Tiszaújváros have oil refinery, Pétfürdő has chemical industry and Beremend has cement production, all of which highly contribute to GHG emissions.



14 AMOUNT OF EMISSION ALLOWANCES ALLOCATED FREE OF CHARGE (2015–2020)

Water quality

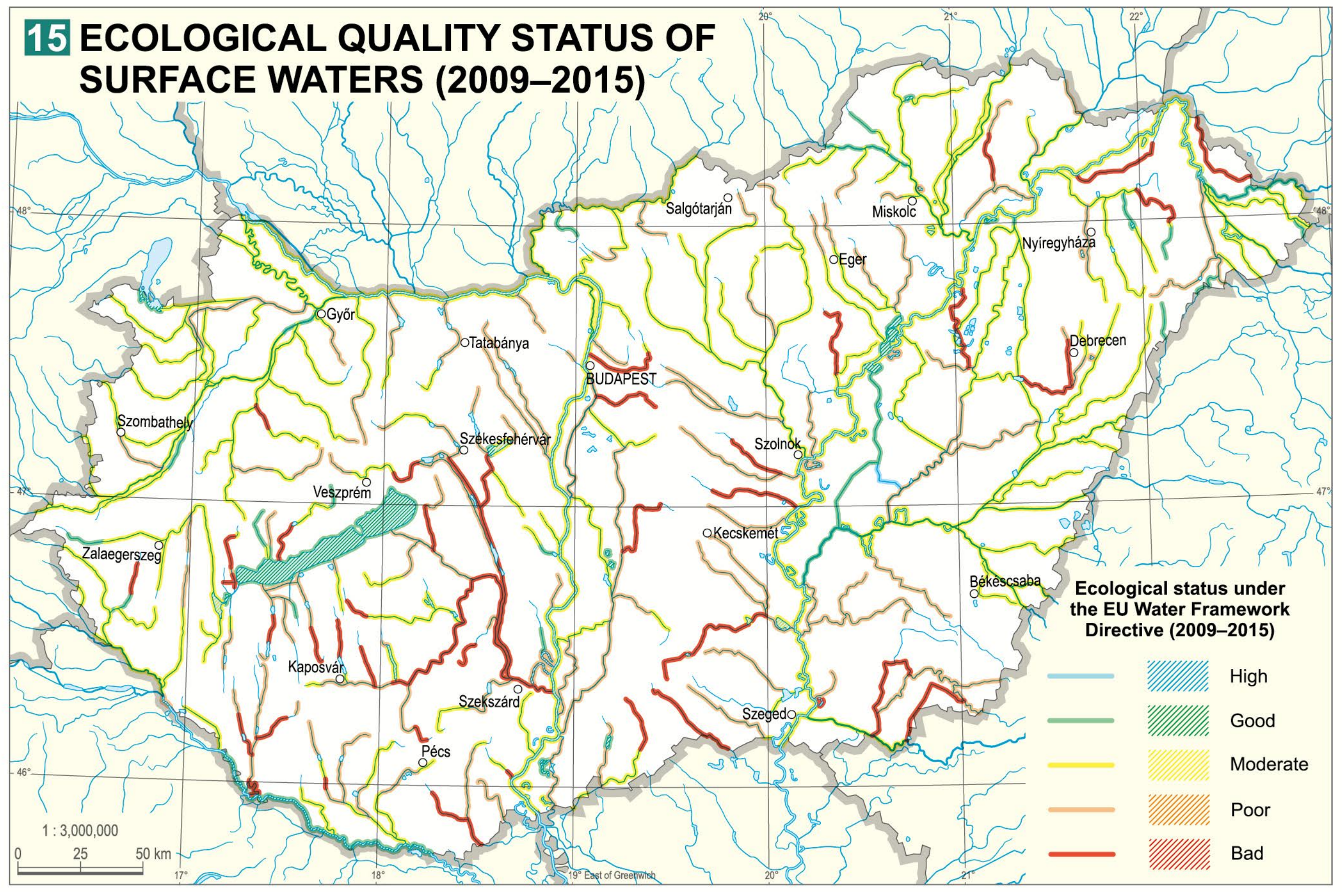
In the Earth's water cycle, water flows into rivers and lakes on land, below the Earth's surface it is stored in the pores and cracks of rocks, and moves under the influence of gravity and other forces. Water is an excellent solvent, means of transport and living space that can contain dissolved gases, salts and organic matter, as well as floating substances and living beings. In a chemical sense, pure water does not occur naturally, distilled water is best represented by rainwater, but that also contains gases and dust from the atmosphere.

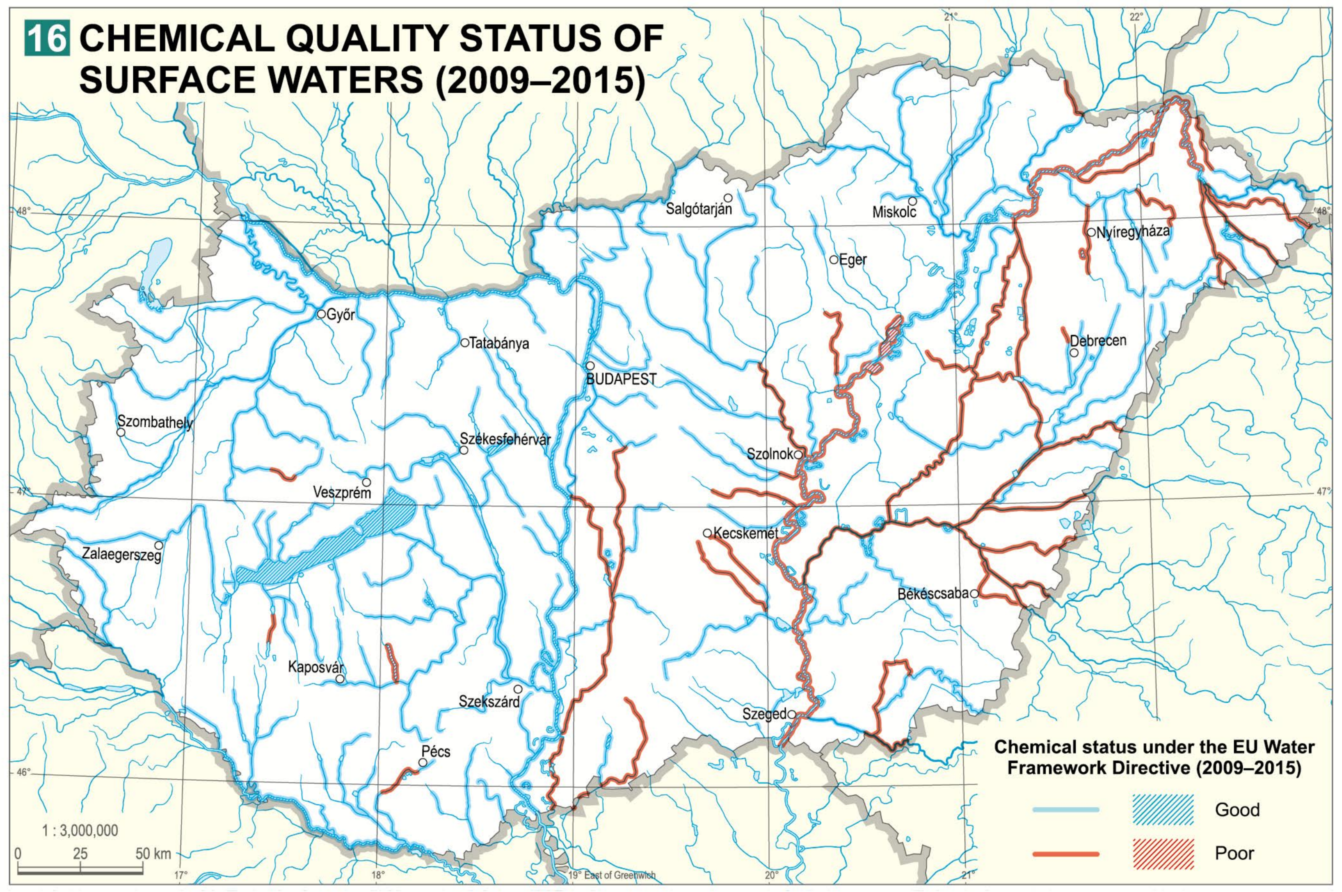
Water quality is the entirety of physical, chemical and biological properties. For the purpose of determining water quality, important features are typically measured and evaluated depending on the planned use. In Hungary surface and subsurface water is used to supply households, to meet industrial needs and to meet the water needs of agriculture, so rating or status assessment is usually the result of the water's compliance with drinking water, industrial water, irrigation water, bathing water, mineral water, etc. relevant standards.

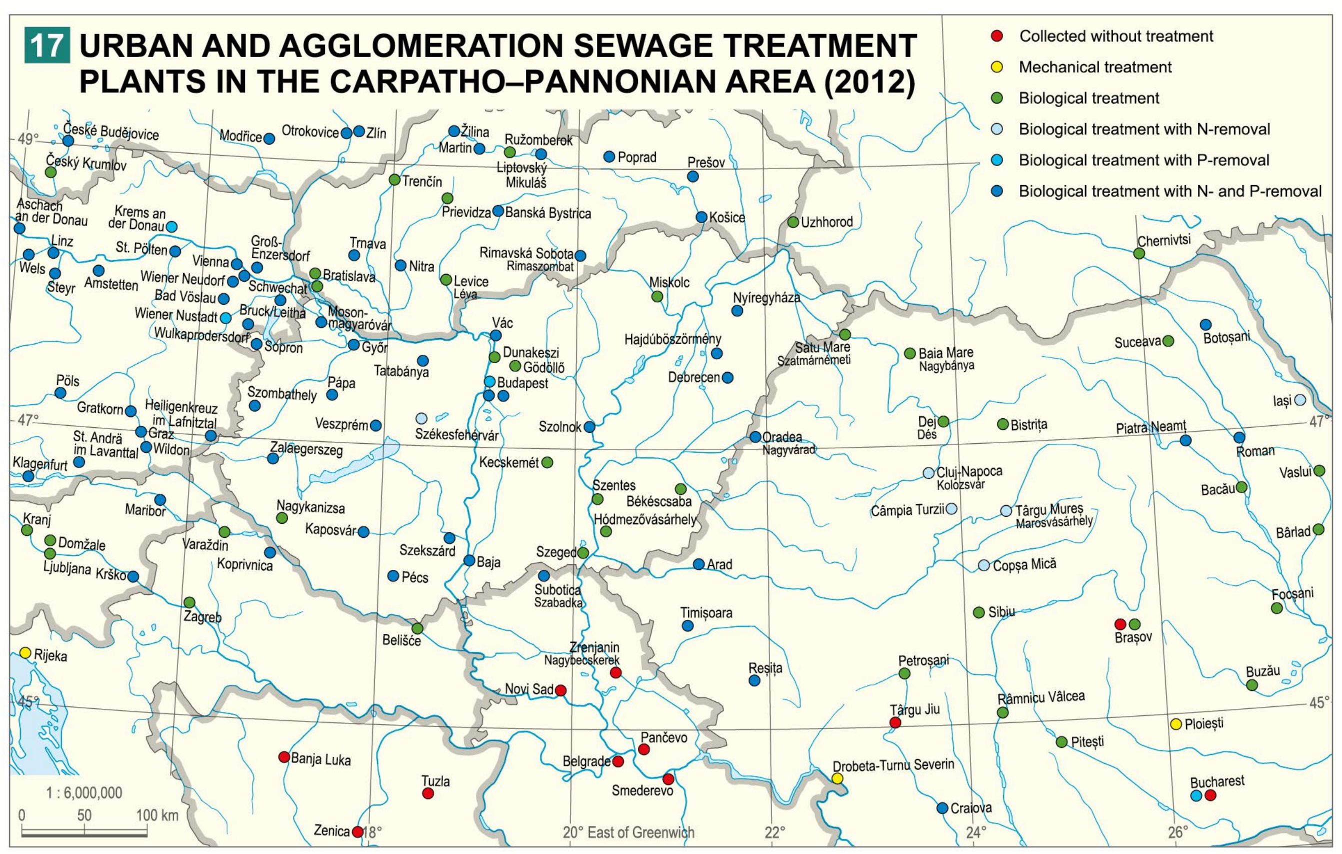
Surface waters

For surface waters the *European Union Water Framework Directive (WFD)* treats the waters taking into account their strategic importance and has a new approach in the field of water quality compared to previous regulations at national level, which were different in nature and stringency. According to the WFD, a good water quality status means not only the purity of water, but also the natural state of water-related habitats and the availability of the required amount of water. The excellent water quality status for surface water would be natural, undisturbed conditions not affected by anthropogenic effects. This depends, for example, on the geological environment surrounding the surface waters, the water's location above sea level, the terrain and the water regime. What is natural in a lowland salty lake is unacceptable in a mountain stream. The natural state of waters is referred to as a reference state; their rating according to the WFD is based on the degree of deviation measurable from the reference state. Based on their ecological status, five 15, based on their chemical quality, two quality classes 16 are defined by the WFD, these are indicated by colours.

