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Review article

The quality of Albanian natural waters and the human impact

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Abstract

Albania possesses a wealth of aquatic ecosystems, many of enormous natural and biological value, such as the Lakes Ohrid, Prespa and Shkodra, glacial lakes, river valleys, and coastal lagoons. Although many habitats are highly polluted by inorganic and organic wastes, detailed knowledge on the water quality is still lacking. For the first time, an environmental assessment of the water quality is presented and the main polluting sources identified. As a consequence, a systematic control and the establishment of routine monitoring of surface and groundwater is proposed, which elucidates the present environmental state and helps to develop new strategies of waste and wastewater management. It would help allow Albania to reach an international standard in environmental protection, as a part of UNECE Convention, the Mediterranean Action Plan, the MAP/UNEP Medpol Program and the Basel Convention.

Keywords: Albania; Aquatic ecosystems; Wastewater; Water quality; Monitoring; Hydrology; Environmental assessment

Contents

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1. Introduction

Albania, a country covering landscapes from high mountains to the seacoast, is rich in water resources. These shelter an interesting flora and fauna, and its biodiversity is of international importance. However, at present, many habitats are seriously endangered. The transformation of the Albanian economy to an open market situation during the past decade caused a significant damage to the natural resources of the country, mainly to natural waters, most of them exposed and unprotected. The existing legal situation on property and ownership could not avoid overexploitation of sensitive ecosystems. The situation is especially dramatic in the Albanian western lowlands where most of the rivers pass. This region became heavily populated and large industrial centers and intense agriculture developed. Most urban and industrial waste is disposed directly into the rivers. Neither liquid nor solid waste is controlled, nor are samples taken regularly of surface and ground water. An attempt to survey the environmental problems in Albania was presented in 1997 (Sallaku et al., 2002). The increasing countrywide demand for water, including drinking water, water for irrigation, aquaculture, hydro-electricity and recreation should force health and environmental authorities to be interested in the evaluation as the basis for restoration and protection.

The objectives of this overview are: (1) to summarize the current situation regarding the pollution of the Albanian aquatic ecosystems, (2) to address the environmental problems in Albania caused by human impact, (3) to provide the foundation for restoration and protection of aquatic ecosystems in developing appropriate measures. The paper is based on reports, most of them hardly accessible outside Albania, and on our own work, part of it carried out within the framework of the first phase of a Scientific Cooperation Between Eastern Europe and Switzerland (SCOPES) joint project, supported by the Swiss National Science Foundation. The discussion is completed by the personal experience of the Albanian authors and describes for the first time the environmental quality of the water resources in Albania.

2. Albania, a general overview

Albania is a small country (total surface=28,748 km^2) in the Southern part of the Balkan Peninsula, bordering north and northeast with Montenegro, Kosovo and Macedonia, and south and southeast with Greece. From the present day borders (total=1094 km), about 427 km are seacoast, 48 km riverside and 72 km lakeside (Fig. 1); from west and southwest, it is largely opened to the Adriatic (273 km) and Ionian (154 km) sea. The geology, different rocks stemming from the Paleozoic to the Quaternary, builds up a variety of formations. Jurassic ophiolithes are the largest of Alpine–Mediterranean formations, composed of ultra-basics (rich in Cr), granites and effusives. Terrigenous sediments like flysch and molasse of Pliocene–Quaternary occupy more than 58% of the territory and about 27% is composed of effusive and limestone sediments (mainly limestone and dolomites), dominated by karstic processes (Kabo, 1990–91).

The geography of Albania is diverse and complex. Almost 3/4 of the territory extends between 200 and 2000 m a.s.l., with a mean value of 708 m, twice that of the European continent. Monocline crests dominate, mainly in mountainous and hilly chains, with steep and narrow valleys that drive up from Southeast to Northwest (Figs. 3, 6, 8, 9). Due to its geographic location, Albania has a typical Mediterranean subtropical climate, characterized by a mild and wet winter, and a hot and dry summer. Precipitation is abundant, with the multi-annual mean from about 1300 mm $year^{-1}$ in the South to more than 2000 mm $year^{-1}$ in the North, and decreasing in easterly direction. Around 40% of the rainfall occurs in winter, 32% in spring, and the rest in autumn and summer. Rain showers are short, heavy and within a few minutes they create torrents of water, washing down the eroded soil to the sea (Kabo, 1990–91).

