Water resources and waste water management in Bosnia and Herzegovina, Croatia and the State Union of Serbia and Montenegro

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Abstract

This work provides an inventory of water resources and presents the current status of water supply, water quality as well as wastewater management in Bosnia and Herzegovina, Croatia and the State Union of Serbia and Montenegro, established after the break-up of the former Yugoslavia.

All three countries are very rich in water resources, pertaining in a large percentage to the Adriatic and Black Sea basins. However, this richness is not adequately reflected in the current status of the public water supply. Water supply is satisfactory only in bigger cities, whereas rural populations still largely depend on the local sources. Furthermore, with respect to integrated water management, there is a big discrepancy between the capacities of water supply and drainage and those for municipal and industrial wastewater treatment. Only a small percentage of wastewaters receive at least some treatment, putting those receiving natural waters at considerable risk. Nevertheless, available reports on the water quality of ambient waters do not reveal the existence of this problem on a wider scale, but indicate only few hot spots. Microbiological pollution near big cities and patchy elevated levels of heavy metals and organic pollutants around industrial plants and agricultural lands belong to these exceptions. Such a relatively favourable situation is, partly, a consequence of a significant decrease in economic activities, which is characteristic of all transition countries, but it also reveals the impact of the recent wars in the region.

Political and military conflicts in the region generated mutual distrust and lack of cooperation between the three countries. However, attempts are being made to resolve most of the issues related to cross-border contamination by signing international and regional treaties.

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As a part of pre-accession activities, all three states are harmonizing their legislation with the EU and are joining scientific projects on the water protection of other western countries. This is expected to bring considerable benefits to the local population and to make economic development more vigorous.

**Keywords:** Bosnia and Herzegovina; Croatia; State Union of Serbia and Montenegro; Water policy; Water quality; Wastewater management; Harmonization with the EU *Acquis communautaire*

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**Introduction**

Numerous environmental problems in all transition countries have been generated by an inadequate institutional infrastructure, an industry based predominately on old technologies, characterised by low efficiency and insufficient application of environmental protection measures, and a lack of systematic monitoring. The main part of industrial and municipal wastewaters is discharged without adequate treatment before release into the environment, while solid waste disposal sites are often unprotected open dumps, without liners and leachate collection systems.

The three successor states of former Yugoslavia – Bosnia and Herzegovina (B&H), Croatia and the State Union of Serbia and Montenegro (SCG) – have suffered irreparable human losses and material damages to the economy, cultural heritage and environment during the past 15 years. Many infrastructural objects, including water supply and drainage facilities, have been damaged too. Over the past few years the conditions have gradually improved owing to new programmes, aiming to harmonise national environmental legislation with international agreements and conventions on environmental protection, and in particular with the environmental *acquis*. The individual countries in the region are at different stages regarding the accession process to the European Union, but substantial investments are needed in municipal and industrial wastewater treatment facilities in the whole region.

In all countries in the region, the corresponding environmental law regulations include polluter-pays and user-pays principles. The responsibility for water management is shared between the corresponding environmental state agencies (i.e. state directorates for water management) and regional and/or local authorities. The financing of the water management goes primarily through the taxation system, which is divided in three major segments: water use fee, water protection fee and water drainage fee. The fees, collected through the taxation system, represent a major contribution (>50%) to the financing of the water management activities, while additional important sources represent national budgets and budgets of the regions and local communities. The total annual spending for environmental protection in Croatia is of order of magnitude of €200 million, of which about 50–60% is currently being used for the water management. Generally, only minor contributions originate from international loans, which have been realised for the larger investments (i.e. wastewater treatment facilities) and restructuring programmes in the water sector.

In 1999 the international community initiated the Stability Pact for South-eastern Europe, which provides an important basis for cooperation in this region. Joint activities of the south-east European states in the area of environmental protection are recognised as an important factor in helping to build bridges between these countries, thereby helping to safeguard long-term peace. An environmental programme entitled the “Regional Environmental Reconstruction Programme” (REReP), approved in March 2000, has been initiated to help these countries design their own environmental programmes (*Keinhorst et al., 2003*). The water and wastewater sector is one of the major investment priorities for the
Stability Pact countries. Improving water quality conditions, particularly with respect to wastewater
treatment will bring long-term benefits not only for the three countries considered in this report but
should result in improvements in all downstream countries of the Adriatic and Black Sea regions,
including the Danube and other key river basins (Water Strategy, 2001).

National environmental programmes should be consistent with the objectives set by international
conventions and the community water policy, especially the EU Water Framework Directive (WFD),
which applies an integrated approach to water management. An important part of the overall concept
is a reduction in the emission of various environmental pollutants, via wastewater effluents and
improvement of the quality of surface waters, ground waters and marine waters by implementation of
strict environmental quality standards (EQS) and pollution control and mitigation at the source (MED
EUWI, 2003; Barceló, 2004; Grathwohl & Halm, 2004).

Most of the water quality criteria, which are presently applicable in the region, have been set in
compliance with international conventions such as Convention on the Protection of the Danube River
(Bucharest Declaration, signed in 1993) and the Convention on the Protection of the Mediterranean
Sea, in particular the Protocol on the Protection of Mediterranean Sea from Land-based Sources (so-
called LBS-protocol from 1993) (London Convention, 1972; Malta Protocol, 2002). In order to
achieve the goals of these conventions, comprehensive monitoring schemes have been established
both for the surface waters and for coastal waters. As to the Danube river basin, the existing structure
of the Transnational Monitoring Network (TNMN) in riparian countries mainly deals with the
monitoring of basic water quality parameters and only a few selected hazardous inorganic and
organic contaminants. Moreover, despite the relatively reduced number of specific organic
contaminants to be surveyed, the implementation of the programme in Croatia has not always been
carried out to its full extent, while the national monitoring programmes of neighbouring Bosnia and
Herzegovina as well as Serbia and Montenegro have not been integrated into the programme in its
initial stage.

It should be pointed out that most of the national criteria on hazardous substances in surface waters
and the coastal sea, set during the 1980s and 1990s (e.g. the Croatian Ordinance on the maximum
allowable concentrations from 1984) were adopted from a well-known list of priority pollutants, which
was introduced by US Environmental Protection Agency (EPA) (Sittig, 1980). Thus, the regulatory part
of the water management, which contained a comprehensive list with over 100 different hazardous
pollutants, provided a solid basis for the protection of natural water resources. However, the capacity of
the regional environmental laboratories to deal with this complexity was often insufficient and the
implementation of the existing legislation could not always been carried out to full extent. The imminent
process of accession to the European Union will require adoption of all criteria given by the WFD from
all countries in the region. WFD defines 33 priority substances divided into three groups, some of which
represent complex mixtures of related compounds. This fact will certainly represent a major challenge
for the regional environmental laboratories and will make criteria for their authorization to perform
monitoring activities more difficult.

Moreover, it has to be stressed that destruction of infrastructure, military and industrial facilities
during the recent war conflicts in Croatia, Bosnia and Herzegovina and Serbia and Montenegro has led to
a widespread contamination of soils, surface and groundwater, possibly including some less common
pollutant types, which are not necessarily foreseen as a part of regular monitoring programmes and
should be regarded as possible candidates for emerging contaminants.
Therefore, one of the priority objectives of the Regional Environmental Reconstruction Programme (REReP) in south-eastern Europe has been focused on the capacity building of riparian countries for water quality assessment and water management. Moreover, in order to resolve many accumulated water management issues and to join the latest European trends in wastewater characterization, Bosnia and Herzegovina, Croatia and the State Union of Serbia and Montenegro have joined several European research and development projects.