The most important ones out of the 1,078 water bodies in general, but not without exception, are classified into the good and moderate categories, thus the ecological and integrated nature of the seven water bodies that make up the Hungarian section of the Danube, with a chemical classification, are moderate. The Hungarian section of River Tisza is made up of eight water bodies, seven of which have moderate, and one has good ecological status, but the chemical status of five is objectionable due to their toxic metal content. One of the two water bodies of River Dráva is good and the other is weak. The latter is caused by the condition of aquatic vegetation. Five of the six water bodies of River Rába are in moderate and one (the estuary section) is in good condition. The two water bodies of Rivers Sió and Zala are weak and poor,







moderate and weak, again based on biological characteristics. The three water bodies of River Kapos are moderate, poor and bad in the order of the direction of flow, the problems are indicated by fish and floating algae. Both water bodies of the River Hármas-Körös are moderate, which is primarily due to chemical load. The same can be said about the Kettős-Körös and also the Fehér-Körös (Crişul Alb), Fekete-Körös (Crişul Negru) and Sebes-Körös (Crişul Repede). The water bodies of Berettyó (Barcău) and Szamos (Someş) and the two water bodies of the Túr Rivers are of moderate quality, caused by both metal loads and ecological problems. Due to the biological characteristics of Kraszna (Crasna), it is in a weak status. The Bodrog, the two water bodies of the Hernád (Hornád) and the lower part of Sajó (Slaná) are moderate, while the upper part of Sajó (Slaná) is in good status. The upper section of Tarna is weak due to several biological characteristics, while the middle and lower water bodies are moderate. The two water bodies of River Zagyva, which has only Hungarian catchments, are moderate.

Overall (despite the above mentioned quality issues) we can conclude that the water quality of our rivers has considerably improved compared to their severely polluted state before the change of the political regime.

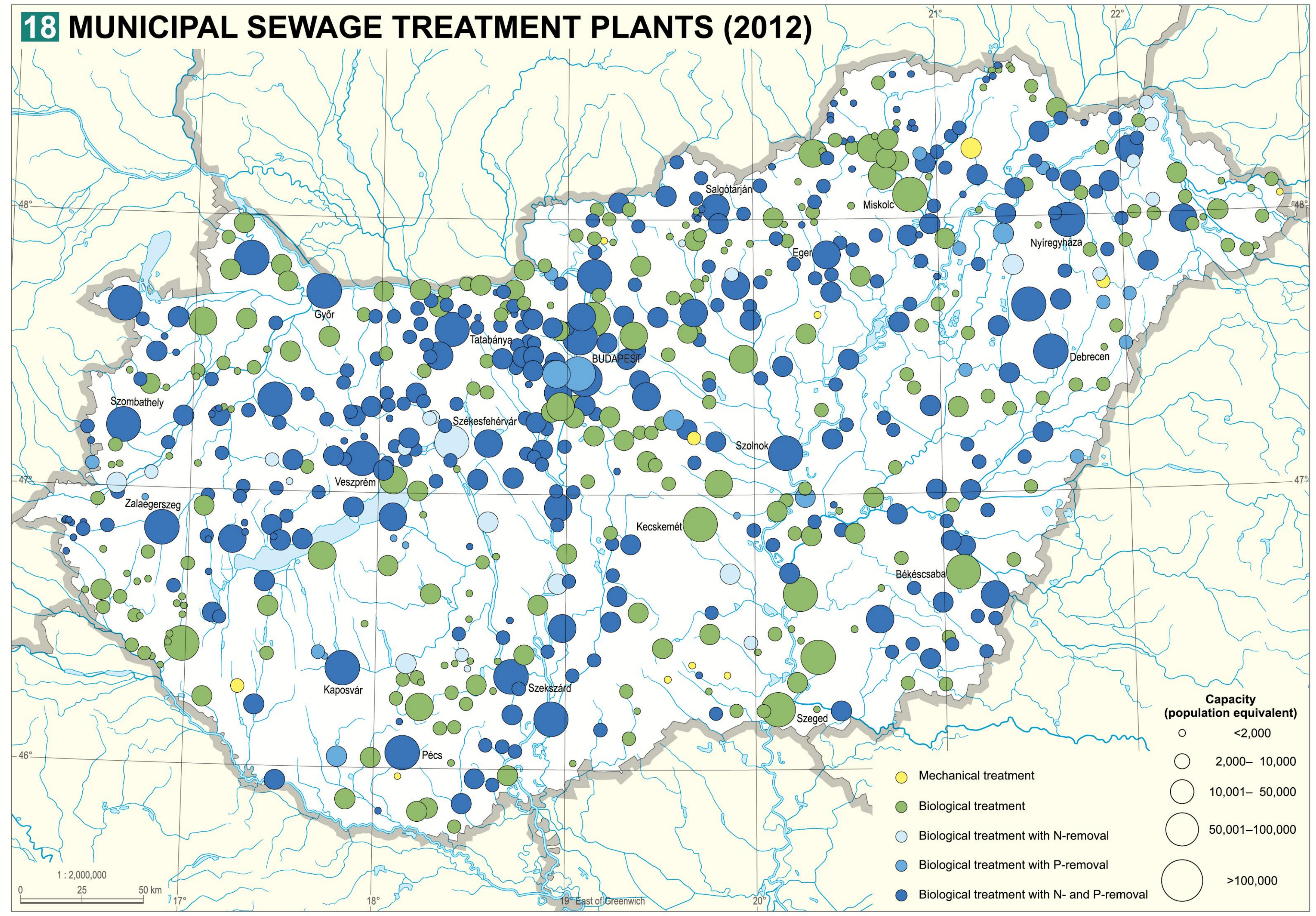
Further changes of water quality in Hungarian streams are primarily determined by the pollution sources on their river basins. Maps of potential sources of pollution of the Carpathian Basin 17 19 20 21 provide an overview of the diversity of potential pollutants. The data is from the databases of the *European Environment Agency (EEA) and the European Pollutant Release and Transfer Register (E-PRTR)*.

The most important sources of pollution in the rivers are low efficiency urban and agglomeration wastewater treatment plants. High capacity wastewater *treatment plants* in many cases clean the wastewater of several settlements, and of so-called sewage agglomerations. Such are also located in Hungary. It is fortunate that sewage plants that collect sewage without purification are all south of us and have no impact on the quality of our river waters. Of the 149 sites depicted on the map, biological treatment is carried out with the removal of nitrogen and phosphorus in 84 wastewater treatment plants, and this is beneficial for our good water quality.

Map 18 also depicts wastewater plants with a capacity of less than 2,000 population equivalents (PE) in Hungary. (Population equivalent is not the same as the population of the given settlement, but it is the organic content of the wastewater per day delivered by one inhabitant per day.) Biological treatment is carried out at 269 locations of a total of 659 sewage treatment plants, while biological treatment is completed by nitrogen and phosphorous removal at 330 sites. Only 14 small capacity (<10,000 PE) wastewater plants perform only mechanical treatment. Wastewater treatment plants are constantly being modernized 5 6.

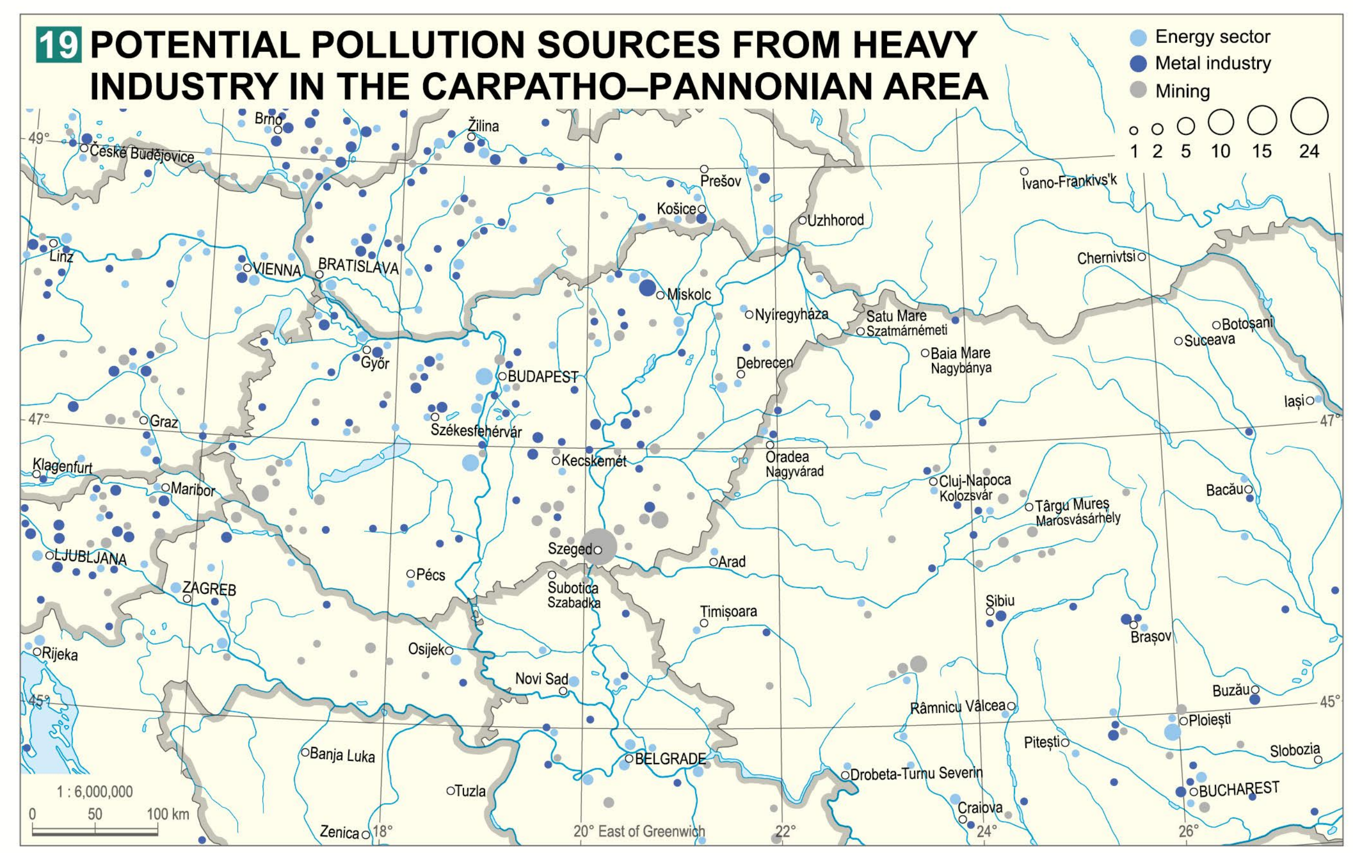
5 *Dorr-type settlers (foreground) and biological wastewater treatment basins (in the background)*

Regarding the sources of contamination, it should be noted that the term 'metal industry' 19 includes a full range of metal production and processing. Most of the polluting chemical, wood and paper-based plants are located in Slovakia 20. Other sectors include textile and leather factories, facilities using organic solvents, such as Magyar Suzuki Ltd. Regarding potential pollution sources related to animal husbandry, aquaculture and the food industry 21, the density of plants is highest in the Alföld due to its favourable agricultural conditions. Inadequate operation of livestock farms often means not only potential but also actual pollution 7.



Hungarian lakes, especially Lake Balaton, have outstanding natural and touristic values. This is largely determined by the quality of water, which has undergone significant changes over the last fifty years. The rapid development of holidays and tourism, the development of drinking water and sewerage systems, the impact of intense agriculture (fertilization and large livestock farming) and the development of lakeside settlements since the 1970s have accelerated the aging of the lake – which would also occur under natural conditions in the long run – and has adversely affected the water quality of the lake.