3. Important aquatic habitats in Albania

Albania is rich in water resources like lakes, rivers, springs, lagoons, with a high quantity of available water. The Albanian territory covers about 65% of a total watershed area of 43,905 km^2. The mean annual flow is 1308 m^3 s^{-1} (min. 649 and max. 2164 m^3 s^{-1}). The total water volume annually reaches 42.25×10^9 m^3, from which 30% belongs to subterranean waters. This accounts for more than 13,000 m^3 $capita^{-1}$ $year^{-1}$ (Stanners and Bourdeau, 1995). About 247 natural lakes are dispersed throughout the country, most of karstic or glacial origin and often very small (down to only 1 ha).

3.1. Trans-boundary lakes

Lake Ohrid represents a distinct environment among all aquatic habitats in the Balkan for its origin, hydrology,

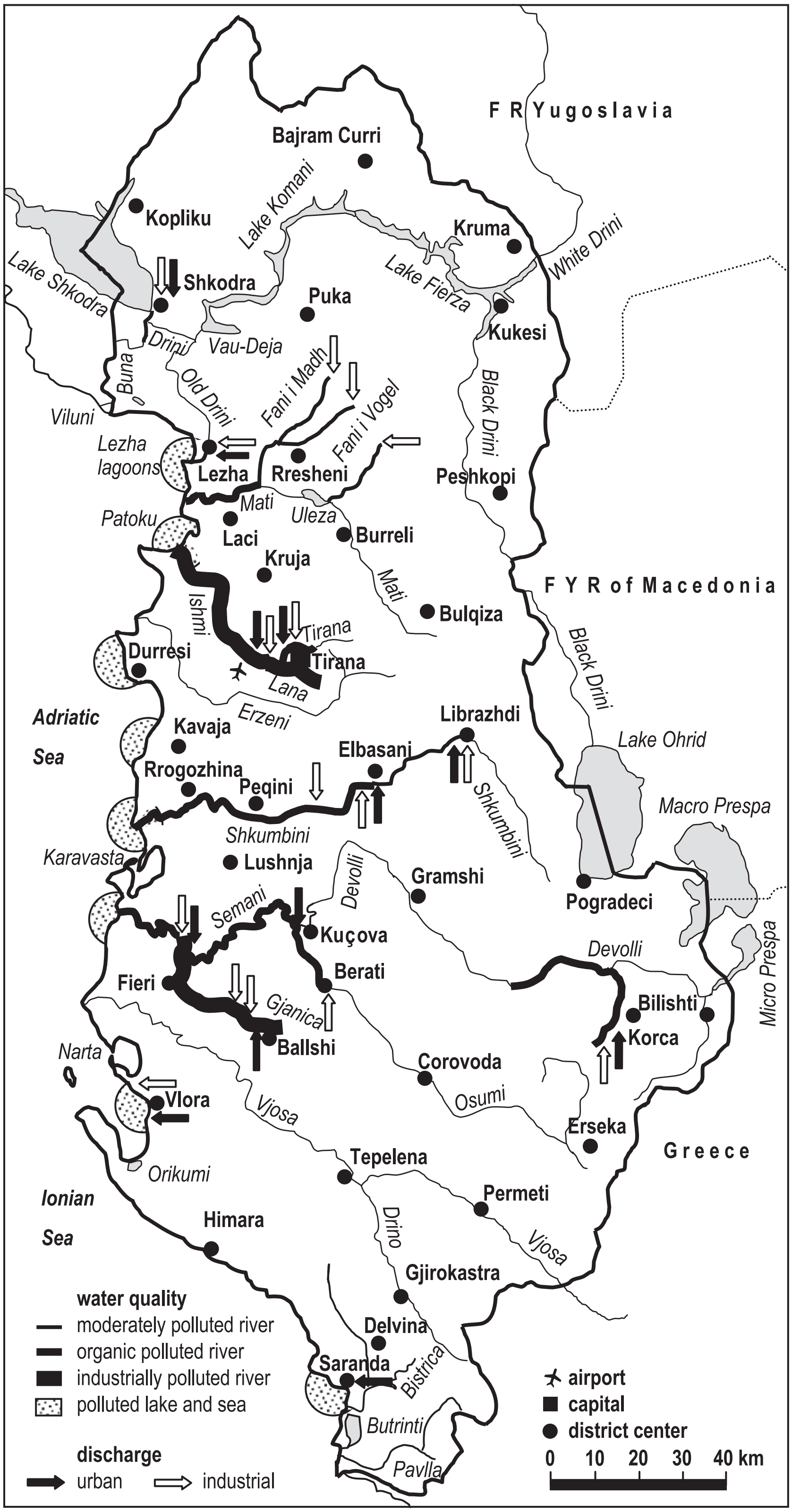

Fig. 1. Hydrological map of Albania with the main polluting sites, drawn modified from UNEP (2000).

and biodiversity. Some characteristics are given in Table 1. The lake is oligotrophic and characterized by a very high transparency of the water, down to 15–25 m. The important problem of its watershed management has been discussed by Spirkovski et al. (2001). As Lake Ohrid is thought to be about 4 million years old, species diversity

Fig. 2. Aquatic wetlands near Lake Shkodra in the Kopliku region (May 2002, Photo: A. Miho).

and the endemism are of particular interest. Not only some fishes are endemic, i.e., "koran" (*Salmo letnica* ssp. *ohridanus*), 'belushka' (*Salmothymus ohridano*), but also more than 70% of the tubular worms, more than 80% of the shrimps and as many as 90% of mollusks species. More than 550 taxa of diatoms (Bacillariophyceae) are found, of which about 100 are rare or tertiary relicts (Miho and Lange-Bertalot, 2003). Lake Ohrid is furthermore a nesting and roosting site for some globally threatened species of waterfowl during wintertime. Two groups of springs, St. Naumi (Macedonia) and Driloni (Albania), feed into the lake, while the water of Black Drini leaves in northern part in the direction of the Adriatic Sea.