Nevertheless, a database on pollutant inputs via wastewaters and their impact on the quality of surface waters that receive them, with an emphasis on trans-boundary pollution, is still missing. This paper provides a brief inventory of water resources and reports on the current status of legislation and practice in wastewater management in these countries and tries to discuss specific regional problems with a special reference to European regulations.

Bosnia and Herzegovina

Water resources and legislation

According to the national legislation on waters (Water Law), the territory of Bosnia and Herzegovina is divided into eight basic river basins, most of them belonging to the Danube River (Black Sea) basin (Sava River and its tributaries, Una River with Korana and Glina, Vrbas River, Bosna River and Drina River). Only one larger watershed (Neretva River) and two smaller ones (Trebišnjica River and Cetina River) belong to the Adriatic Sea basin.

All waters in B&H are managed by three public water management companies: the Public Enterprise for the Sava River Basin located in Sarajevo, the Public Enterprise for the Adriatic Sea Basin located in Mostar and the Directorate for Water located in Bijeljina.

Before the war, wastewater management efforts were focused mainly on satisfying European Union (EU) demands, that required construction of wastewater treatment plants (WWTP) for all settlements above 2,000 inhabitants by 1998. The water management authorities have selected all settlements with more than 5,000 inhabitants and all municipal centres, regardless of their size as top priority in the construction of WWTPs (Barbalić & Ristić, 1994) but the fulfilment of the plan was prevented by the 1992–1995 war.

After the war, the economy shrank to only 20% of the pre-war capacity and thus the planned time schedule for the accomplishment of the objectives set could not be achieved from economic reasons. Instead, emergency measures with relatively small investments were adopted. The EU, World Bank (WB) and many countries and international institutions, through donor funds, loans and donations assisted B&H authorities in implementation of these measures which helped to solve some crucial problems for water supply, sewerage and solid waste disposal.

It is interesting to note that reduced industrial activity during the war (1992–1995) resulted in an auto-purification of many surface waters. However, with a gradual recovery of the economy, it will be rather difficult to maintain such a situation, unless careful measures to control harmful emissions at source are adopted. This problem is recognized by the National Environmental Action Plan (NEAP), which represents the national strategic document in the field of environmental protection. The NEAP identifies the problem of the non-existence of municipal and industrial wastewater treatment plant and lack of sustainable water/wastewater management at all levels. The main causes of this problem, as identified by
NEAP, apart from a lack of financial resources, are a lack of trained staff, equipment and institutions and a lack of research and training activities at all levels.

On the other hand, ministries responsible for the environment in both entities in B&H have recently adopted a new Law on Water Protection with the aim of ensuring sustainable water use by preserving and improving its quality. According to Article 3, the principles of water protection are based, among others, on: (a) prevention of water pollution and improvement of sustainable water use; (b) public participation; (c) application of the best available techniques and new scientific achievements in environmental protection.

**Wastewater management**

The total pollution load from industrial and municipal sources in B&H is given in *Tables 1 and 2*, by source, type and distribution over river basins (Barbalic & Ristic, 1994). The methodology for the determination of organic load in wastewaters consists of determination of the following general parameters: flow (Q), suspended matter (SM), chemical oxygen demand (COD), biological oxygen demand (BOD) and toxicity determined by a test with Daphnia magna, and their recalculation to obtain the population equivalent (PE). Nitrogen and phosphorus are not taken into account in this calculation, but are determined separately as specific parameters. Depending on the type of wastewater, the analysis of specific pollution parameters such as phenol, cyanide, heavy metal, alkalinity, acidity and pH may also be required. However, specific organic compounds were not analysed until now, except in the polyurethane industry in Tuzla, owing to the lack of necessary equipment in the institutions authorized for wastewater quality analysis.

In 1991, only 38% of the population of B&H was connected to the public sewerage system (80% in cities and 11% in villages), while 62% of population uses septic tanks (Bezdrob, 1998). The planning and construction of sewerage systems was done without proper documentation providing partial and inadequate solutions. The constructed pipelines are usually of smaller dimensions than required with the final aim of discharging collected wastewater to the nearest water recipient. Inadequate attention was paid to the maintenance of sewerage systems which were left to deteriorate without any monitoring and management supervision. During the war, many of the systems were damaged and their repair was

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### Table 1. Total pollution load from industrial and municipal sources*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Municipal wastewater</th>
<th>Industrial wastewater</th>
<th>Total wastewater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (m$^3$/s)</td>
<td>6.057</td>
<td>23.797</td>
<td>29.854</td>
</tr>
<tr>
<td>Suspended matter (kg/day)</td>
<td>144.231</td>
<td>674.539</td>
<td>818.770</td>
</tr>
<tr>
<td>COD (kg/day)</td>
<td>293.721$^b$</td>
<td>594.813$^c$</td>
<td>888.534</td>
</tr>
<tr>
<td>BOD$_5$ (kg/day)</td>
<td>162.459$^b$</td>
<td>274.913$^c$</td>
<td>–</td>
</tr>
<tr>
<td>Population equivalent</td>
<td>2,707.633</td>
<td>6,873.100</td>
<td>9,580.733</td>
</tr>
<tr>
<td>Total nitrogen (kg/day)</td>
<td>20,008</td>
<td>2,995$^d$</td>
<td>29,003$^e$</td>
</tr>
<tr>
<td>Total phosphorus (kg/day)</td>
<td>8,392</td>
<td>250$^d$</td>
<td>8,642$^e$</td>
</tr>
</tbody>
</table>

*a Data belong to the pre-war period for urban settlements with more than 2000 PE.

$^b$ Refers to values fixed on the basis of raw sample.

$^c$ Value for sample allowed to sediment for two hours.

$^d$ Data are missing for many industries.
Table 2. Pollutant emissions from municipal settlements (larger than 2000 inhabitants) and industrial sources.