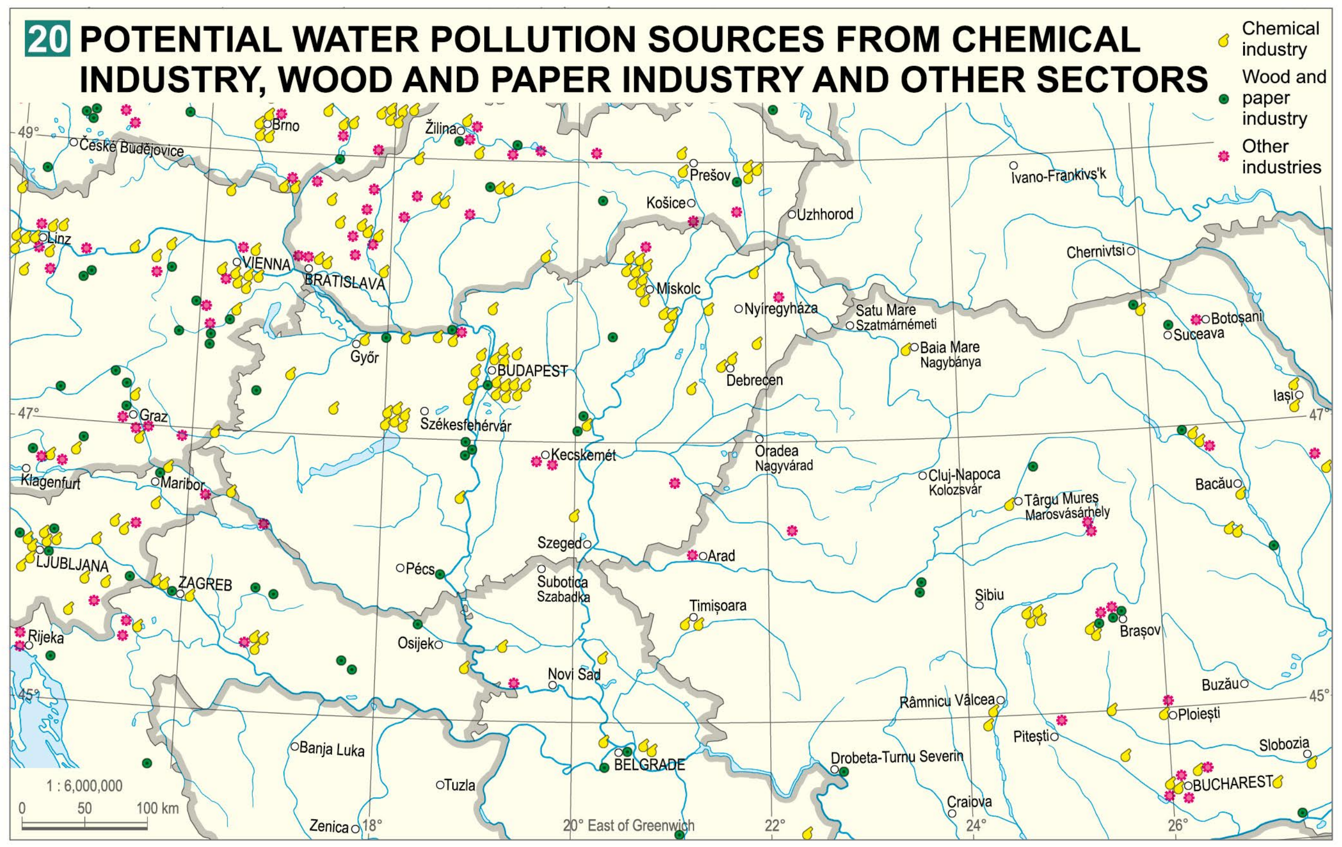
The primary public enemy of the water of Lake Balaton – like of all Hungarian lakes – is *eutrophication*, i.e. the increased growth of aquatic plants caused by the enrichment of nutrients, which may be the result of natural, mineral or artificial effects (fertilisation, discharge of wastewater) or can be caused by the accumulation of inorganic substances resulting from the natural degradation of organic substances in water. Its first signs were observed in the 1950s, when nutrient load from external river basins increased. Eutrophication was particularly intense in the western part of the lake, in the Keszthely Basin. Fish deaths have occurred, and in 1994 there was extensive algal bloom all over the lake (Cylindrospermopsis raciborskii proliferation of filamentous cyanobacteria) and hypertrophic state (extreme concentration of nutrients) was characteristic. However, in the past decades, the environmental status of the lake and its catchment area

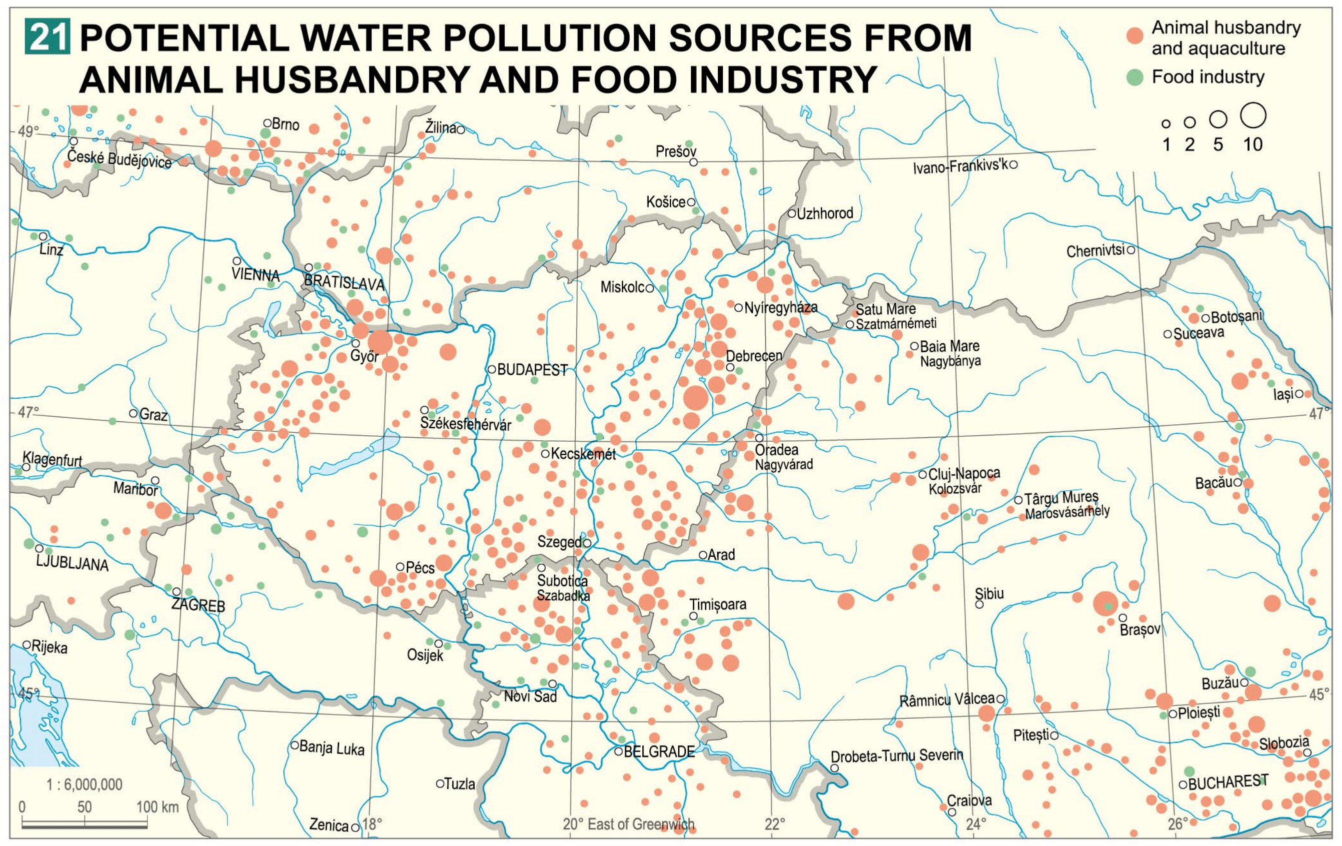


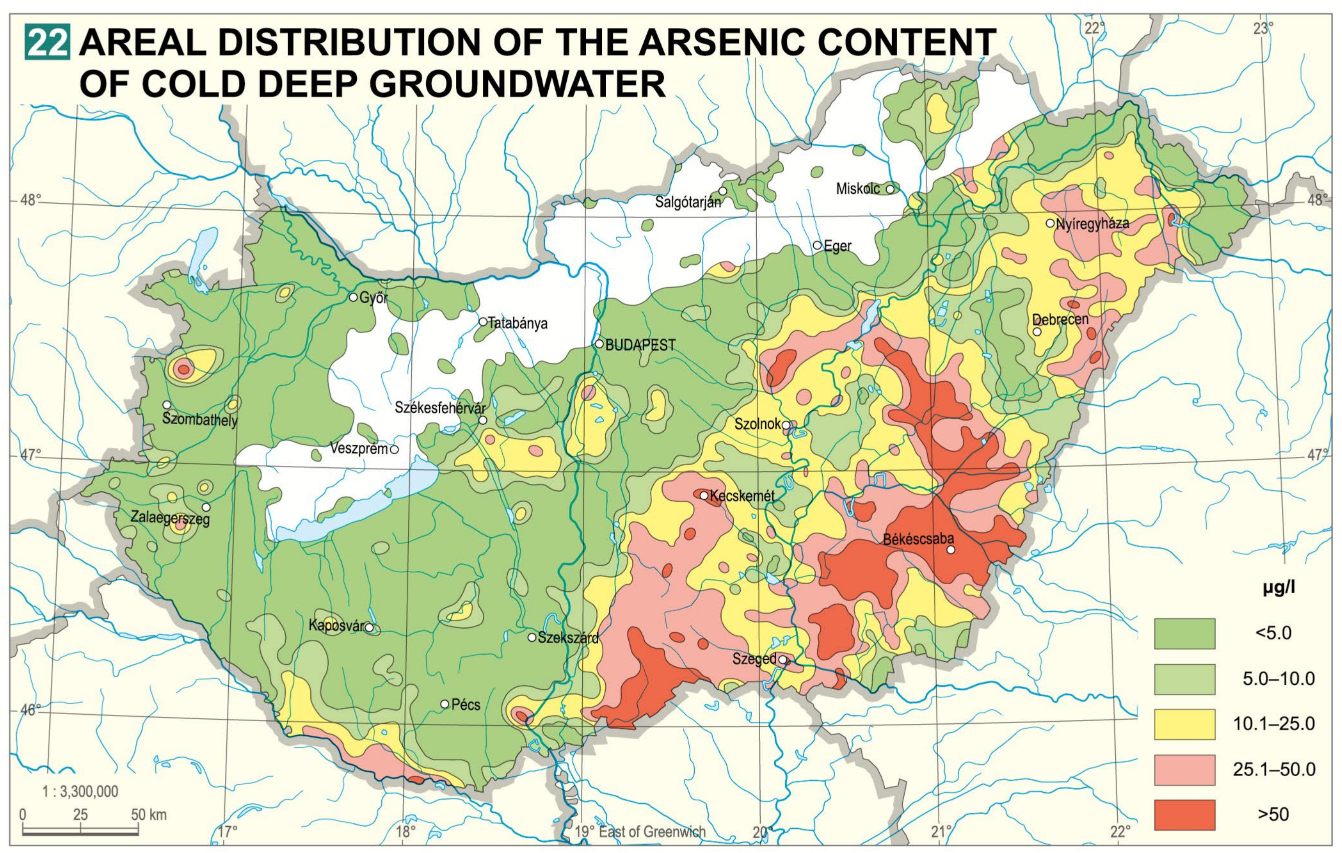
6 *Biological sewage treatment with activated sludge system, with putrefactive towers in the background*

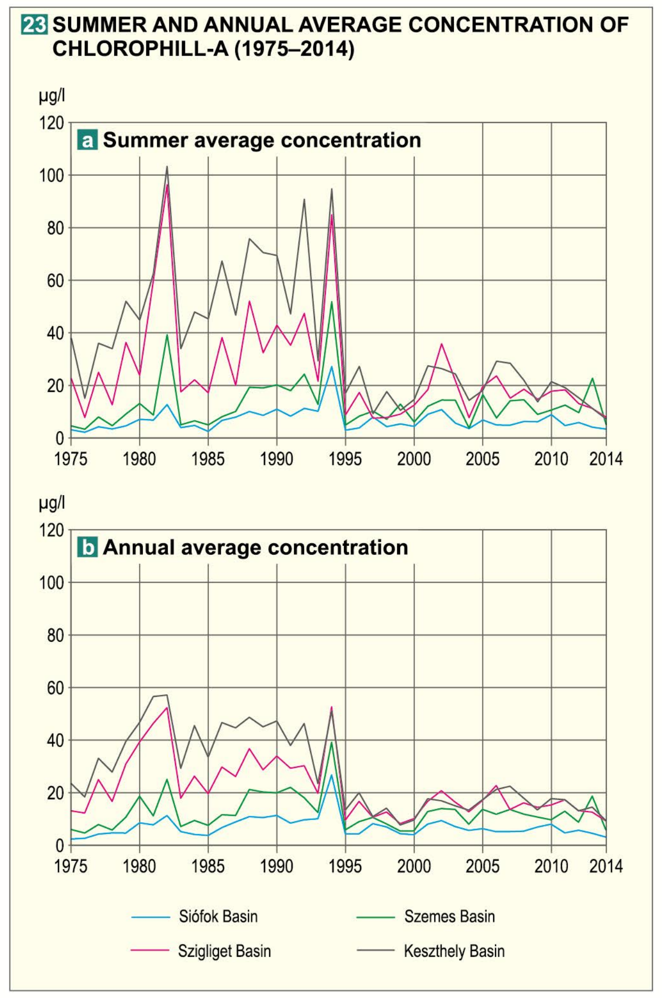
7 *Water pollution from stalls in the Alföld*

XI.









has improved considerably, for example, fertiliser usage has decreased, intense livestock production ceased in the catchment, significant sewage and wastewater treatment investments have been completed, and waste management has been largely reformed. In addition, the *Kis-Balaton Water Protection System project phase I and II* have been completed which has a significant nutrient-filtration function for surface waters in the Keszthely Bay and the regular maintenance and restoration of reed stocks also takes place.

The lake's water is oxygen-rich, calcium-magnesium hydrocarbonated. The average annual water quality status pertaining to the physico-chemical and biological components tested under WFD has improved from moderate to good in recent years. The measured change is indicated in the change of concentration of α-chlorophyll in the so-called Balaton lake centre monitoring station 23.

The western part of Lake Velence is good, while the middle and eastern parts, used heavily by tourism, are moderate. Lake Tisza is also moderate, where good ecological rating is degraded by metal pollutants, which come from tributaries of the left bank reflected by their classification. At the same time, the water quality of our smaller lakes (oxbow and saline lakes) and backwaters leaves in most cases room to be improved, most often due to the excessive amount of plant nutrients 8.