Prespa lakes (Macro and Micro Prespa, Table 1) are trans-boundary ecosystems as well. Most of the Albanian part of Micro Prespa forms a typical wetland, covered with reed, important for water biota, especially for waterfowl. The water from Micro Prespa flows to Macro Prespa through the Kula canal, then to Ohrid by a subterranean path.

Like Ohrid, Prespa lakes are well known for their biodiversity and endemic fish species, like the Prespa barbel (*Barbus meridionalis* ssp. *prespensis*), bleak (*Alburnus albidus* ssp. *prespensis*) and *Chondrostoma nasus* ssp. *prespensis*. Water birds migrate through and winter in the region. Most important are the Dalmatian pelican (*Pelecanus crispus*) and pygmy cormorant (*Phalacrocorax pygmeus*); furthermore, many duck species regularly visit the lakes. More than 270 species of diatoms were found in the Albanian parts, most of them rare or endemic (tertiary relicts), such as *Cyclotella fottii*. Prespa lakes represent the core area of the trans-boundary Prespa Park, established in the year 2000 (www.medwet.org/prespa/).

Shkodra Lake is the largest lake in the Balkan, shared with Montenegro (Table 1). The lake was formed through tectonic shifts combined probably with karstic processes. River Buna is the only outflow at the western lakeside; it joins Drini River just 1.5 km from the outlet. Lake Shkodra is characterized by a rich flora and vegetation (Fig. 2). More than 80 species of aquatic higher plants are found, some of them again endemic or endangered species, like *Marsilea quadrifolia*, *Nuphar* spp., *Trapa natans*, *Sagitaria sagitifolia*, *Najas marina*, *Schoenoplectus lacustris*, *Potamogeton*, *Leucoium aestivum*, etc. The lake harbors about 49 species of fish, among them six trout species. Several fish species migrate to the sea, e.g., the worldwide threatened *Acipenser sturio*.