<table>
<thead>
<tr>
<th>River basins</th>
<th>Municipal wastewater</th>
<th></th>
<th></th>
<th>Total wastewater</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q (m³/s)</td>
<td>SM (kg/day)</td>
<td>COD (kg/day)</td>
<td>BOD₅ (kg/day)</td>
<td>PE</td>
<td>Q (m³/s)</td>
<td>SM (kg/day)</td>
<td>COD (kg/day)</td>
</tr>
<tr>
<td>Glina and Kupa</td>
<td>0.040</td>
<td>917</td>
<td>1,944</td>
<td>1,076</td>
<td>17,917</td>
<td>0.163</td>
<td>533</td>
<td>1,711</td>
</tr>
<tr>
<td>Una</td>
<td>0.558</td>
<td>13,439</td>
<td>27,153</td>
<td>14,831</td>
<td>247,183</td>
<td>1.122</td>
<td>201,625</td>
<td>139,282</td>
</tr>
<tr>
<td>Vrbas</td>
<td>0.801</td>
<td>19,104</td>
<td>38,271</td>
<td>21,519</td>
<td>358,650</td>
<td>2.587</td>
<td>27,481</td>
<td>174,852</td>
</tr>
<tr>
<td>Vrbas</td>
<td>0.117</td>
<td>2,739</td>
<td>5,612</td>
<td>3,298</td>
<td>54,967</td>
<td>0.036</td>
<td>2,425</td>
<td>1,558</td>
</tr>
<tr>
<td>Bosna</td>
<td>2.953</td>
<td>70,414</td>
<td>144,769</td>
<td>79,835</td>
<td>1,330,583</td>
<td>17.576</td>
<td>392,139</td>
<td>216,737</td>
</tr>
<tr>
<td>Drina</td>
<td>0.325</td>
<td>7,871</td>
<td>15,800</td>
<td>8,668</td>
<td>144,467</td>
<td>1.176</td>
<td>4,896</td>
<td>18,908</td>
</tr>
<tr>
<td>Sava</td>
<td>0.591</td>
<td>13,664</td>
<td>27,800</td>
<td>15,329</td>
<td>255,483</td>
<td>0.483</td>
<td>16,242</td>
<td>30,856</td>
</tr>
<tr>
<td>Cetina</td>
<td>0.068</td>
<td>1,694</td>
<td>3,363</td>
<td>1,855</td>
<td>30,917</td>
<td>0.037</td>
<td>545</td>
<td>1,350</td>
</tr>
<tr>
<td>Neretva</td>
<td>0.504</td>
<td>12,095</td>
<td>24,146</td>
<td>13,358</td>
<td>222,633</td>
<td>0.601</td>
<td>28,444</td>
<td>8,421</td>
</tr>
<tr>
<td>Trebišnjica</td>
<td>0.100</td>
<td>2,294</td>
<td>4,863</td>
<td>2,690</td>
<td>44,833</td>
<td>0.016</td>
<td>209</td>
<td>1,138</td>
</tr>
<tr>
<td>Total</td>
<td>6.057</td>
<td>144,231</td>
<td>293,721</td>
<td>162,459</td>
<td>2,707,633</td>
<td>23,797</td>
<td>674,539</td>
<td>594,813</td>
</tr>
</tbody>
</table>
supported by many foreign countries and donors who helped in purchase of the necessary equipment and spare parts. However, a variety of supplies from different manufacturers and differences in quality, shape and dimensions, gave rise to problems of repair and maintenance making it even more complex.

Most municipalities have sewerage systems that collect wastewater and discharge it directly to the water recipient without any treatment. Most city sewerage systems are of a combined type serving as collectors for municipal wastewater, industrial wastewater and storm waters, thus making it difficult to determine an optimal treatment process for certain types of wastewater. Almost all municipalities have gravity sewerage systems that frequently clog or overflow. Of the 69 municipalities surveyed in the study carried out by DHV Consultants for the World Bank, 44 have problems with wastewater overflow; 80 km of drainage channels are heavily damaged and need replacement and 850 km of drainage channels need unclogging and cleaning of sediment (Bezdrob, 1998).

The three municipal hot spots with high priority are: Sarajevo, discharging municipal wastewaters of 484,467 PE directly in the Miljacka River causing pollution of Sarajevo water supply intake zone; Tuzla, discharging municipal wastewaters of 110,017 PE directly into the rivers Jala and Spreča polluting Lake Modrač, which is used for swimming, irrigation and water supply; Banja Luka, discharging municipal wastewaters of 203,117 PE directly into the Vrbas River polluting agricultural land in Lijevče polje and jeopardizing the health of downstream water users. The contaminant loads from diffuse (non-point) sources such as villages, cattle breeding, agricultural land and forests, were also considered.

The total emission of organic substances and nutrients from non-point sources in B&H in a dry season is 5.6 tonnes of BOD₅ per day, 25.2 tonnes of nitrogen per day and 1.6 tonnes of phosphorous per day. The highest emissions are observed in the Bosna River basin (20%), followed by the Una River basin (15%), Sava River basin (13%), Drina River basin (12.5%) and Vrbas River basin (10%). The contribution of organic loads from non-point sources is relatively small in all hydrological conditions and ranges on average from 0.1 to 0.2 g/m³ of BOD₅. However, the contributions of individual macro-nutrients can be comparatively high and range between 0.5 and 0.8 g/m³ for nitrogen and 0.03 and 0.05 g/m³ for phosphorous (Barbalić & Ristić, 1994).

The 74.3% of total industrial wastewater produced in B&H (Table 1 and Table 2) is discharged into the Bosna River basin, a significant portion of which is made up of cooling waters (12.1 m³/s) and other industrial effluents from thermo-power plants (Kakanj and Tuzla), iron factories (Zenica, Vareš, Ilijaš) and chemical industry in Lukavac.

The daily discharge of suspended particles from industrial plants in B&H is 674.5 tonnes, mostly in the Bosna River basin (58.1%) and Una River basin (29.9%). The main sources of suspended materials are mines, metal factories and thermal power plants. Total daily emission of organic pollution from industry in B&H is approximately 275 tonnes of BOD or 6,873,100 PE. The largest part comes from the cellulose, paper and viscose industry (51.3%), followed by the food industry (19.2%). Industries with the largest organic pollution loads are located on the rivers Vrbas (32.2%), Bosna (29.5%), Una (20.5%) and Sava (10.4%). A list of largest industrial polluters and their location within the river basin is given in Table 3 (Bezdrob, 1998).

The majority of industries discharge wastewater, which contain a wide variety of toxic substances, mostly heavy metals, cyanide, phenols, mineral oils, emulsions, organic solutions, as well as other different organic substances originating from the basic organic chemistry, viscose, linen and leather industries. Data on individual toxic contaminants are very scarce and exact data on these specific inputs are not available. An indication of the extent of toxic emissions from various wastewaters was obtained on the basis of the volumes of the receiving river water that is necessary to dilute these wastewaters below
observable toxic effects (Table 4). The total quantity of water needed to dilute all toxic wastewater inputs in B&H is 700 m$^3$/s, which is much greater than the total flow in all the rivers in B&H. Highly toxic waters are being discharged mainly in the Bosna River and its tributaries (78.0%), then in the Vrbas River (9.4%) and the Una River (6.5%). The largest emission sources of toxic substances are located in the Tuzla region (polyurethane chemistry, chemical industry, coke industry) and from the mines and iron smelter in the Zenica region (Barbalić & Ristić, 1994). In the basins of the Bosna, Drina and Una Rivers a number of mine tailings, ash dumps and wet quarries without adequate lining protection and with poorly maintained dams were identified as a major environmental risk.

### Wastewater treatment plants (WWTP)

In the period before 1992, only 35% of the population in B&H was connected to the public sewage system, of which only 9.2% was treated in the WWTPs. Only 0.5% of settlements in B&H were connected to the WWTP. At present, only seven municipalities in B&H have WWTPs, including Čelina (30,000 PE), Gradačac (30,000 PE), Ljubuški (5,000 PE), Sarajevo (600,000 PE), Trebinje (30,000 PE), Tmovo (5,000 PE) and Srebrenik (20,000 PE). Sarajevo and Tmovo WWTPs are not in operation owing to physical damage and lack of equipment, while the remaining ones that are functioning serve 1.2% of the total population of B&H. All of them provide mechanical treatment, primary sedimentation, biological treatment, secondary sedimentation and aerobic digestion or stabilization of the sludge. Besides these six municipalities, the municipality of Neum has only mechanical pre-treatment with coarse grid and grit removal since there is a plan to perform the final treatment in a fully equipped mechanical–biological WWTP in Croatia to be constructed in the Stone municipality.