Groundwaters

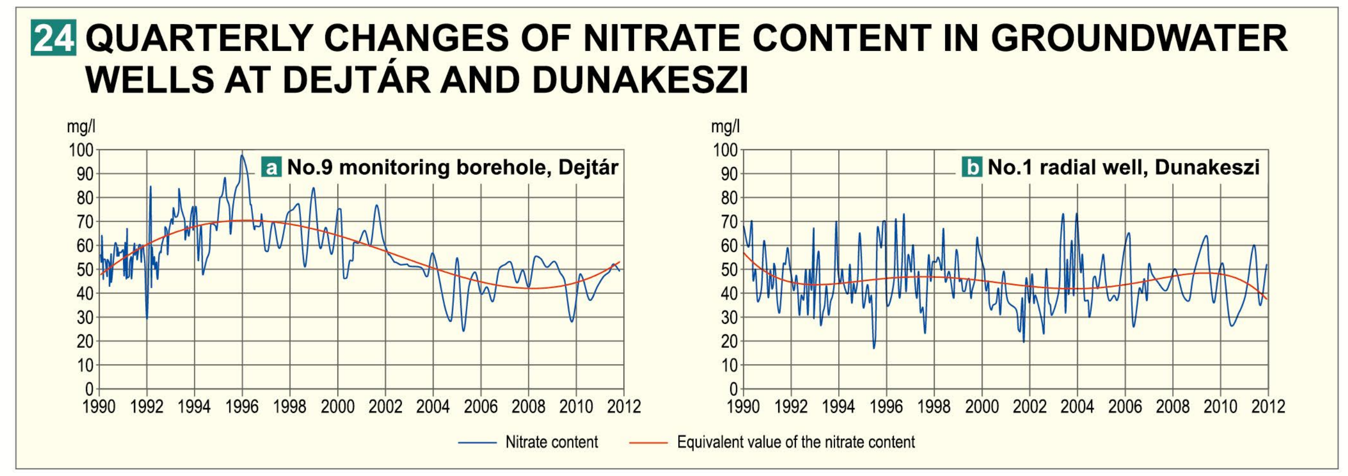
Their quality is determined by the fact that during their subsurface stay the chemical composition and physical properties of the water change significantly due to natural processes and the water can be contaminated due to human activities. A fundamental feature of the processes is rock–water interaction. The appearance of different elements in groundwater depends not only on the base rock, but also on the mobility of the elements; for example, silicon, aluminium and iron are common in rocks, but rare and not very mobile in water; calcium, magnesium rocks are moderately common, but are common and mobile in water; chlorine is rare in rocks, common in water and very mobile. In subsurface waters, both gases and solids can dissolve, which can have significant effects: such as with CO_2 and H_2S dissolving in the water becomes slightly acidic, that is chemically aggressive.

High arsenic content is of natural origin, which is a peculiarity of our subsurface waters, especially groundwaters. The concentration is especially high in the eastern and southern part of the Alföld, which is about a quarter of the country's territory 22. The amount of arsenic in drinking waters from such aquifers exceeds the EU standard (10 μg/l), so water can be consumed only after expensive arsenic removal or after mixing with other piped waters.

Springs and bank-filtered waters form a transition between surface and subsurface waters. From the water-bearing, water-storing rocks located near surface waters, we produce the most filtration waters, which are of paramount importance for drinking water supply, and thus, being in contact with the rock layers, their water supply is mainly derived from surface water. Accordingly, the quality of extracted water is similar to that of surface waters, but it also mixes with background groundwater, which can have a significant effect on composition. Filtered water is vulnerable due to the location of the water resource and therefore requires increased protection.

The original quality of groundwater is altered by pollution coming from human activities – particularly near the surface. In the case of groundwater, pollution is generally persistent; its duration can be up to decades or centuries, if the contaminant does not decompose.

Nitrate contamination of groundwater is primarily caused by agricultural activities, which poses a risk if the contamination exceeds the limit of 50 mg/l by 10–20% (5–10% for karstic waters). Its value is much higher in Transdanubia, where the proportion of fertilised areas and specific nitrogen fertiliser use is much higher than in the Alföld. At the same time, the fluctuation of nitrate concentrations in surface waters is significant because the infiltration of the contaminant is caused by intense precipitation events. Based on the results of monitoring, the nitrate contamination has been practically unchanged since the turn of the millennium in two thirds of the monitoring locations, while in one third it is increased or decreased roughly half the proportion 24.

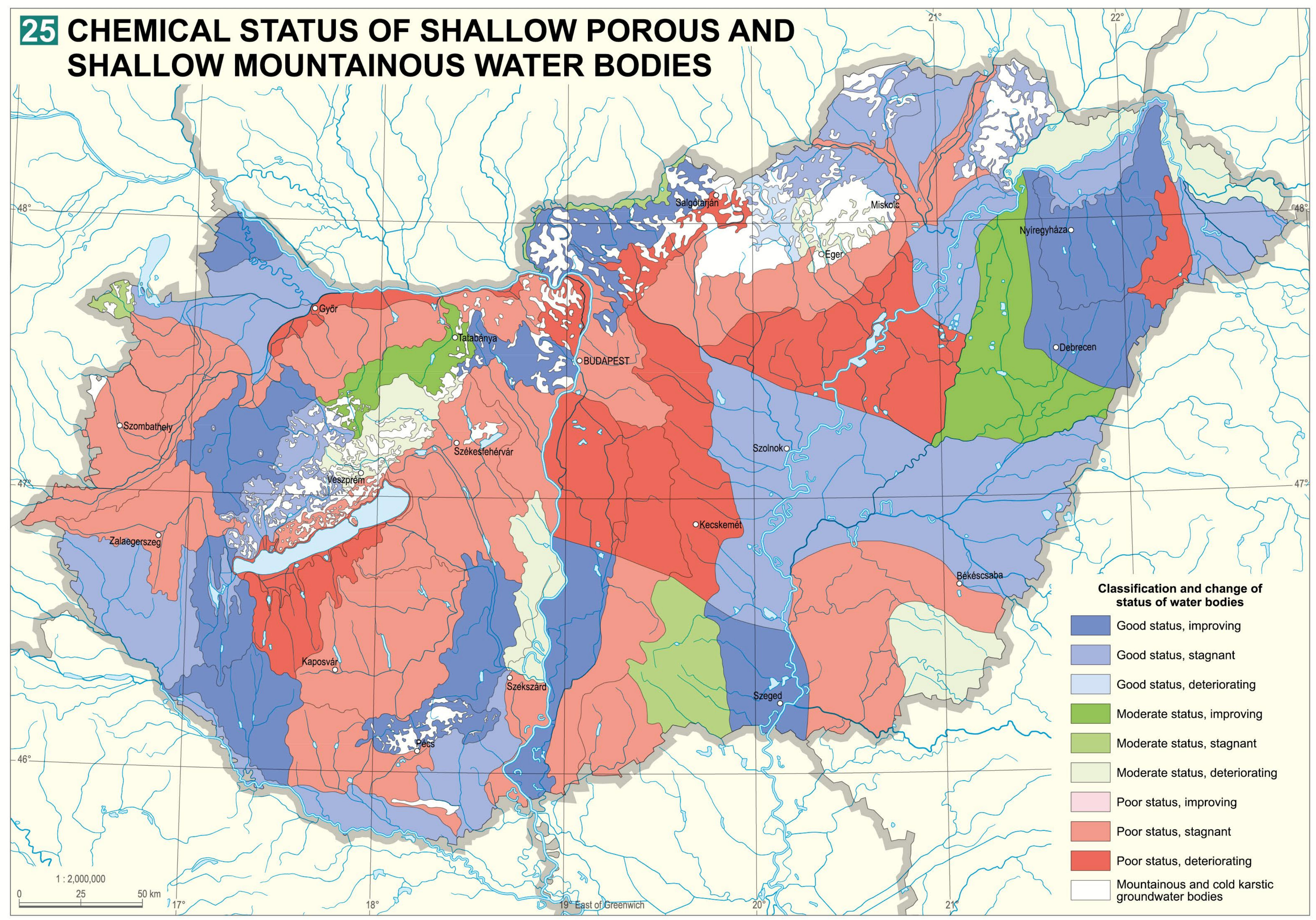



8 *Eutrophication in Cserőközi-Holt-Tisza*

The ratings of the groundwater body chemical status is based on the detection of concentrations above the threshold in the observation wells. The threshold was determined per water body for the following components: nitrate, ammonia, conductivity, chloride and sulphate. National thresholds include, among others, all organic carbon, cadmium, lead, mercury, pesticides. Based on the analysis, water bodies were classified into 'good', 'weak' and 'good, but weak state at risk' categories. Regarding the status of the country's shallow porous and shallow mountain water bodies 25, 33 of the 55 shallow porous water bodies are 'weak', and the trends of change are not favourable: many of them are deteriorating water bodies. In addition to nitrate, among the active substances of pesticides, atrazine is most common in groundwater, but no water body has been classified as 'poor' due to pesticide loads.

The aggregate classification of groundwater bodies was carried out on the basis of a joint assessment of chemical and quantitative aspects. From the latter point of view, fewer bodies of water have proved to be 'weak', but the number of groundwater and terrestrial ecosystems dependent on groundwater is high: from this aspect 18 water bodies are 'weak', such as Lake Balaton with Nagyberek, the 4 water bodies of the Danube–Tisza Midland Ridge and the Hortobágy.

Out of the Environmental policy documents aiming at the protection of water quality the already mentioned Water Framework Directive is determinative in the EU. In the spirit of this, Hungary prepared the revised 2015 *River Basin Management Plan*, which basically sets the framework for water management and water conservation, while specific actions include a number of programmes and legislation, including international conventions such as *International Danube*



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Protection Convention (Sofia, 1994), in which Hungary is involved with 13 other countries, and neighbouring countries have bilateral water management and water protection co-operation agreements.

Environmental state and protection of soils

Following air and water, soil is the third environmental element, which is used comprehensively by society, while human activity has an unfavourable influence on many soil properties. The *Soils* chapter of present Atlas gives a detailed review on how human activities deteriorate favourable soil characteristics, or impede their predominance.

Factors limiting soil functions are included in the following three groups:

- effects of natural factors;
- processes accelerated by Man (i.e. erosion, deflation);
- human-induced damages: pollution, acidification, etc.

Despite the relatively and generally favourable agro-ecological potential of the Carpathian Basin, soil multifunctionality is limited by the following factors in major areas of the basin 26:

- extremely high sand or clay content (coarse or heavy texture);
- extremely acidic or alkaline soil reaction (salinity and/or alkalinity);
- waterlogging or peat formation;
- parent rock near the surface (shallow depth).

These factors are *natural* (land site) *conditions* which we either adapt to with rational site-specific land use,

9 *Severe sheet erosion (light spots) in Hajdúhát arable fields*

proper cropping system and adequate agrotechnology, or – if possible, necessary, reasonable and rational – change or modify by soil reclamation and amelioration, soil conservation practices or water management.

Soil degradation caused by natural factors – resulting from limitations in normal soil functions, unfavourable changes in soil processes and soil properties – is discussed in more detail in the chapter on *Natural hazards*.

Influence of human activities on soil deterioration (degradation) processes

Soil erosion

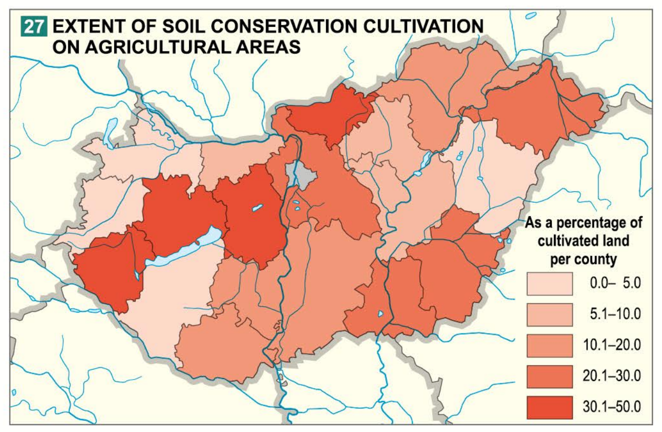
Water and wind erosion is dealt with mainly in the *Natural hazards* chapter, their soil degradation role accelerated by anthropogenic influence is discussed in present chapter.