Table 1
General characteristics of the large trans-boundary lakes

Name	Surface (km^2) (within Albania)	Mean depth (maximum) (m)	Altitude of water level a.s.l. (m)	Drainage basin (km^2)	References
Lake Ohrid	384 (111.4)	145 (286)	695	1414	Kabo, 1990–91
Prespa Lakes	253.6 (45.6)	18 (55)	853	1425	Dimirovski et al., 1997
Mikro Prespa	47.4 (3.9)	4.1 (8.4)	855		
Lake Shkodra	368–542 (149)	7–10 (44)	4.4–9.4	5180	Hollis and Stevenson, 1997

3.2. Glacial lakes, karstic lakes and springs

Around 134 glacial lakes are situated mainly in Lura (Burreli), Ballgjaj (Bulqiza) and Dhoksi (Peshkopi) regions at altitudes of 1500–1800 m a.s.l. Generally, they are small, formed mainly over magmatic (mainly of ultra-basics) and terrene formations. The most famous and well preserved are the 12 Lura lakes; they are surrounded by dense forests of birch and pines (*Pinus heldreichii* and *P. leucodermis*). Not much is known about their flora and fauna. About 430 forms of diatoms were described recently by Miho and Lange-Bertalot (2001), most of them oligotrophic ones. The most interesting glacial lake was Allamani Lake (Bulqiza), where some new species were found, like the diatom *Navicula pseudopugnata*. Situated away from urban centers, they have conserved an oligotrophic state.

Among the karstic lakes (about 94), situated mainly over limestone and gypsum, the Dumrea Lakes, located between Shkumbini and Devolli valleys (Peqini), are the best known. Most of them are small, generally less than 1 ha in size and less than 10 m in depth. These lakes have neither inflows nor outflows and their water levels oscillate drastically during the year. The surrounding of the lakes has been completely deforested during recent decades and transformed to cropland.

Fig. 3. The Vjosa valley in Carshova (Permeti) (May 2002, Photo: A. Miho).

In the karstic zones, there are about 110 springs with a mean flow of more than 0.1 $m^3 s^{-1}$ (Kabo, 1990–91), the largest being Bistrica (Delvina) with a total mean flow of 18 $m^3 s^{-1}$, Driloni (Pogradeci) with a total mean flow of 16.3 $m^3 s^{-1}$, Uji-Ftohte (Tepelena), Borshi (Saranda), Dajti (Tirana), and Llogora (Vlora). Besides their economic importance as source of water supply and recreation, the springs are interesting for their aquatic flora and fauna, especially for water birds and endangered fish species.

3.3. Rivers and artificial lakes

More than 152 torrents and small rivers finally form the seven large rivers, Buna, Drini, Mati, Erzeni, Shkumbini, Semani, and Vjosa, which run southeast to northwest towards the Adriatic coast. Especially in the eastern, mountainous part, the rivers exhibit a torrential and erosive regime, forming large and undulated beds in the western coastal lowland. Table 2 summarizes the hydrographic data from the main rivers. Albanian rivers are characterized by a high flow rate; the total annual mean flow is 1308 $m^3 s^{-1}$, which corresponds to an annual water volume of 41,250 km^3. Buna combined with Drini reaches a mean annual volume of 21.4 km^3, which makes them one of the principal rivers of Mediterranean region (Table 2). The rivers, fed mainly by precipitation (69%), show a typical Mediterranean regime, with a seasonal variation in the flow rate, high flow during October to May, which amounts to 73% of total annual water in Bistrica up to 93% in Drino (Kabo, 1990–91).