Industrial facilities in B&H were built mostly on the riverbanks and in larger cities which had existing infrastructure for industrial development. However, since only seven municipalities in B&H have WWTPs, in most cases, industrial wastewaters share the fate of municipal wastewaters and...
are discharged directly into the receiving waters. At present, there are only a few, larger industries in B&H that have full wastewater treatment\(^2\). Smaller industries, mainly belonging to the food-processing sector, in general, have a system of septic tanks for separation of oil and grease and settlement of suspended matter.

### Republic of Croatia

#### Water resources and water supply

With an average annual surface water discharge of about 5,900 m\(^3\) per capita, Croatia is a one of the richest European countries regarding water resources. As a consequence, water quantity problems,

\(^2\) Waste water treatment plant in Kakanj thermal power plant has primary and secondary settler, coagulation and flocculation. Soft drink factory Coca-Cola in Hadžići town has biological treatment (activated sludge treatment. Brewery “Uniline” in Grude town has anaerobic treatment.
especially in the northern areas, are not pronounced. However, some problems do occur along the coast and on the islands during the summer tourist season owing to the increases in population.

The total renewable water resources amount to $156.3 \times 10^9$ m$^3$ (BCM) or 35,200 m$^3$ per capita, of which approximately 17% are generated in Croatia and the rest in Austria, Hungary, Bosnia and Herzegovina and Slovenia. It is estimated that total water consumption amounts to 1.40 BCM of which industry and cooling waters account for 36% and public water supply for approximately 38%. The rest is attributed to agriculture, fishponds, hydro-power plants, and so on (Table 5).

The Act on Waters defines the following water basins in Croatia: the Sava River catchment area, the Drava and Danube Rivers catchment areas, the Littoral and Istrian catchment areas and the water basin of the Dalmatian catchment areas. In addition, there are also 34 catchment areas comprising minor individually managed recipients.

The level of water supply in Croatia, especially in the larger cities, is generally satisfactory. Water is supplied from 411 groundwater sources and 19 surface water sources. The grand total capacity of water supply is ca 26,500 m$^3$/s. Specific consumption per capita is within the range of 140 and 150 m$^3$/capita/day. There are significant differences between the reservoirs of water resources in the northern Croatia and middle and southern Croatia in terms of their geological background. The northern and eastern regions of Croatia consist largely of the alluvial deposits of the Sava, Drava and Danube Rivers, with their groundwater aquifers supplying drinking water to these areas.

The middle part (Lika region) and coastal areas of Croatia, including the belt of near-shore mountains of the Velebit and Dinara complexes, represent regions of karst, formed in sedimentary carbonate (mainly limestone and some dolomite) rocks. These karst regions are characterised by their fast flowing subterranean rivers and thus are extremely sensitive to chemical pollution. Contamination from heavy metals or organic pollutants will be transported over significant distances. The Velebit mountain complex forms a hydro-geological barrier, which controls groundwater flows in specific directions. The groundwater of the karstic terrain is a very rich and valuable water resource (ca. $4.6 \times 10^9$ m$^3$ per year), also providing water for the coastal tourist areas along the Dalmatian coast. Such an asset requires strict and efficient protection. Some of very big karst sources (the Gacka and the Kupa Rivers) are currently in partial use only, but they have a significant strategic role.

Average supply by the public water supply systems to the population accounts for 76%\(^3\). This is a significant increase with respect to the year 1990 when it accounted for 63%. Almost all residential areas along the coast have a water-supply network with the accompanying facilities. The islands are supplied

\(^3\) Water supply for the population at the Adriatic Sea and Black Sea catchment areas accounts for 86% and 71%, respectively.
from the coast and, to a smaller degree, from their own sources, from aquifers, tank rain collectors or by desalination (the islands of Lastovo and Mljet). There is, however, a problem of water loss from the public water-supply systems which accounts for 46%.

Water consumption in the period from 1992 to 1998 had been gradually reduced owing to the war and decreased industry needs, but it has increased from 1998 (Figure 1).

Of the total industrial water consumption in the year 2000 from the public water-supply systems, the share of the Black Sea catchment area was significantly higher than in the Adriatic Sea basin, accounting for 87%. Water consumption from their own sources in the Black Sea and the Adriatic catchment areas was equal.

Wastewater management

Uncontrolled urbanization and construction of industrial plants without adequate wastewater treatment, wastewaters discharge systems and their sustainable maintenance increases the risk to groundwater quality. The issues are particularly controversial in the vicinity of bigger industrial centres.

Croatia has a unitary system of water management with sub-national authorities, organised in autonomous regions (counties). Planning and implementation of water management are carried out by the Croatian State Waters Directorate and its executive agency the Croatian Waters Enterprise (Hrvatske vode). The latter is responsible for investment in water infrastructure, environmental protection, water resource management, water quality and land drainage from national water fees. Croatian Waters Enterprise is managed according to the principles of sustainable development, harmonized with Directive 2000/60/EC of the European Parliament and Council, which sets the framework for EU action in the area of water policies (WFD/EU).

There is a widespread need in Croatia for investments in municipal and environmental infrastructure. In war-affected areas, some of the water supply systems have been badly damaged or destroyed. Most of the major cities and towns, including Zagreb, do not have adequate facilities for treatment of municipal wastewater. Moreover, as reflected in an apparent discrepancy between the percentage connection to the

Fig. 1. Water consumption in the period 1998–2000 in millions of m³ annually.
public water-supply system (76%) and drainage (40%), there are significant losses of wastewaters from the sewerage networks, which increase the risk of polluting groundwater. On the other hand, massive leakages from water supply networks significantly increase the costs of water supply. Only 12% of urban wastewaters are treated, of which 11% receive only pre-treatment, 52% primary (mechanical) treatment and 37% secondary (mechanical + biological) treatment, which is ca 4.4% of the total municipal wastewater volume (RSE, 2003).

In 2003, industry discharged about 320,000,000 m$^3$ of wastewater, of which 16.9% went to the public sewerage system (85.3% without pre-treatment), while 83.1% (95.6% without pre-treatment) was discharged into other places, mainly surface waters (Statistical Yearbook, 2003). Irrespective of a still unfavourable situation, things improved to some extent after 1997 when the percentage of the industry discharge connection to the sewerage system accounted for 35% and to municipal wastewaters treatment plants for about 10%.

Systematic monitoring of industrial wastewater quality has been carried out at 1,529 monitoring sites. The major part of the wastewater is attributed to the chemical and petrochemical industry, except in the catchment area of the Drava and Danube Rivers, where the food industry represents the dominant source. After 1997, the volume of process wastewater has decreased and the level of their pre-treatment increased to some extent (Figure 2). In 2003 wastewaters from chemical plants were released mainly into surface waters (71.8%; 98.5% of them without pre-treatment) and into public sewerage system (28.2%) (RSE, 2003).