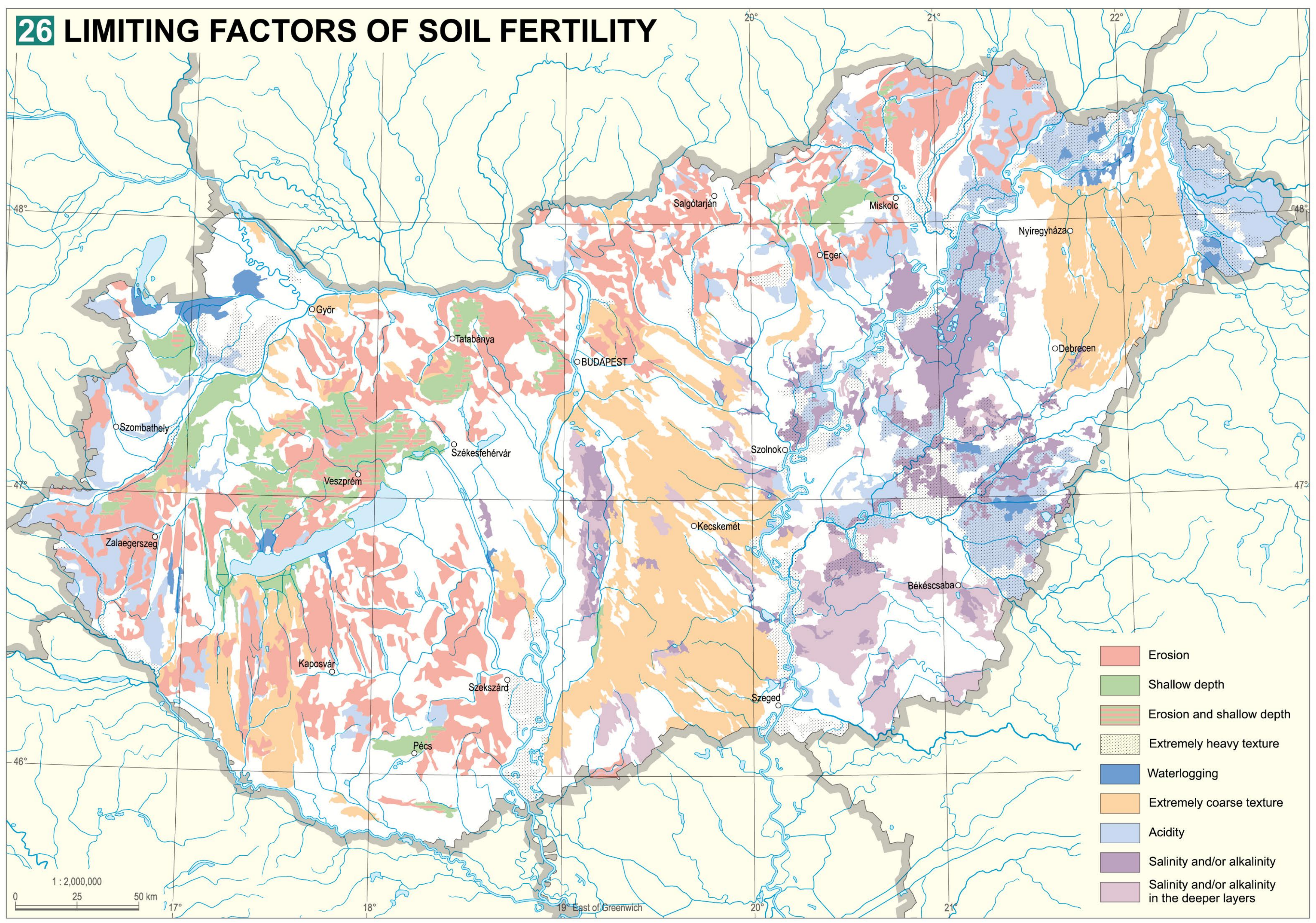
In sloping areas the physical destruction of soil due to water erosion occurs only if the speeding up of degradation is higher than the rate of soil formation. Without human intervention, on areas covered with permanent and dense natural vegetation – with the exception of very steep slope gradients – the two processes are in equilibrium, soil fertility is unaltered. As a consequence of agricultural activities, erosion accelerates, therefore this processes is called *accelerated erosion*.

During field crop cultivation there is always a period (from stubble stripping to leafing of the cultivated plant) during which the soil is almost entirely exposed. In this period even the impact of falling raindrops induces structure destruction on the soil surface, and with the sedimentation of structural elements (aggregates) the rate of sheet erosion is significantly increased 9.

On slopes, surface runoff joining in channels during heavy rains may transport two orders of magnitude larger amounts of soil than that by usual natural erosion. The rate of soil formation is much slower, therefore the tilth layer becomes shallow. Primarily the most fertile humus-containing layer is removed by water, therefore the soil's natural fertility decreases significantly. The distribution of territories with slight, moderate or severe erosion is variable.

Several methods are known for delaying or preventing accelerated erosion. On slight slopes the use of different types of soil protective cultivation – i.e.





10 *Consequence of wind erosion: sand cover deposited on arable field (Nyírség)*

contour ploughing, strip till, conservation crop rotations – were well proven. Usually these do not require surplus investments. On steep slopes frequently only technical procedures (terracing, drainage of excess waters) provide efficient solutions. There is a great difference in the extent of the application of soil protective cultivation methods at regional and county level 27.

Wind erosion (deflation) occurs most frequently on sandy soils (coarse textured soils 26). Soil tillage carried out too frequently and under unsuitable soil moisture conditions may also cause the dustiness of structured soils, therefore the erosive effect of wind (deflation) may assert itself. Damages are caused when soil particles transported by wind accumulate and cover the freshly spearing crops 10. The risk of this process can be moderated by soil covering (mulching). On structured soils the prevention of the disaggregation of structural elements is of utmost importance, which is attainable by precise cultivation carried out only when necessarily required and at the appropriate time.

Soil acidification

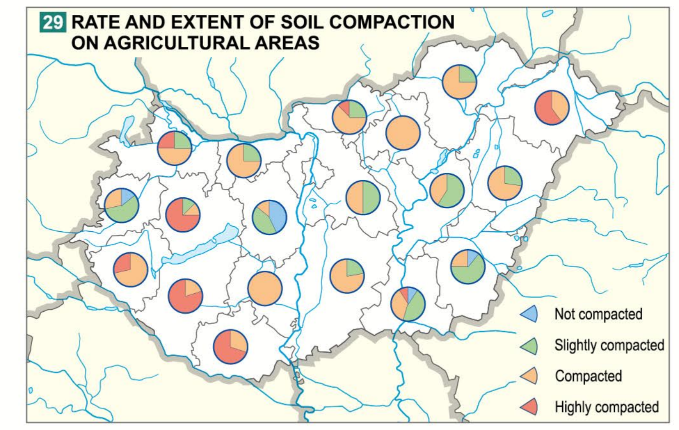
The decrease of soil pH is unfavourable for the nutrient uptake of cultivated crops: 8% of Hungarian soils are strongly, 18% moderately and 20% slightly acidic. Crops are not grown on the majority of soils strongly acidic due to natural conditions. The three main causes of soil acidification are irrational fertiliser application, acidic atmospheric deposition, the irregular disposal of acidic industrial by-products and wastes. Fortunately, more than half of Hungary's territory is non- or only slightly susceptible to acidification 28. Soils susceptible to acidification occur at a larger rate in the Nyírség and Transdanubian Hills. Further soil acidification can be effectively eliminated by controlling acidic loads and sustainable liming.

Salt accumulation, secondary (human-induced) salinisation/alkalisation

Eight percent of Hungary's territory is covered with various salt affected soils 26 (*Soils Chapter* 3). Salt accumulation in the deeper soil horizons or stagnant groundwater with high salinity rising near the soil surface – mainly due to seepage from unlined canals and reservoirs, or from areas having inadequate irrigation practice, local over-irrigation – pose a potential hazard of secondary salinisation-alkalisation on further extensive areas. This, however, can be prevented effectively by compliance with the guidelines of modern soil surveying and early warning system.

Physical degradation

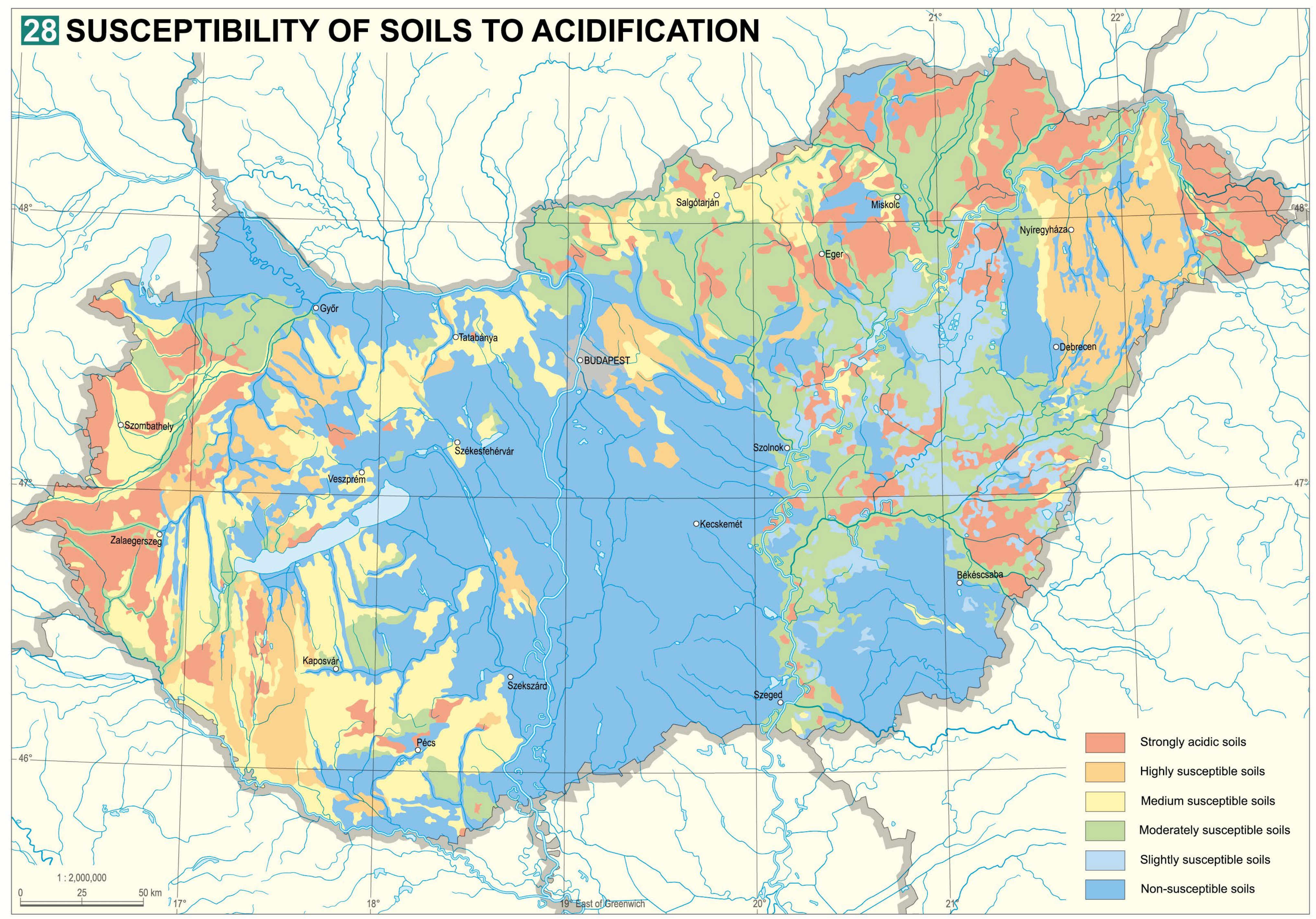
Structure destruction, compaction, surface crusting and silting up of the surface belong to this soil degradation process: 23% of Hungarian soils are slightly, 18% moderately and 13% highly susceptible to struc-



ture destruction and compaction. Structureless calcareous sandy soils (11%) are susceptible to compaction, salt affected soils (10%) are susceptible to both structure destruction and compaction. The extension of soil compaction is very diverse on agricultural lands 29. The ecological and plant production consequences of structure destruction and compaction are varied, they may lead to extreme moisture regime, soil aeration problems, unfavourable changes in the nutrient regime; the limitation and time reduction of soil moisture state suitable for appropriate agrotechnical measures ('minute' soils); increase in the energy requirement of soil cultivation, etc.

Soil pollution, toxicity

Soil pollution may be caused by several human activities. In respect of its territorial extension, agricultural practice is the greatest potential pollution source, while the most severe pollutions result from inefficient waste deposition, oil pollution and other dangerous wastes. In these cases – with the application of elaborate physical and biological methods – the solution of the problem can be in situ cleaning 11, or the removal of soil 12.



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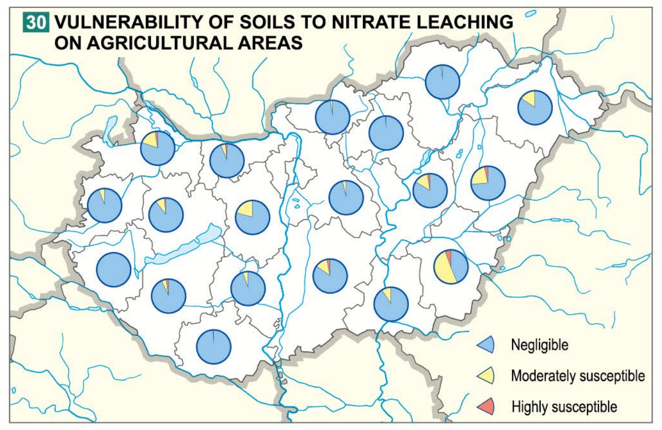
XI.

11 *Remediation of a former military airfield: cleaning of oil polluted soil and groundwater*

Mineral fertiliser application is typical of all kinds of plant production. Nitrogen fertilisers – applied to soil the most frequently and in the highest quantity – mainly contain nitrogen in the form of water-soluble nitrates. As the total nitrate content is never taken up by plants, the remainder may be leached into deeper soil layers or groundwater by precipitation or irrigation water. Fortunately, in respect of the scientifically estimated risk of nitrate leaching, it is negligible in the majority of the country, with the exception of the Alföld and Kisalföld regions, where the category for moderate risk occurs in a relatively larger ratio 30. This is mainly due to the decrease in fertiliser application.