The aquatic flora and fauna of the rivers seem to be rich, with some rare or endemic species, but the information is scarce. An ecological assessment for Shkumbini River (Cake, 1996) revealed about 17 fish species dominated by Cyprinidae; eight species belong to the checklist of rare and endangered species of the Albanian red book (REC, 1997), like *Pachychilon pictum* (endemic in the Adriatic region), *Gobio gobio* ssp. *albanicus*, and mountain trout (*Salmo trutta* ssp. *macrostigma*, globally endangered). About 115 microscopic algae, mainly diatoms, were also found along Shkumbini; some of them are rare. A similar situation is expected for other rivers, especially for their upper mountain part, which is still well preserved.

The largest artificial reservoirs serve for hydroelectric power generation, i.e., reservoirs in a cascade above Drini (Fierza, 72.5 km^2 with a maximal depth of 128 m, Komani and Vau-Deja, 24.7 km^2 with a maximal depth of 52 m), Mati (Uleza, 13.5 km^2 and Shkopeti near Burreli) and Bistrica; they all are essential for the Albanian economy (Fig. 1). Other lakes are used for irrigation, more than 700 reservoirs with a total surface of 40 km^2, and a total water volume of 400 million m^3 is dispersed in the country. Starting in 1998, drinking water for the town of Tirana with more than 700,000 inhabitants is supplied from the Buvilla reservoir situated about 30 km North of Tirana. It

Table 2
Hydrographic data of the principal Albanian rivers (Kabo, 1990–91)

River	Length (km)	Drainage basin (km^2)	Mean altitude (m)	Average flow ($m^3 s^{-1}$)	Max/min flow ratio
White Drini	134	4964	862	68.2	10.4
Black Drini	149	3504	1132	118	4.7
Drini	285	11 756	971	352	5.1
Buna	1.5	5187	–	320	5.3
Buna and Drini combined	32.5	19 582	~770	680	–
Mati	115	2441	746	103	9.3
Ishmi	74	673	357	20.9	5.9
Erzeni	109	760	435	18.1	11.2
Shkumbini	181	2444	753	61.5	13.2
Semani	281	5649	863	95.7	13.7
Devolli	196	3130	960	49.5	1.7
Osumi	161	2073	852	32.5	13.2
Vjosa	272	6706	855	195	7.2

is fed by water from the Ishmi tributaries Terkuza and Zallbastari.

3.4. Coastal lagoons

Despite the massive land reclamation for agricultural purposes, about 109 km^2 of coastal wetlands or lagoons still exists, especially along the Adriatic coast. They are formed of Quaternary deposits, mainly of alluvial origin (Peja et al., 1996). The lagoons and their wetlands act as shelter and reproduction sites for a wide range of aquatic organisms of ecological interest, like fish or water birds. They are important for wintering of migratory birds; more than 70 species are known (NEA, 1999). The lagoons are also significant regions of tourism and recreation, and important centers of fishing.

Karavasta lagoon represents the largest lagoon in Albania and is among the biggest of the Adriatic basin. It is 43 km^2 in size, has a mean depth of 0.7 m and a maximum depth of 1.3 m. It is formed by the activity of Shkumbini and Semani rivers. Divjaka forest, a typical dune forest of 12 km^2, spreads in the northwest of the lagoon. It is bordered by brackish or freshwater, and pines (*Pinus halepensis* and *P. pinea*) grow up in old dunes, mixed with shrubs, grasses or reed near lagoon shores. It harbors globally threatened water birds, especially the Dalmatian pelican. Karavasta and Divjaka National Park have been considered recently a Ramsar site (see http://www.ramsar.org/profiles_albania.htm).

Lezha lagoons extend on both sides of the Drini delta, Ceka lagoon in the southern part of river delta, Merxhani lagoon and Kenalla pond on its northern side. The lagoon system is 10 to 15 km in length and 3 km in width, with a total area of about 22 km^2. Of this, 11.6 km^2 belongs to lagoons, 2-km^2 ha to forests (Vaina and Kune) and 7 km^2 to wetlands.