Connection of bigger cities to the sewerage system accounts to ca 75%, whereas in the majority of residential areas less than 10,000 residents do not have a sewerage system (Figure 3). Municipal wastewaters are one of the largest sources of input for various specific contaminants. Their composition strongly varies, because most of the sewerage systems are of the mixed type, including highly variable percentages of industrial wastewaters and street run-off waters. A comprehensive analysis of Croatian wastewaters (Ahel & Giger, 1985) indicated the presence of large number of specific organic contaminants with a predominance of the two main categories – petroleum hydrocarbons and surfactants.

While petroleum hydrocarbons belong to the classical pollutants and are included in all regular surveys, the importance of some classes of surfactants was recognized more recently. The most prominent examples are non-ionic surfactants of the alkyl phenol polyethoxylate type, which were shown to be biologically transformed into more lipophilic and therefore more toxic and endocrine-disrupting metabolites. The presence of these compounds in Croatian municipal wastewaters is well-documented (Kvestak et al., 1994). Owing to risk reduction measures introduced in Western Europe during the last 15 years, the concentration of these compounds in Croatian wastewaters has significantly decreased. The occurrence of pharmaceutical compounds in Croatian municipal wastewaters has also been documented (Jeličić & Ahel, 2003). The concentrations of selected compounds were in the same range as in the Western Europe, indicating similar consumption rates and similar input patterns. Moreover, some pharmaceutical compounds, such as analgesic propyphenazone, are incompletely eliminated during sewage treatment and consequently significant percentages of these compounds may reach natural waters though in a rather dilute form. Pharmaceutical compounds were found in much higher concentrations in the wastewaters of the municipal solid waste landfill, indicating that unprotected landfills (which predominate in Croatia) should be regarded as possible hot-spots for their input into the environment, especially into groundwater aquifers.
Administrative law sets the responsibility of municipalities and municipal public corporations for water and waste treatment services and gives them the right to collect use fees. The investments are funded from service charges, municipal surcharges, local government budgets and other local levies. The reforms permit private sector investment, operating concessions, tariff setting flexibility and discounts on national surcharges to utilities for capital investment or debt servicing.

While local governments have autonomy in deciding about their revenues and expenditures, the major obstacles they are facing now are due to their inexperience in financial management and local funding of municipal infrastructure, and to the absence of stable sources for long-term capital financing. Although municipal capital improvements should be financed mainly from the use fees and other local sources, in practice, the revenues, generated by the utilities are insufficient.

Owing to the central government budget constraints, few funds have been channelled to environmental investments. The Municipal Environmental Investment Programme (MEIP) has been initiated. The Croatian Bank for Reconstruction and Development is the borrower of the bank’s loan. The loan proceeds finance the extension and improvement of sewerage, wastewater treatment, water-supply systems in Trogir, Kaštel, Split, Solin and Pula and the establishment of wastewater monitoring.

Fig. 2. (a) Volume of process wastewaters released to sewage system points in thousands of m³ waste water per year. (b) Volume of process wastewaters released to the environment by the treatment type in thousands of m³ waste water per year.
in the Brač and Split channels. The project is in an advanced stage of implementation, having been financed by EBRD and the World Bank in 1996 (Secrest, 2001; IRIP, 2004).

The City of Zagreb, Croatia’s capital and the most industrialised region, has recently signed a concession contract with a major international private consortium for a waste water treatment plant (WWTP) on a BOT (build operate transfer) basis. The Zagreb WWTP will be the biggest plant in the region in the coming years. It demonstrates a new developing trend in the water sector in Croatia, as the majority of large and medium-size cities are considering private sector involvement through BOT structures or privatisation of their respective water utility companies. In the period from 1997 to 2001 considerable funds were invested in the construction of the system and municipal wastewater treatment plants4.

According to the national water protection plan, the construction of municipal wastewater treatment plants (and of the higher level treatment plant) in excess of 50,000 PE is foreseen5. They will considerably reduce the public pollution load which is actually a national commitment arising from the international conventions.

**Water quality**

Municipal wastewaters, agriculture and industry are the main sources of water pollution. There are a number of large settlements in Croatia without municipal wastewater treatment plants. Despite this fact, pollution has been reduced in the last decade as a result of an abrupt decrease in industrial activity in the early 1990s and a very slow economic recovery following the war in Croatia. Water quality has been monitored systematically since 2000 at 242 sampling points of surface waters (rivers, lakes and artificial accumulations) and sources.

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4 The following facilities have been constructed: Čakovec, Baška, Brtonigla, Trilj and Vis (pre-treatment). Some constructions have been completed but are not fully functional mostly owing to an incomplete sewerage system.

During 2003 systematic monitoring of ground water quality was performed, especially at the sources, in compliance with national regulations defining requirements for the hygienic quality of drinking water. According to chemical parameters, Croatian freshwaters fall mostly into category II (suitable for drinking water supply after a minor pre-treatment) and category III. However, with regard to microbiological indicators, they often belong to categories III and IV, which can be used for drinking water supply only after thorough treatment. The data have been collected by the state Central Bureau of Statistics (Statistical Yearbook, 2003) in cooperation with the Ministry of Environmental Protection, Physical Planning and Construction, the State Weather Bureau and the Ministry of Interior. Data about water consumption, use and pollution are collected and kept by all counties and cities numbering more than 40,000 inhabitants. An information development project for water, as a part of future e-government, has been initiated in 2001 and is financed from the EU programme CARDS 2002.

The rivers of the central lowlands of Croatia, draining into the Danube River, have relatively good water quality, although the Zagreb urban area does cause significant pollution of the Sava River (Ahel, 1989; Ahel, 1991). A comprehensive characterization of organic pollution in the Sava River using the GC/MS (gas chromatography/mass spectrometry) technique (Ahel, 1989) indicated the presence of numerous specific organic contaminants, which were not regulated by the ordinance on maximum allowable concentrations. It turned out that some of the compounds identified in the analysed samples belonged to the compounds classes that 15 years later became prominent candidates for the so-called emerging contaminants. For example, Croatia was one of the first countries to introduce water quality criteria for nonylphenol. Nonylphenol was included in the Croatian Ordinance 15 years before it was accepted as a priority pollutant in the Water Framework Directive. The coastal strip rivers from karstic highlands, discharging into the Adriatic Sea are generally of excellent quality as there are few settlements and industries in this area. Surface waters in the areas of intense agricultural activity, mostly in the Danube River catchment area, are occasionally overloaded with pesticides and nitrates (RSE, 2003).

**Water policy in Croatia and its harmonization with the EU Acquis communautaire**

The Water Management Master Plan of Croatia is a long-term planning document defining the principles of water management, water balance and improvement in the water system, ensuring an integrated and coordinated water regime in the Republic of Croatia and in each water basin. It should instigate improvement in the integrated needs of specific sectors, in particular of nature protection and water management policies.

A positive aspect is that Croatia has signed cooperation agreements with Hungary, Slovenia and Bosnia and Herzegovina for management of their shared river basins and development of integrated river basin management plans, in particular the Danube basin, and with a view to implementing the EU Water Framework Directive. This Directive should be gradually incorporated into Croatian water management system, with special focus on standardization of their own national data and methods and on their harmonisation and exchange with the EU.

At the regional level, Croatia is co-presiding over the regional environmental protection programme (REReP) and is taking part in the activities of the European Agency for Environment (financed by CARDS) and the LIFE-third countries programme. Croatia has signed the International Convention on the Protection of the Danube River and works on drafting the River Basin Management Plan. A proposal for a bilateral cooperation agreement on water management with Serbia and Montenegro is currently...
under discussion. In line with the Transboundary Water Quality Assessment Programme, monitoring of water quality is planned in all Croatian counties.