30 VULNERABILITY OF SOILS TO NITRATE LEACHING ON AGRICULTURAL AREAS



The toxicity of soils and that of the environment in general is often caused by heavy metals toxic even in low concentration. At the representative observation points of the *Soil Information and Monitoring System* the concentrations of 9 heavy metals are measured regularly. In our soils the majority occur in concentrations below the limit value. There are such locations 31, however, where the concentration of one or two heavy metals exceeds limit values. Evidently, there are numerous places where the concentration of one element, that of arsenic exceeds its limit value, but this is due to geological reasons. Locations where the concentration of two heavy metals exceeds the limit values are found only in patches, i.e. in the Bükk and Mátra regions or along the Upper Tisza River.

12 *Environmental remediation of former waste depot*

The role of soil database in soil conservation

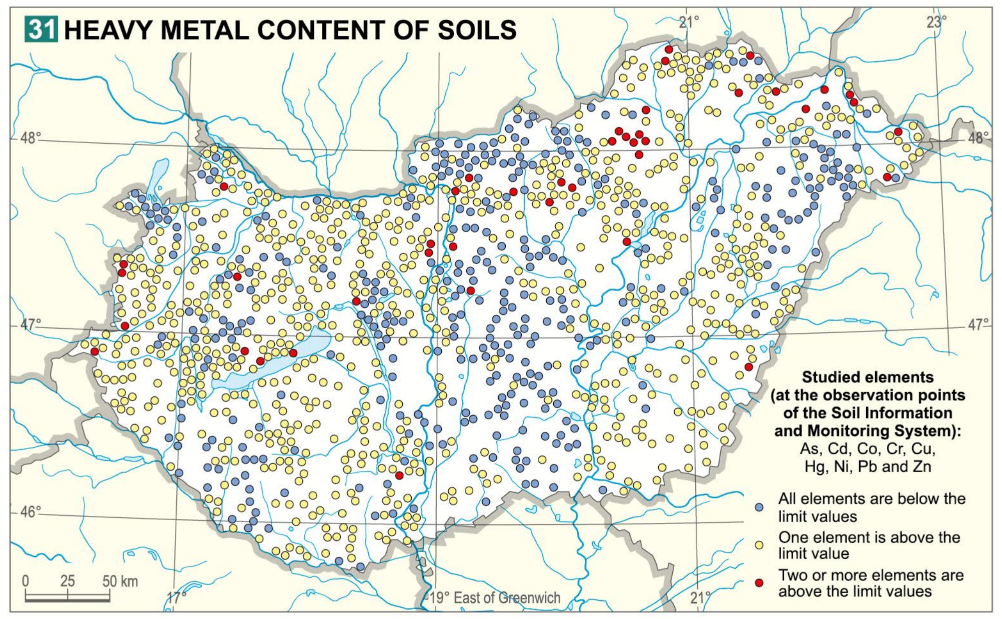
Soil degradation processes are not inevitable and unavoidable, with rational and appropriate land use most of these processes can be efficiently prevented, eliminated or at least moderated to a tolerable limit. This requires scientifically based actions to ensure the preconditions of the renewal of soils, the elaboration of which needs a modern and up-to-date soil database that serves with adequate information on the environmental state of soils, the changes taking place, as well as the environmental susceptibility and vulnerability of soils.

According to their changeability, the physical, chemical, biological and agronomical soil properties developing soil functions range in a wide spectra, as some soil properties become modified only slowly and with difficulty, with a magnitude of thousands and even hundreds of thousands of years on the geological time scale, and there are some that change in an instant. Based on such information, the rational and effective survey methodology (for registering the ongoing changes) of the soil monitoring and information system can be developed and operated. The determinant elements of such a system are spatial and temporal information density appropriate for the given objective, on the one hand, and the determination of measurement and sampling methods that ensure spatial and time representativity, on the other hand.

The Soil Information and Monitoring System operating since 1992 – by monitoring the state of soils countrywide – serves with information for soil-related decisions at all levels. From the 1,200 observation points 800 are located on agricultural land, 200 in forests, and 200 in environmentally threatened 'hot spots' or in protected areas. The measurement frequency (yearly, every three years, every six years, or at the start on one occasion) of the observed more than 50 soil parameters was determined depending on the changeability of the given soil parameter. Monitoring is extended to all of the main characteristics, among others to important data related to 21 chemical elements. On the basis of this information, the 'environmental susceptibility/vulnerability' of soils can be determined, quantitatively characterized, the limit values can be determined, and taking these into consideration the irreversible damages can be predicted, the harmful contamination can be stopped or neutralized.

An indispensable element of a modern plant nutrient replenishment and pollution management system – ensuring the quality control of our soils and waters, and the maintenance and increase of soil fertility/productivity – is the monitoring of mass and energy processes in soils, the elaboration of the possibilities and implementation of their regulation.

31 HEAVY METAL CONTENT OF SOILS



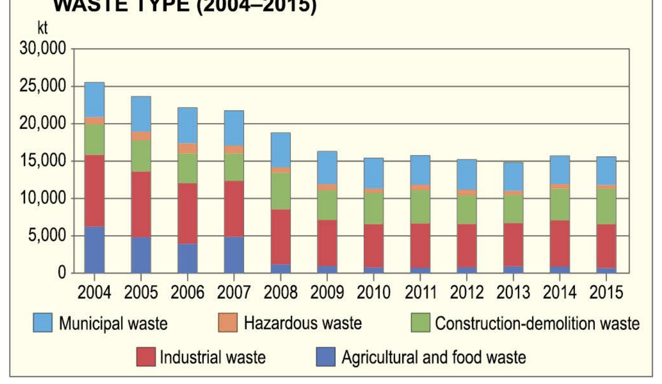
Waste treatment

Quantity and composition of waste

Act XLIII of 2000 on waste management and Act CLXXXV of 2012 on wastes replacing the former one, qualify production, service and consumption residue as waste that were or will be parted with the owner or the owner is obliged to part with the residue. This indicates that whether a material is qualified as waste or not depends fundamentally on the level of social, technical and economic development. What is today a valueless waste may become an important base material to be recycled tomorrow. The quantity, composition and recycling rates of produced wastes are influenced significantly by technological advance and economic necessity (limited availability of natural resources) in the long-term and by market and law regulations in the short-term.

Reliable data based on measurements regarding the annual quantity of solid waste in Hungary are available from 2004. The total amount of produced waste decreased from 25.5 million tons at that time to 15.5 million tons by 2015 32. The quantity of agricultural and food waste decreased from 6.2 million tons to 0.68 million tons due to the reduction of cattle and

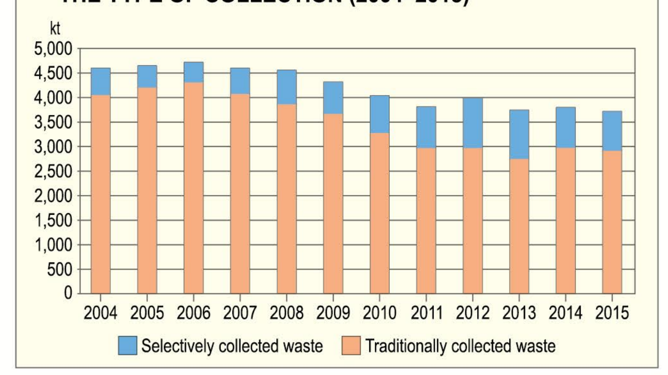
32 THE QUANTITY OF PRODUCED WASTE ACCORDING TO WASTE TYPE (2004–2015)



recession in the processing industry and also because plant and animal by-products and manure are not considered waste since 2007. The quantity of industrial waste decreased by 40% between 2004 and 2009 in accordance with reducing domestic production. Following 2009 the amount of industrial waste did not exceed 6 million tons due to the advance of sectors with small material demand and programmes aimed at preventing the production of waste and also due to the effects of legal and market incentives. The quantity of construction–demolition waste varied according to the level of construction industrial investments. It was stagnating as a whole but its ratio within the produced waste types doubled. The quantity of hazardous waste decreased below 0.5 million tons by 2015 due to primarily the fact that the major state remediation programmes were finished and some of the waste types were not classified as hazardous waste any more. Red sludge for example that caused an industrial catastrophe in 2010 could be classified only as hazardous waste before 2002 while after that year it could be categorised either as non-hazardous or hazardous waste.

Since 2003 every Hungarian settlement has been obliged to organise waste collection and since 2014 every household has been included in the public service. In the years following the turn of the millennium, around 4.5–4.6 million tons of municipal waste were produced in Hungary. Since 2009, however, this amount has been decreasing, initially as a result of the economic crisis and later due to new regulations and market incentives (green tax, dumping contribution) aimed at avoiding waste production. The 3.7 million tons of municipal waste produced in 2015 are 20% less than that produced in the first years of the 21st century 33.

33 THE QUANTITY OF MUNICIPAL WASTE ACCORDING TO THE TYPE OF COLLECTION (2004–2015)

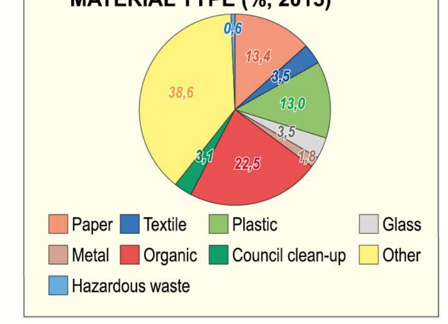


A condition of the recycling of wastes is their selective collection which is relatively simple in the case of waste from production processes, however, it is more difficult in the case of municipal waste. By 2015 for 60% of the residents some kinds of selective waste collection became available in Hungary. This selective collection is based on collection islands established in public areas. With these, the ratio of selective collected municipal solid waste increased from 12% to 21% between 2004 and 2015. The national plan targeting the involvement of 80% of the residents by 2020 prescribes direct collection services instead of static collection islands compulsory for public service providers.

In 2015, 77% of the total produced municipal waste (2.86 million tons) was taken away from households, public areas and other institutes as part of public services. The remaining 840,000 tons of municipal waste includes mostly sludge formed in municipal sewage treatment plants, green waste from parks and other separately collected waste (e-waste, accumulators, batteries, track light, household hazardous waste, bulky waste) that were produced in households but they are transported away not as part of public services. Public service providers collected 289.7 kg/capita waste on average in 2015 and 34 kg/capita out of which were collected selectively. Specific quantity of transported municipal waste was greatest in Budapest (361.6 kg/capita) and smallest in Szabolcs-Szatmár-Bereg County (219.5 kg/capita). Public service providers transported significantly more waste in Somogy and Veszprém and significantly less waste than the average in Borsod-Abaúj-Zemplén and Nógrád Counties 34. Spatial differences of specific waste quantity reflect the different economic and social weight of the counties, the special role of the capital regarding labour market and central services and the size of tourism as well.

Composition of waste collected from residents varies by settlement types and also by residential areas. The difference is influenced dominantly by lifestyle and ratio of built-up areas. The ratio of material potentially utilised as secondary raw material was around 35 volume % nationally in municipal waste while in the capital and in larger towns this ratio was around 40–45 volume % in recent years 35. The *Waste Directive* specifies that half (50 weight %) of the paper, metal, plastic and glass waste produced by households have to be recycled by 2020.

35 AVERAGE COMPOSITION OF MUNICIPAL WASTE TRANSPORTED FROM RESIDENTS AS PART OF PUBLIC SERVICES ACCORDING TO MATERIAL TYPE (%, 2015)



Waste treatment

Environmentally sound waste (material) management is composed of strategic elements based on each other. The first element is to reduce the amount and hazardousness of waste, i.e. prevention. The next element is to recycle waste either as secondary raw material or as an energy resource. Finally, unusable waste has to be disposed in accordance with environment protection requirements, by either incineration or landfill.

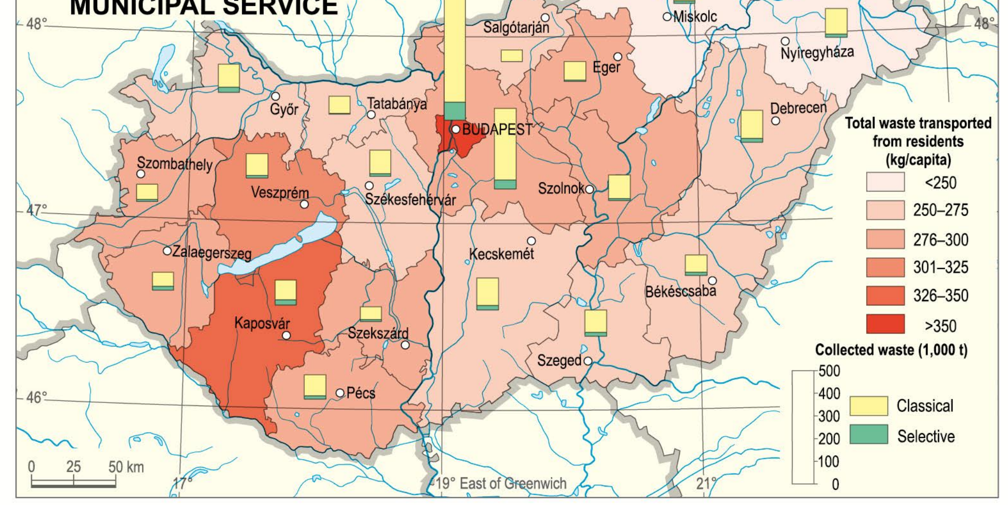
In 2015 the two typical disposal methods of solid waste in Hungary were recycling and landfill 36. Most striking reduction, however, occurred in the amount of landfill in the last decade (reduction by 60%). While in 2004 almost 15 million tons, i.e. 58% of the produced waste were placed in landfill, by 2015 this ratio was modified to 40% (6.2 million tons) so that quantities in landfill were reduced to half or third in the case of every waste type. Almost half, third and fifth of the waste placed in landfill were industrial, municipal and construction–demolition waste in 2015 37.