Narta lagoon (Vlora) is situated at the southern Adriatic coast; it is 42 km^2 in size and has a depth of 0.3 to 1.0 m. It is formed under the regime of the Vjosa River. Water salinity varies from 28 ‰ in winter to 75 ‰ during summer. About 1/3 of the surface is exploited as saline since the beginning of the last century. The lagoon is separated from the sea by a narrow littoral belt of alluvium dunes. Other important lagoons at the Adriatic coast are *Patoku* (5 km^2, Laci), *Orikumi* (1.5 km^2, Vlora), and *Viluni* (1.6 km^2, Shkodra).

Butrinti lagoon is 16.3 km^2 in size with a mean depth of 14 m and a maximal depth of 21 m. It is situated in the southern part at the Ionian Sea. Butrinti is a permanently stratified lake with an anoxic hypolimnion. In spite of that, the lagoon was used intensively during the last few decades for aquaculture of mussels (*Mytilus galloprovincialis*) with a yearly gross production of 2000 to 4500 t.

4. Human pressure on Albanian aquatic ecosystems

The most important aspects of human pressure on Albanian aquatic ecosystems are summarized, based on existing information (KMM, 1995–1996; WB, 1997; NEA, 1997–1998; NEA, 1999; UNEP, 2000). Within the ongoing SCOPES project, heavy metals and water quality were studied during 2002–2003 on five field tours along the most impacted rivers of the Adriatic lowland: Mati with the effluent Fani, Ishmi with the effluents Lana and Tirana, Shkumbini and Semani with its effluents Gjanica and Osumi (Fig. 1). A preliminary report has been presented recently (Cullaj et al., 2003).

4.1. Albanian transition and the environmental impact

Environmental problems in Albania have evidently increased since the last socialist regime, when the economy was centralized by the state and private ownership and activity were not allowed. In the year 1991, Albania left the communist epoch as the poorest country of Europe. More than 65% of its population lived in villages and were employed in state agricultural enterprises or cooperatives or state industrial factories. These all were stopped and most went in ruins due to the lack of state control and administration. As a consequence, a massive emigration occurred from 1990 to 1993, abroad mainly to Greece and Italy and within the country towards coastal regions, mainly to Tirana, Durresi, Shkodra, Fieri and Vlora. In 1997, about 54% of the Albanian population lived in the lowlands near the coast, resulting in a density of 179.3 inhabitants km^{-2} (NEA, 1999). The economy slowly transformed from state-owned to private. Besides the diminished state-owned economy, private and foreign enterprises started to compete in food industry, commerce, construction, transport, tourism, and agriculture.

This drastic change within the fragile reality of the Albanian economy forced environmental overuses and abuses, the aquatic ecosystems being the most exposed and unprotected ones. Aiming at a rapid development, means were often uncontrolled and unsustainable. This trend has not protected even special areas and symbols of the Albanian natural environment, like the Pogradeci lakeside or the forest belt over coastal dunes from Lezha to Vlora. Several present environmental problems are directly or indirectly linked to aquatic ecosystems, like urban and industrial waste management, water pollution or land erosion.

4.2. Pollution from solid waste

The most striking impact of the new economic system was the enormous increase of urban solid waste derived mainly from the increase of imported or newly produced everyday products. Their management did not function properly; in most cases, the dumping sites were neither correctly selected nor controlled. This is most evident in the large urban centers like Tirana, Durresi or Fieri. Often the solid wastes were dumped on riverbanks (Fig. 4) or burned with harmful effects on air, water and biota, human health included. Moreover, the insufficient management of waste disposal has obviously diminished the beauty of the landscape near inhabited centers (Fig. 5). One of the worst 'hot spots' is Sharra dump, a few kilometers outside of Tirana. All the urban waste collected in Tirana town is incinerated there. The dump has no protection layers and no drainage system. Water may leach into Erzeni River or contaminate the ground water, which is often the main water source of local people (UNEP, 2000).