Current legislation on water quality is a good basis for harmonization with the EU *acquis communautaire* although by-laws at the local level are often missing. However, inventories of water contaminants are incomplete, requiring additional scientific studies and exceptionally large financial and management efforts to provide a basis for reliable risk assessments, following the adopted EU guidelines.

The Republic of Croatia has the following strategies and laws relating to water management: the National Water Protection Plan (1999); the National Environmental Strategy (2002); the National Environmental Action Plan (2002); the Law on Environmental Protection (1999); the Law on Financing Water Management (1995, 1996, 1997); and the Act on Waters (1995). The National Water Protection Plan also includes the Development Plan for Wastewater Facilities and Treatment Plant, which is to be gradually supplemented in the period from 2005 to 2025. Thus, Croatia will join the European countries with a developed infrastructure for water treatment and protection.

### State Union of Serbia and Montenegro

Serbia and Montenegro (SCG) is facing the challenge of restructuring its economy after a protracted period of economic and political hardship and conflict and in the face of a degraded natural environment. Over the last decade the infrastructure in SCG has deteriorated owing to substantial under-investment in the replacement and maintenance of assets. In addition migration to larger cities caused the utilities in the major municipalities to operate at the limit of their capacity. Water shortages are experienced during dry periods, urban wastewater is discharged untreated into the rivers and industrial wastewater receives little or no treatment.

In addition, some parts of the water and wastewater infrastructure, particularly in towns such as Novi Sad, were damaged during the NATO campaign in 1999. Municipal water and wastewater utilities were indirectly affected by property damage during the war, which in some instances, i.e. refinery spills into groundwater, will be expensive to clean up. The significant need for capital investments in the sector is mirrored by the requirement for major sector decentralisation.

### Water resources

Overall average annual water resources in the State Union of Serbia and Montenegro are estimated to be about $12 \times 10^9$ m$^3$. About 87% of the state territory is within the Black Sea basin. The Adriatic Sea basin covers 11% and 2% of SCG’s territory belongs within the Aegean Sea basin. Bearing in mind that most SCG territory is supplied by the Danube, one of the most powerful European rivers, and considering the numbers of population within its basin, it is possible to say that there are sufficient water resources in this area (*Ministry for Protection of Natural Resources & Environment, 2003*).

However, SCG is categorized among the water-poor countries in Europe, given its low per capita water flow and domestically generated water resources (annual per capita water flow is about 1,600 m$^3$). Water flow is seasonally uneven, leading to quantity problems throughout Serbia. Water supply shortages are the
most significant in southern Serbia. Water shortages have required the construction of reservoirs, for example on the Drina, Danube and Lim Rivers in Serbia, as part of a regional water supply strategy.

The country is also poor in terms of internally renewable water resources, since about 84% of available water originates outside the territory of SCG. Yearly groundwater reserves are about 244 m³ per capita. Groundwater sources are extremely important especially for Serbia where they are estimated to supply 90% of domestic and industrial needs and 70% of drinking water needs. The main characteristics of a most rivers in SCG are: lower concentrations of oxygen, increased concentration of $\text{BOD}_5$ and $\text{COD}$, as well as of major ions, including ammonium, ferric, cupric, zinc, nitrite and nitrate.

The quality of water resources, both surface and groundwater has experienced a continuous decline and is considered unsatisfactory. From 1994 onwards, water quality in most Serbian rivers deteriorated from second class to third class quality (Ministry for Protection of Natural Resources & Environment, 2002). Some of the decline is attributed to higher levels of pollution in those water sources entering the country. These tend to be contaminated with nutrients, oil, heavy metals and organic components. Examples of very clean water – Class I and I/II are very rare, and are situated in mountainous regions.

The water quality of Montenegro’s most important rivers, namely the Moracˇa/Zeta, Lim and the Tara/Piva is generally within the required level for most of the year (Ministry of Environmental Protection & Area Planning, 2002). The water quality of Lake Skadar also meets all standards for its category, with the exception of ammonia and of eutrophication. The quality of coastal marine waters of SCG is generally satisfactory, especially in open stretches. Nevertheless, more confined bays with human settlements are affected by wastewater discharges.

Water supply and sanitation

The water supply and sanitation sector was well developed in the former Yugoslavia and, even today, coverage in urban areas reflects this legacy. In 2000, 98% of the SCG population had access to safe drinking water (Serbian Health Protection Institute “Dr. Milan Jovanovic Batut”, 1999). Around 84% of the population receives a piped water supply to the home or yard. The Republic Institutes of Public Health (IPH) has the responsibility for monitoring drinking water supplies and the authority to close systems which do not produce water according to standards.

The SCG municipalities reporting the best water quality are the large cities (Belgrade, Novi Sad, Niš and Podgorica) where there are more financial resources to operate and maintain water supply systems adequately. Medium size towns and rural areas have the most difficulty providing safe and adequate supplies of drinking water. There are significant regional differences in water quality. The supplies in northern Vojvodina are the worst and are often considered unsuitable for drinking water purposes without treatment (Republic Hydro-Meteorological Institute, 2002).

Rural water supply systems are a combination of formal and regulated piped water supply systems owned and operated by the municipality, unregulated private piped systems that communities built (and operate) themselves and private wells, which are also unregulated. Data is very scarce on rural water supply systems but some estimates indicate that about 50% of the rural population uses an unregulated supply. The Serbian IPH, based on sporadic measurements, estimates that about 90% of the informal, unregulated rural water supply systems do not comply with bacteriological standards. A survey conducted by the Montenegro IPH in 2001 showed that of 194 private wells that were analysed in rural areas, 120 (62%) did not comply with bacteriological standards (Institute of Public Health, 2001).
With the exception of the public/private Montenegro coastal water utility, all water utilities are municipal, publicly owned companies that are managed by the local authorities. Companies providing water supply and sewerage services in Serbia and Montenegro are state-owned. They are organized as public utilities with a municipality as their founder. Services are provided on the municipal, city and regional levels. There are over 90 registered public water utility companies. Production of potable water in SCG could potentially be around 25 m³/s or 800 Mm³ annually (Serbian Health Protection Institute “Dr. Milan Jovanovic Batut”, 1999).

Despite the already mentioned fact that 84% of the population receives drinking water supplies directly to their homes or yards, it is necessary to stress some details. A large percentage of the drinking water provided is of low quality and the water distribution system is outdated and inadequate, leading to large losses (Public Water Management Company “Srbijavode”, 2002). There are significant differences in service delivery between different regions and between urban and rural populations, particularly in terms of drinking water supplies (urban coverage is 97%, compared with 68% rural coverage).

There are approximately 7,000 settlements and communities in Serbia, the majority of which, 90%, have a population of fewer than 2,000 people. The principal municipal point source polluters are settlements with over 10,000 inhabitants, making up only 2.2% of the total number of settlements but causing more than 90% of total pollution load (Federal Institute of Statistics, 2001). There are very few large cities but they account for most of the population. Half of the Serbian population receives service from public water supply systems of which there are 153 serving 168 municipalities and their environs. About half of the population receives water from the three largest water supply systems (Belgrade, Novi Sad, and Niš), with the remainder served by medium-sized public water supply systems of which there are 72 serving municipalities with populations of 10,000 to 100,000 (Federal Hydro-Meteorological Institute, 2000).