The ratio of energetically utilised waste doubled and reached 8% by 2015. The engine behind the increase was agricultural and food waste 70% of which was utilised energetically and 28% of which was recycled in Hungary in 2015.

Energetic utilisation of waste was basically performed in incineration plants, at some sewage treatment plants and at some regional waste disposal sites before the turn of the millennium. In 2015, 86 biogas power plants and heating plants were operated in Hungary with the capacity of 71.9 MW electric energy production. 42 out of the plants utilised sewage and landfill gases while 44 utilised agricultural material and waste. Typically the latter small capacity plants were established near major cattle breeding sites where the source of the base material, liquid manure is close 38.

Half of the produced waste is recycled in Hungary. 45%, 35% and 15% of the recycled waste are construction–demolition, industrial and municipal waste respectively. The ratio of recycling increased in recent years primarily in the case of construction–demolition and municipal wastes. Nowadays three quarters of construction–demolition waste is recycled and only the remaining portion is placed in landfill. Smallest degree of change occurred in the case of hazardous waste treatment in recent years. With decreasing quantities around one third of the waste is recycled, one third is combusted and placed in landfill and the final third is treated in other ways 39.

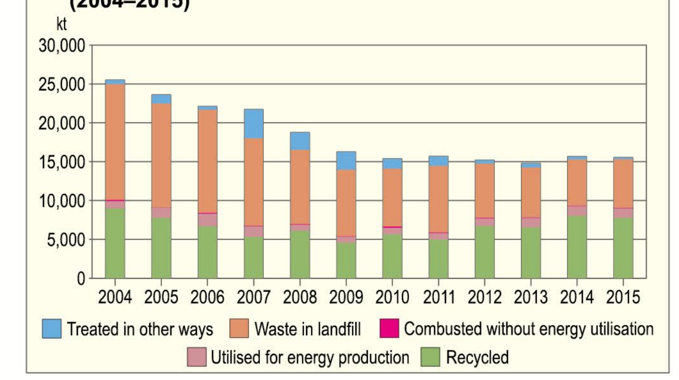
34 SPECIFIC QUANTITY OF MUNICIPAL WASTE TRANSPORTED FROM RESIDENTS AS PART OF MUNICIPAL SERVICE



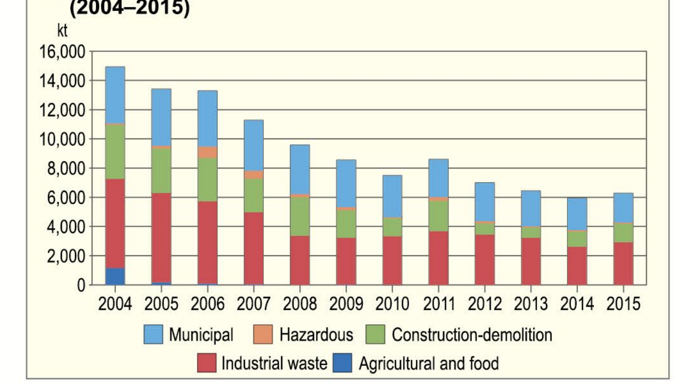
More than 80% of municipal solid waste was placed in landfill between 2000 and 2008. This rate was reduced to less than 60% (2.1 million tons) by 2015. Landfill contribution introduced for depository operators made the increase of the ratio of recycling and composting an elementary business interest. Energetic utilisation in the case of this waste type was increased to 14% which is primarily the result of the work of the *Waste Utilisation Plant of Budapest* with the capacity of 420 thousand tons/year 40.

Considering waste collected as part of public services in 2015, 64%, 15% and 21% were placed in depositories, utilised for energetic purposes and recycled respectively. This latter utilisation significantly exceeded the national average in Veszprém and Fejér Counties while stayed well below the national average in the counties of the Northern Great Plain and Northern Hungary regions 41. Utilisation for energetic purposes is significant in Budapest and in Baranya and Győr-Moson-Sopron Counties while landfills are as dominant as at the time of the turn of the millennium east of the Danube and in Vas County.

36 TRENDS IN THE METHODS OF WASTE TREATMENT (2004–2015)



37 THE QUANTITY OF WASTE DISPOSED IN LANDFILL (2004–2015)



Waste management facilities

More than 2,500 organisations carry out permit required waste management activities in Hungary. The majority only deals with waste produced at their own premises (collection, register, data supply and transfer to a third party entitled for appropriate treatment). Every company in the premises of which more than 100 kg of hazardous waste or more than 2,000 kg of non-hazardous waste are produced is obliged to supply the appropriate data. The number of companies having permit for collecting and transporting waste is around 300 and 600 respectively. More than 250 permits were issued for utilising agricultural waste and around 300 permits were issued for utilising packaging waste. Regarding the utilisation of construction and demolition and other industrial wastes, more than 600 permits were issued. Issuing the permit is conditioned to technical and operational solutions. Utilisa-

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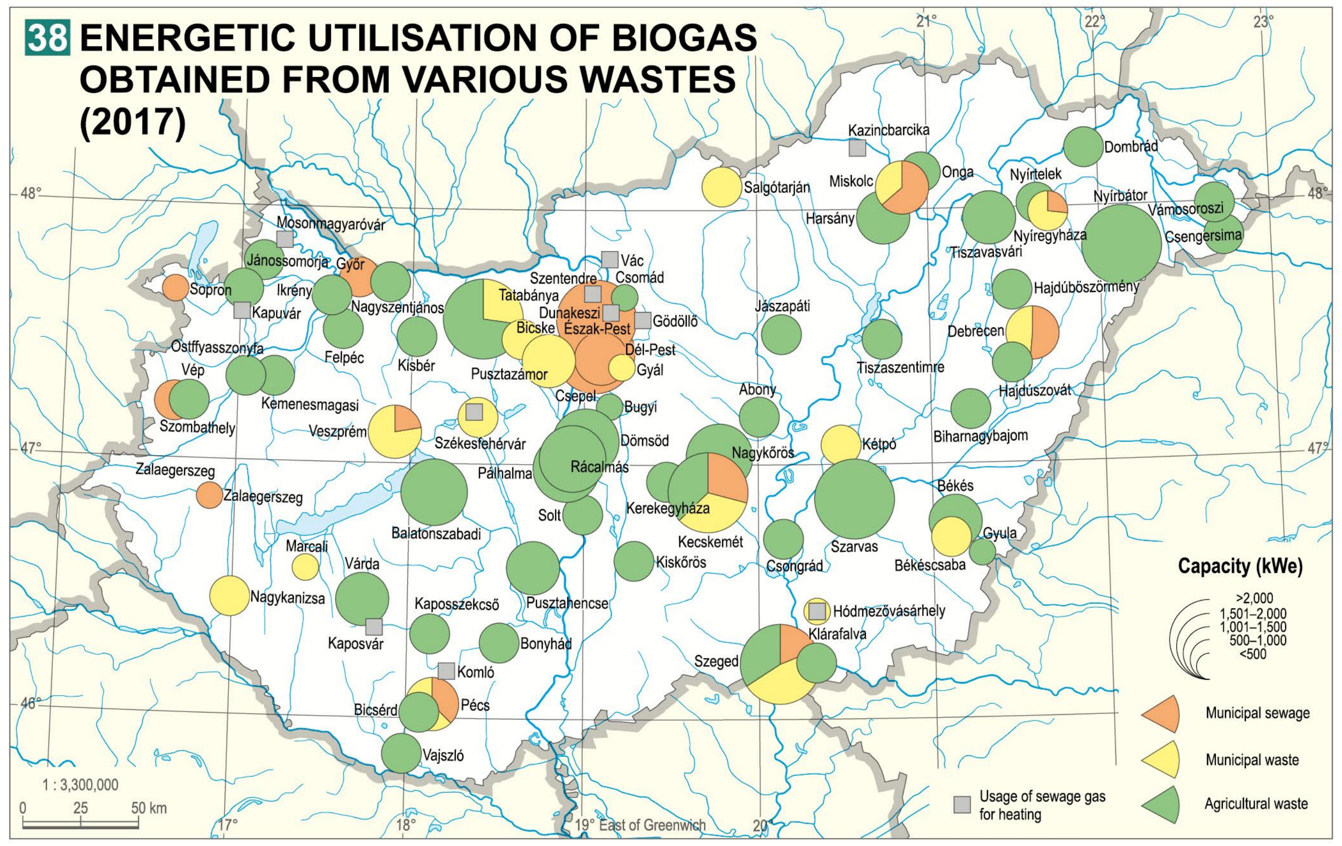
13 *Mountainous insulated landfill in open pit*



38 **ENERGETIC UTILISATION OF BIOGAS OBTAINED FROM VARIOUS WASTES (2017)**

tion of municipal wastes and hazardous waste is carried out at almost 300 and 46 sites respectively. In the case of these two waste types, the role of disposal, i.e. landfill and incineration (although this latter one is mostly energetic utilisation as well) is still significant. Technical requirements and operational conditions of depositories and incineration are regulated in separate decrees.

Prior to 2003 waste was placed in almost 2,700 depositories over an area of 2,992 ha but two thirds of them never had the permit. Landfill sites were appointed by the settlements operating the depository prior to the 1990s and they considered economically valueless and not cultivated areas with good accessibility the most suitable. As a result, most depositories were established near settlements either in former quarry sites (pit holes) or in deep areas with high groundwater table and possibly excess water in the Alföld. At two thirds of the depositories conditions were disadvantageous regarding environmental aspects and did not guarantee safe disposal that would impede pollution. More extended heap landfills can be found near the capital and county centres. While the average area of landfills was 1.1 ha most of them were smaller than 0.5 ha 42.

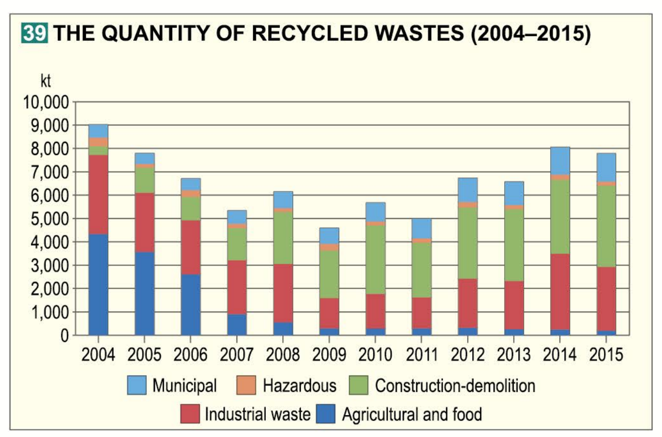
Following 2003 green authorities permitted the operation of depositories the equipment and operation of which met the new Hungarian legislation in accordance with European Union regulations 13. In the meantime the environment protectional revision of the several thousand abandoned sites was started together with the remediation of contaminated areas and the rehabilitation of waste disposal sites.

Considering municipal waste depositories, the spatial and size concentration of landfills together with the formation of regional waste management districts apart from the reduction of the quantity of waste represent a significant change. In the two financial periods of the European Union between 2000 and 2014, 13 EU supported waste management projects were completed in the framework of which high capacity regional waste disposal sites were constructed and already existing ones were extended. In total 71 municipal waste disposal sites received permit in Hungary in 2014. They cover 580 ha of depository area in total, i.e. the net area size used for deposition decreased to one fifth. The annual quantity of waste placed in landfills was reduced by 40% compared to 2003, however, concentrated disposal also requires increased site size therefore such regional sites have increased landscape effects.

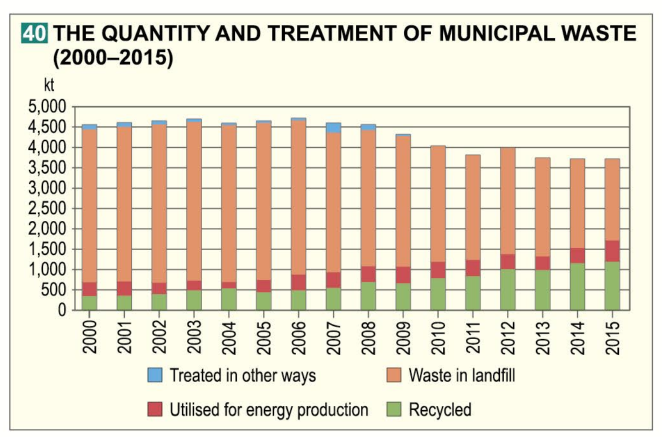
The number of active hazardous waste disposal sites in Hungary decreased significantly in the last two decades. The number of sites where hazardous waste was displaced even though they had no appropriate permit – even in the middle of the 2000s – is around 300. These had no appropriate infrastructure, were signed as temporary disposal sites, accepted waste with unknown origin as well or their owners or operators ceased without legal successor. One of the most infamous of these was the case of a site at Garé settlement where 60,000 barrels of toxic chemical industrial waste were placed into earth depositories constructed originally for leather industrial hazardous waste. The elimination of most of these has been carried out by the state in the framework of the national environmental remediation programme. In 2015 only 20 depositories received permit for disposing hazardous waste while at 18 sites aerobic biodegradation, composting of hazardous waste is going on 43.