Other serious problems are linked to the management of harmful solid industrial waste, which is disposed throughout the territory. According to the UNEP (2000) assessment, about 1500 t of chemicals and toxic remains from previous industrial activity, i.e., pesticides, are left. During the past decades, mining, enrichment and metallurgy industries have produced high quantities of solid or liquid waste, often dumped on riverbanks or directly into rivers. In the years of highest production of copper, about 650,000 t $year^{-1}$ of solid waste was dumped in Rubiku, Rresheni, Burreli, Puka, Shkodra and Korca, as well as about 10 million m^3 of polluted water released yearly into the rivers Fani, Drini and Mati (Shehu and Malja, 1998). Shkumbini River was strongly impacted by the Metallurgic Complex of Elbasani (Fig. 6b). Air quality ameliorated after 1992, as a result of the breakdown of the old fashioned industry. However, air quality is still low in urban centers, especially around Tirana, caused by heavy public and private traffic (mainly old vehicles), heating of buildings, waste incineration and cement factories.

Fig. 4. Depository of solid waste on the riverbank of river Osumi near Kucova (November 2002, Photo: A. Miho).

Fig. 5. Heavy water and riverbank pollution in river Ishmi (near Tirana). The solid organic materials on trees and bushes are remains of the previous high water situation (March 2004, Photo: A. Miho).

4.3. Pollution by urban and industrial wastewater

Urban and industrial wastewater continues to be discharged through canals without treatment directly into rivers, lakes or seas. Monitoring has been irregular and the information given is often not reliable or even contradictory. Some data of the monitoring of water quality of the rivers in the Adriatic lowland in Table 3 probably represent mean values (KMM, 1995–96; NEA, 1997–98). Other and more recent data give minimal–maximal values of the same parameters. As example, the situation for ammonia, nitrate, phosphate and the heavy metal copper is illustrated in Fig. 7.

Table 3 shows that high levels of nitrites were found in rivers Lana, Ishmi, Gjanica, Osumi, Semani, Shkumbini and Tirana; they exceed the EC guide values for high quality fresh water (<0.01 mg l^{-1} for Salmonid waters and <0.03 mg l^{-1} for Cyprinid waters). In Shkumbini, Tirana, Gjanica and Semani, nitrates even exceeded the EC guide value of 25 mg l^{-1} given for surface water. The same holds for total ammonia, where EC guide and imperative values are <0.04 and <1 mg l^{-1} (Salmonid waters), and <0.2 and 1 mg l^{-1} (Cyprinid waters), respectively (BMZ, 1995). The high levels of ammonium and nitrite indicate reducing conditions in the water, due to a high organic load. About 30 to 35 million m^3 $year^{-1}$ of liquid waste with a high content of toxic compounds were discharged directly into in Shkumbini River; furthermore, about 300,000 t $year^{-1}$ of solid waste were disposed on its riverbanks (Cake, 1996). The situation has been slightly improved since then, but strong sources of pollution from Elbasani town and from the rest of the Metallurgic Complex still remain.

A characteristic diversity of microscopic algae was found within periphyton communities (Cullaj et al., 2003); more than 250 species of diatoms were determined. The composition of the diatom population indicated medium organic and inorganic pollution (α/β-mesosaprobic) in Mati, upstream of the rivers of Tirana, Shkumbini and Osumi, as already suggested by the levels of nitrogen and phosphorous. However, most of the tributaries (Lana and Ishmi, downstream Shkumbini and Gjanica) were in a α-mesosaprobic to polysaprobic state.