There are significant regional differences in water quality between central Serbia and Vojvodina. The primary problems with physical and chemical water quality parameters are turbidity, iron, manganese, nitrate and, in the case of Vojvodina, arsenic. Vojvodina has severe problems with both physical/chemical and bacteriological standards (67% of water samples do not meet standards). Central Serbia’s main problem is bacteriological contamination with greater than 41% of samples not meeting standards. Only in Belgrade is the water quality generally adequate with greater than 90% of water samples falling within standards (Ministry for Protection of Natural Resources & Environment, 2003).

There are 25 municipal water supply systems in Montenegro supplying 213 settlements (40 urban and 173 rural) and approximately 500,000 people. Over 90% of the population receives piped water to their house or yard. Only two water systems (Pljevlja and Herceg Novi) utilize water from surface supplies. Almost all drinking water supplies come from groundwater resources, primarily springs (70%), which are of very high quality and deliver 109,403,000 m³/annually (or 3.5 m³/s). Of this quantity produced, only 48% (1.7 m³/s) is delivered; 52% is unaccounted for and can be regarded as the drinking water losses. Elimination of these enormous water losses should be one of the top priorities in the sector ( Laušević & Katić, 2001).

Deterioration of water supply networks and chlorination systems over the past 10 years has had an impact on drinking water quality with 25% of samples in 2000 not meeting bacteriological standards (Ministry for Environmental Protection, 2000). As in Serbia, the range of unacceptable water varies significantly regionally, with coastal cities generally faring the worst. Larger cities, for example Podgorica and Danilovgrad, are more likely to be able to afford disinfection of drinking water supplies,
which is reflected in the higher water quality figures, with greater than 97% of samples meeting bacteriological standards (Ministry for Environmental Protection and Area Planning, 2001).

Water pollution sources

The quantity of the wastewater\(^6\) discharged into waterways is constantly increasing with the increase in living standards, enlargement of the population, urbanization and intensification of industrial and agricultural production. The basic characteristics of wastewater are a high level of organic pollution and microbiological pollution. Industrial capacities in SCG are located around cities and, very often, industrial wastewater is mixed in with municipal wastewater, without treatment (Tables 6 and 7). Small industrial objects are mainly located in the urban zones and they discharge their wastewater into the public sewerage network. Larger industrial objects are generally located outside the settlements, usually near river banks or in their immediate vicinity, which holds true for all mining facilities too. The wastewater from these facilities is directly discharged into the waterways and channels of the Danube/Tisa/Danube system, with or without previous treatment. Generally speaking, by far the greatest quantities of the industrial and mining wastewater are discharged into the Sava and its tributaries, owing to the high specific demand of the facilities located in its basin. However, the basin of the Timok is the most endangered one, owing to the composition of the present industrial and mining wastewaters, the level of their purification and the recipient capacity (Republic Hydro-Meteorological Institute, 2000).

In 2000, the estimated quantity of municipal wastewater in SCG was about 660 × 10^6 m\(^3\) and treated wastewater, at a different level, was about 80 × 10^6 m\(^3\). Construction of municipal and industrial sewerage systems in Serbia during the past decades has lagged behind that of water supply development.

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\(^6\) Municipal, technological, sanitary wastewater, water from agricultural areas, wastewater from farms, cooling water.
There are distinct regional differences in sanitation coverage with 45% of Vojvodina connected to the public sewerage network versus 67% for central Serbia (including Belgrade). It is necessary to emphasize that the term municipal wastewater includes used wastewater from households, institutions, companies and other urban objects. However, some important industrial facilities are located inside the urban agglomerations, discharging their wastewater into the same public (“city”) sewerage system, but with the previous setting to the level of the municipal wastewater quality stipulated by special regulations. This way, for the rational economic reasons, all wastewaters collected in one unique sewerage system are treated in joint “central” facilities. According to this, there are 37 built central facilities for wastewater treatment in the Republic of Serbia, seven of which have only mechanical (“primary”) treatment and 30 of which have the biological (“secondary”) treatment as well. One should keep in mind that only 12–15% of the wastewater collected through the public sewerage system (approximately 2.1 m$^3$/s) is treated and that the quantity of the organic pollution corresponds to one million equivalent inhabitants (EI). The total quantities of the municipal wastewater are currently estimated to be loaded at around 14 million EI.

Quantities of municipal and industrial wastewater discharges have changed significantly in the past decade. Roughly 10% of total wastewater discharged in Serbia is from households and this figure has remained steady throughout the 1990s. What has changed dramatically is the total amount of wastewater from both households and industry. Both have dropped by about 60% since the early 1990s. Meanwhile, wastewater treatment capacity has remained roughly the same for both domestic and industrial wastewater treatment and the treated amount remains similar in 2000 to that of 1990. There are about 120 larger facilities for treatment of the industrial and mining wastewater in the Republic of Serbia, of which the largest number has only the pre-treatment or the minimal treatment capacity, in order to fulfil the conditions that will allow them to discharge into the city sewerage system. Only around 20 larger industrial objects located on the riverbanks have facilities for a complete treatment of wastewaters, but some of them are only partially functioning. Most industrial companies, or facilities, in settlements with particularly contaminated (toxic) wastewater, have the equipment for treatment (usually preliminary pre-treatment) of their own wastewater, to the condition satisfying its discharge into the public sewerage system. At present, there are about 10 facilities for treatment of the industrial wastewater under construction, of which about 50% are already built, and there are 10 more for which project documentation is in the final phase.

Apart from these facilities, around 50 autonomous facilities for some industrial capacities with their own sewerage systems were built as well, among which are the cellulose and paper mills, sugar refineries, base chemistry plants, mining-metalwork plants and so on. The treatment of the manure from livestock farms has, until today, been realised sporadically (in about four cases), and the treatment of the filtrates is only in its initial phase in some municipal trash dumps (planned by technical documentation, but not realised).

In general, the efficiency of the existing plants for municipal and industrial wastewater treatment is low. It is estimated that only 13% of the total number of all treatment plants operate with satisfactory results. As a result of inadequately treated wastewater discharges, the pollution of ambient and drinking water supplies has occurred. The Republic Institutes of Hydrometeorology conduct routine monitoring of surface inland water and groundwater quality. The Republic Institutes of Public Health monitor drinking water supplies. The most comprehensive ambient water quality data available is that for the Danube River basin. There are about 160 gauging stations on rivers within the Danube River basin where both flow and water quality are measured on a regular basis. The water quality of the largest international
rivers in the Danube watershed as well as the water quality of the largest part of SCG national rivers is far from being satisfactory. This is particularly true for river stretches downstream of settlements as the result of untreated municipal and industrial discharges.

Since the mid-1990s, water quality in many of the rivers has deteriorated from second class to third class quality. At the same time, drinking water quality has also deteriorated (Republic Hydro-Meteorological Institute, 2002). The percentage of drinking water samples that do not meet the required standards is at the level of 50% in Serbia and around 15–20% in most Montenegrin cities. Unchecked industrial pollution, untreated wastewater discharges, and trans-boundary inputs are amongst the causes of deteriorating quality. Surface water quality monitoring has found bacteriological pollution in small rivers and channels where there is municipal and industrial wastewater discharge (Waterpower Institute “Jaroslav Černi”, 1997).