Radioactive waste with small and medium activity of institutional origin (hospital, laboratory, etc.) is disposed into the surface depository at Püspökszilágyi while that of nuclear power plant origin is disposed in the underground depository at Bátaapáti. Spent nuclear fuel is stored temporarily in the temporary depository of the *Nuclear Power Plant at Paks*. According to geological research, the most suitable rock for the underground disposing of the latter could be the Boda Claystone Formation in the Mecsek Mountains.

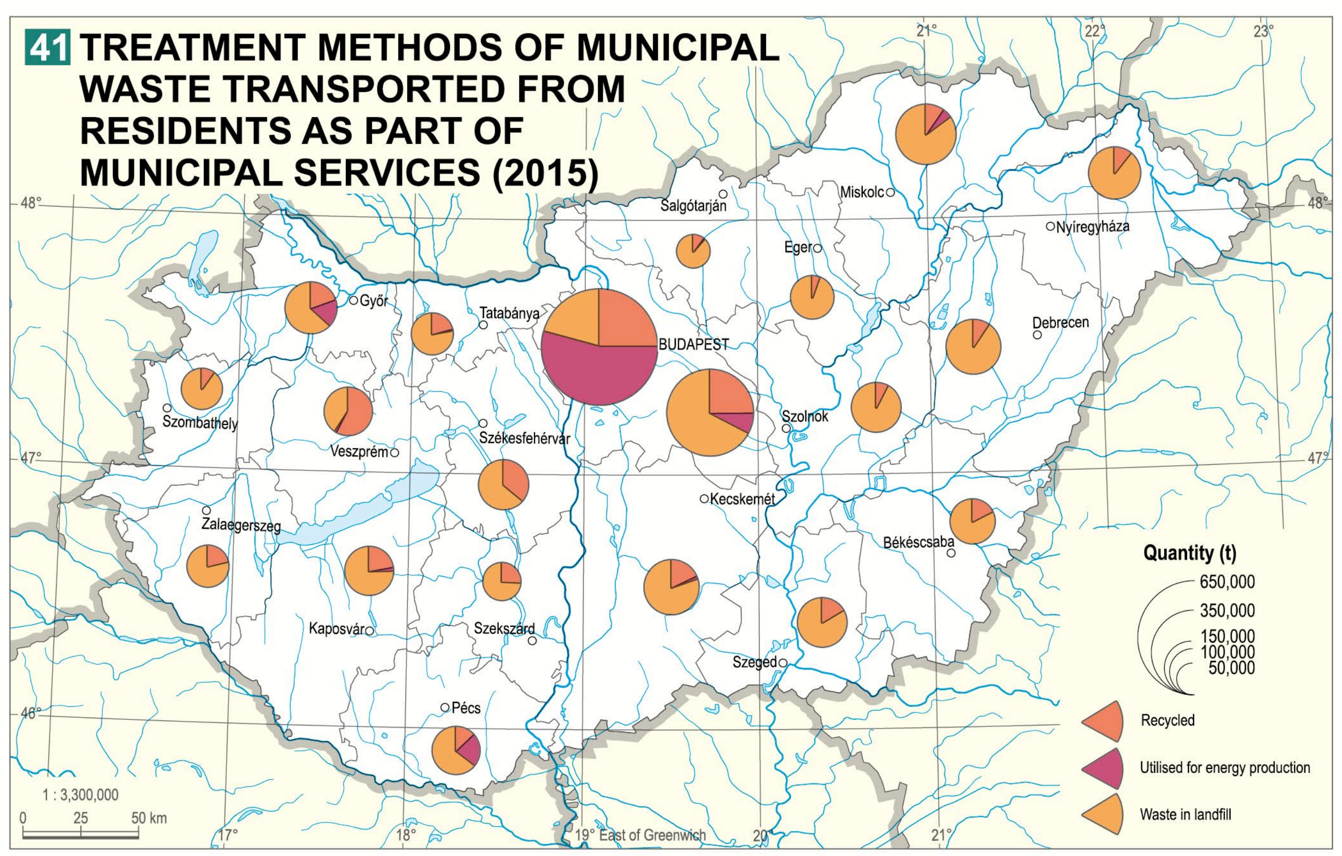
Incineration of municipal waste is carried out only in the *Waste Utilisation Plant of Budapest*. More than half of the municipal waste of Budapest is disposed here providing the annual electricity consumption of 100,000 residents and the district heating for 25,000 residents. Operation of hazardous waste incineration plants is the condition of the integrated pollution prevention and control permit issued on the basis of the best available technology thus numerous incineration plants (mostly hospital owned ones) were closed while others modernized technologically until Hungary joined the European Union in 2004.



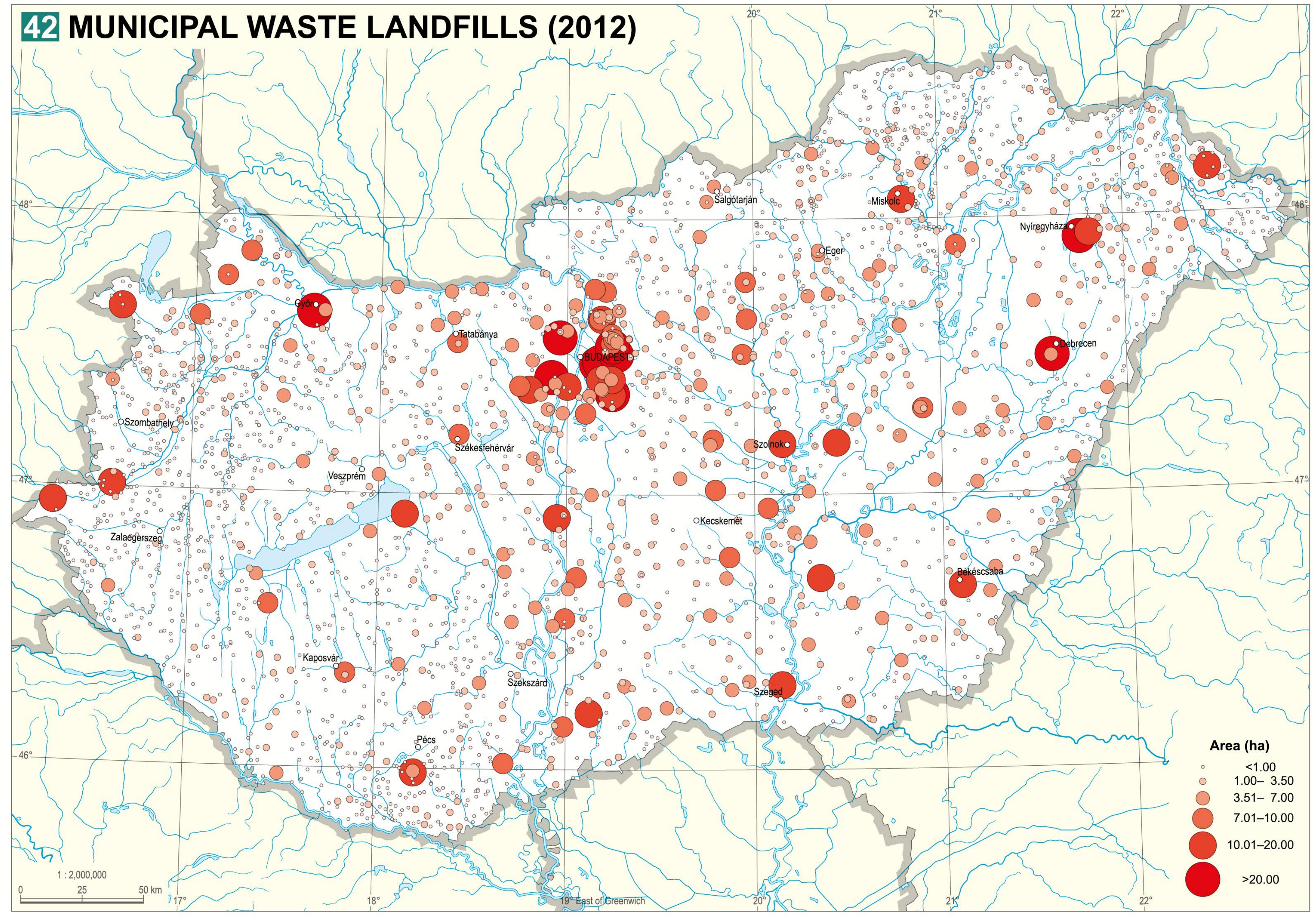
39 **THE QUANTITY OF RECYCLED WASTES (2004–2015)**



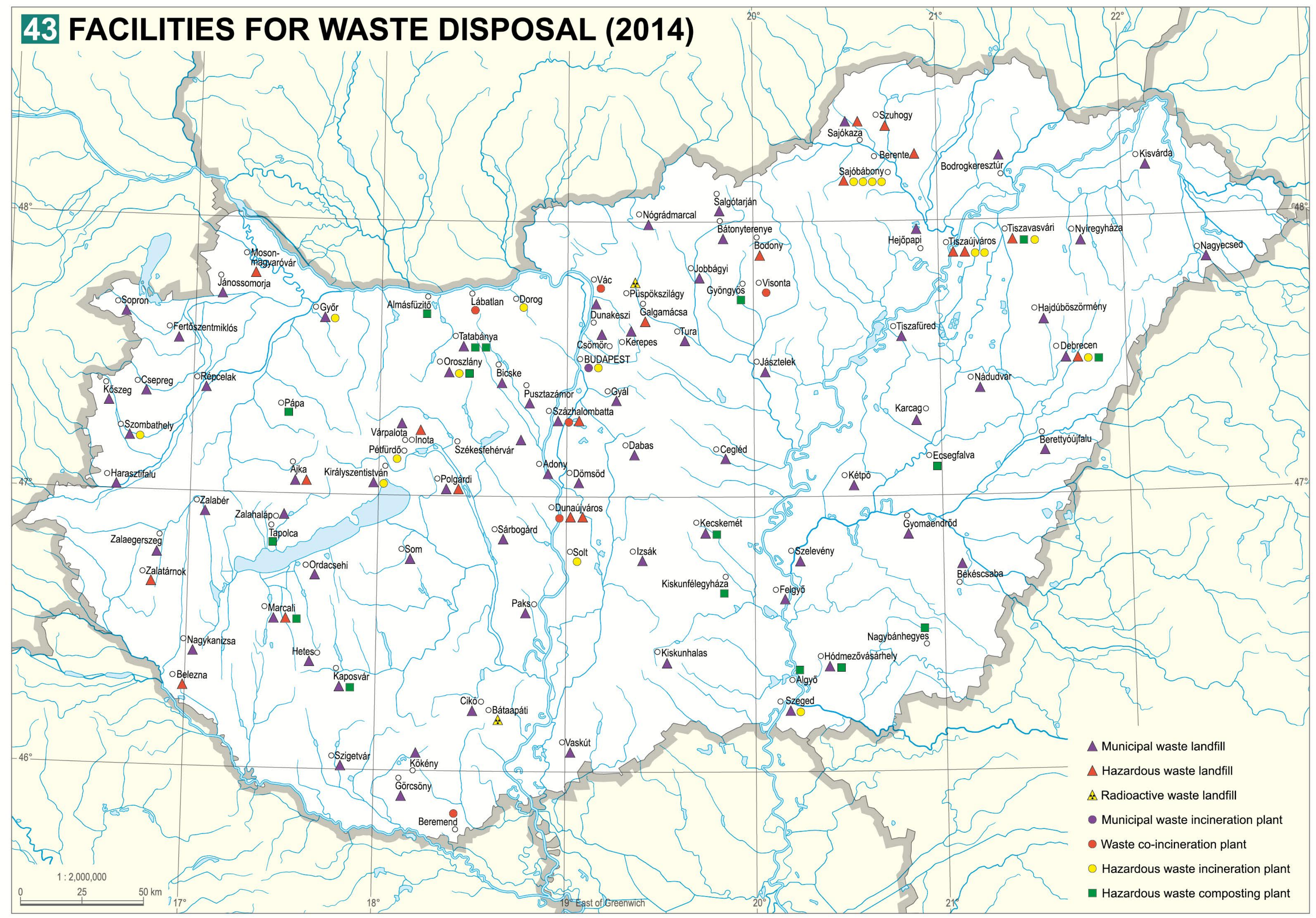
40 **THE QUANTITY AND TREATMENT OF MUNICIPAL WASTE (2000–2015)**



41 **TREATMENT METHODS OF MUNICIPAL WASTE TRANSPORTED FROM RESIDENTS AS PART OF MUNICIPAL SERVICES (2015)**



42 **MUNICIPAL WASTE LANDFILLS (2012)**



43 **FACILITIES FOR WASTE DISPOSAL (2014)**

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