Non-point source pollution contributes to more than 50% of total water pollution. These sources deliver 70% of total nitrogen, 50% of total phosphorus and 90% of faecal and coliform bacteria. Proposed measures to mitigate non-point source pollution have focused on storm water retention, treatment and separation from common sewer systems. Additional measures, which could be taken to reduce non-point source pollution, include regulatory and incentive-based reforms to popularize non-phosphate-based detergents and nutrient reduction programmes for agricultural areas. The sector has prioritized investments focusing on the sewer system and industrial pre-treatment plants. In 2000, the Ministry of Agriculture, Forestry and Water Management (MAFW) financed construction of 33 wastewater-related structures, 20 collector systems, six central wastewater treatment facilities and seven industrial pre-treatment systems.

Wastewater management is also considered a key environmental priority in Montenegro. Only 60% of residents are connected to a public sewerage system with large regional differences. Sewerage systems have been established in the central parts of Podgorica and many of larger towns in Montenegro but are usually not extended to the town margins. The Podgorica wastewater treatment plant was designed for 55,000 people and is now servicing 150,000. This means a large percentage of the wastewater collected is discharged untreated. Outside Podgorica about 55% of the population is connected to sewerage systems (Institute of Public Health, 2001).

An annual volume of at least 18 million m$^3$ of municipal wastewater is discharged into rivers and gorges, often in the vicinity of urban areas and sometimes close to drinking water sources. An unknown volume drains directly into the ground. Commercial enterprises use water from the existing networks and discharge it polluted into the city sewerage system. No information on industrial discharges was available.

A number of projects, for which the Montenegrin Government provided funds, were developed through the Public Works Agency of the Republic of Montenegro. For future investment needs, the sewerage system of each town was assessed with recommendations made for improvement or construction. Some municipalities have developed sewage system rehabilitation, reconstruction, expansion and construction programmes. The funds required to implement these programmes are estimated at €52 million.

Institutions and environmental regulation

Owing to the changes in 2003 (Federal Republic of Yugoslavia became The State Union of Serbia and Montenegro), responsibility for the environment incorporated in all federal laws became part of the
republic’s legal system. The republic’s MAFW are responsible for water economy and water management (except water distribution). A Republic Directorate for Water and Republic Agriculture Service was also established. On June, 2001, the Government of the Republic of Serbia gave a Direction obliged the former Ministry of Health and Environmental Protection to prepare an Environment Protection System Act that would comprise management of sustainable use and protection of natural resources, and introduce environmental principles. Actually, the environmental issues have been addressed to the Ministry for Science and Environmental Protection of the Republic of Serbia. Therefore, the SCG and republic governments are in the process of revising the laws on local government (Bogdanović, 2000).

Water protection and environmental management are the main focus of the Environment Protection Act\(^7\) and the Law on Waters\(^8\). The Environment Protection Act stipulates measures that prohibit the discharge of wastewaters containing hazardous and harmful substances, in quantities and concentrations above legally defined limit values, into ground and other waters. Legislation for wastewater is exclusively based on a water quality objective approach – i e. the quality of receiving water after mixing with effluents. No emission limit values or minimal treatment efficiencies exist and the river low flow criteria for calculating the necessary degree of treatment is a mean 30-day low of 95% probability of ascendance.

Municipal and other companies discharging wastewaters into different receptors and public sewerage are obliged to ensure quality monitoring and impact of waters discharged into different receptors or public sewerage, through the organizations authorized to conduct such monitoring. Companies that conduct monitoring of surface and groundwater, and of wastewater quality, are obliged to submit their results to the Republic Hydro-meteorological Institute and to the Public Waterworks, on a monthly basis, and in case of accidents within the same day.

According to the Law on Waters, the systematic monitoring of surface and groundwater quality is conducted in a legally defined way\(^9\) following the programme adopted by the government. Systematic water quality monitoring is conducted by the Republic Hydro-meteorological Institute. Reports are submitted to the ministries competent in the issues of waterworks, health and environment protection, as well as to the Public Waterworks. In case of accidental water pollution, the named authorities are to be informed immediately. Drinking water quality monitoring control is the responsibility of the Institute of Public Health and is based on several national regulations\(^10\). The drinking water quality standard (Regulations on Hygienic Safety of the Drinking) is adapted to the EU directives for drinking water and WHO’s drinking water recommendations\(^11\).

The Government of Serbia enacts the regulations on the classification of waters and categorization of water flows in the territory of the Republic. The systematic assessment of water quality is performed according to the programme adopted by the government on monitoring spots, in time intervals, according to the parameters and methodology stipulated by the Ministry of Agriculture, Forester and Water Management, in concordance with the Ministry of Science and Environmental Protection. The

government enacts the mid-term plan for water protection. Companies that have facilities, appliances and installations that discharge wastewaters are obliged to ensure systematic control of such waters.

Central and local environmental institutions in both republics are keen to harmonize environmental legislation with the EU *acquis*. In Serbia, with Finnish and other assistance, the environmental law has been revised, much in line with the Integrated Pollution Prevention and Control directive of EU, and work has begun to align relevant laws with the EU Directive on Environmental Impact Assessment and Public Access to Information. The Ministry for Science and Environmental Protection would also like to harmonize with EU directives that deal with water quality and waste management. Experience in EU and EU candidate countries shows that it is quite costly to implement these directives, which implies that transition to full implementation will have to be undertaken over an extended period of time. Therefore, only those EU *acquis*-related actions that are of the highest priority regarding the water quality and waste management are in progress.

Although the Environment Protection Act and Law on the System of Environmental Protection were issued in 1993 and 2004, respectively, SCG has not advanced with its implementation. Consequently, the estimated cumulative time lag behind the developed countries in the field of environmental protection is, at least, 20–30 years. The last official report on the state of the environment, water quality and waste water management in the Republic of Serbia, presented in 2000, should serve as grounds for future activities.

**Conclusions**

Compared to some other European and Mediterranean countries, B&H, Croatia and SCG are relatively rich in water resources. However it was shown that inadequate water management often leads to significant ecological problems and economic losses. It should be emphasized that there are significant high quality drinking water resources in the region, which have been currently only partially exploited and which have a significant strategic role in a broader European perspective. Therefore these resources require strict and efficient protection. Improved performance in environmental protection can be accomplished only through a well-defined legal framework accompanied by the application of an adequate policy and wide public support. The current process of political, social and economic changes in the countries of the south-eastern Europe, catalysed by the accession process to the EU, is a promising basis for the introduction of systemic measures in accordance with environmental *acquis*. Despite the growing potential for private initiatives in the environmental sector, priority measures and activities require active participation of governmental institutions and the close cooperation of relevant authorities as well as the strong involvement of internationally supported actions. The most important part of the approach is long-term systematic sanitary measures. However, because there are acute problems in waste management, some urgent preventive measures should be implemented to mitigate the consequences of pollution in the some critically polluted areas.

These measures comprise a marked socio-economic and technological development and require engagement of significant financial resources. Financial resources, which, in the past, have often been an important obstacle to the realisation of adopted environmental protection policies, should include different sources such as budget funds, private funds, resource usage compensations and so on. It is expected that the process of accession to the EU will result in significant progress in the terms of strengthening regional cooperation on water protection.
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