Due to its geology, large areas of Central and Eastern Albania are covered by serpentine soils, which are highly enriched in heavy metals, such as Cr, Cu, Ni, Fe, Zn (Shallari et al., 1998). Within the framework of the MED POL II program, since 1992 the group of Analytical Chemistry carried out a systematic monitoring of heavy metals and of some organic pollutants in sediments along the seacoast (21 marine and estuarine stations) (Cullaj et al., 2000; Celo et al., 1999; Baraj et al., 1994). High levels were found in certain areas. In the Mati delta, Cu ranged from 62.8 to 624 mg kg^{-1} dry weight, Cr from 264 to 812 mg kg^{-1}, Fe from 40 to 79 g kg^{-1}, Ni from 252 to 413 mg kg^{-1} and Mn from 750 to 1230 mg kg^{-1}. All these values are high compared with the data of Frink (1996) for worldwide estuary sediments, and with that of Bogner et al. (1998) and Martincic et al. (1989) for the sediments in the Adriatic Sea. Very high levels of mercury were found in Vlora Bay (mean value of 0.92 mg kg^{-1} dry weight; Baraj et al., 1994), due to pollution by the former chlorine–alkali complex. High levels of Cd, Pb, Ni, Cr and some organic pollutants of anthropogenic origin were reported in

(a)

(b)

Fig. 6. River Shkumbini upstream of Elbasani (a) and passing the plane close to the industrial area of Elbasani (b) (May 2002, Photo: A. Miho).

Durresi Bay, and a high content of Cr was characteristic for most coastal sediments, particularly at the outlets of Shkumbini, Semani and Vjosa (Cullaj et al., 2000; Celo et al., 1999).

Within the ongoing SCOPES project, heavy metals (Pb, Cd, Cu, Zn, Mn, Fe, Cr, Ni, and Hg) were measured in water and algae (Cullaj et al., 2003) in 13 stations along the various rivers. So far, the results show low concentrations, according to the EC environmental standards (BMZ, 1995). However, the number of data is limited and final conclusions need a longer survey. It seems that the impact of heavy metals on the water quality of the rivers became negligible 15 years after mining activities ceased. Therefore, the UNEP (2000) map on the water quality in Albania (Fig. 1) needs some changes concerning an improved water quality of rivers Fani and Mati, as well as partially of Shkumbini.

Petroleum industry (extraction and refinement) continues to be a principal pollution source of the inland and the coastal waters for the rivers Gjanica, Semani and Vjosa. There are about 2000 petroleum pumping wells in the Patosi plain near Fieri in an area of 200 km^2. Their productivity decreased from 2000 t day^{-1} some decades ago down to 400 t day^{-1}. According to UNEP (2000), the region is highly contaminated. The wells contaminate the ground water, and the leaching from the pumping network pollutes the surface water. About 1–2% of the amount processed escapes into the environment. The Oil Refining Factory in Ballshi is as well giving off high quantities of hydrocarbons to the Gjanica River, as the wastewater treatment plant is not functioning properly.

Table 3
Selected parameters of water quality in Albanian rivers in their plain part (Fig. 1)

Stations	NH_4^+	NO_3^-	NO_2^-	TSS
Devolli (Kucova) (KMM, 1995–1996)	**0.05**	0.70	0.01	**330**
Drini (Shkodra) (KMM, 1995–1996)	–	0.85	0.005	3.5
Erzeni (Beshiri bridge) (KMM, 1995–1996)	0.04	0.35	0.01	10
Fani (Rubiku) (Cullaj et al., 2003)	**0.5/0.3**	3.9/2.5	0.01/0.02	17/**29**
Gjanica (Fieri) (Cullaj et al., 2003)	**1.1/2.2**	6.2/**41.3**	**0.24**/0.05	**237/116**
Gjanica (Fieri) (KMM, 1995–1996)	**0.555**	0.52	**0.35**	**30**
Ishmi (Fushe-Kruja) (Cullaj et al., 2003)	**9.5/5.0**	6.9/3.2	**1.38/0.40**	**62/128**
Ishmi (Ishmi) (KMM, 1995–1996)	**1.65**	1.4	**0.22**	**44**
Lana (Kashari) (Cullaj et al., 2003)	**10.5/42.0**	8.2/4.2	**0.40/0.37**	**123/140**
Lana (Tirana town, three stations) (KMM, 1995–1996)	**7.8–72.4**	4.0 – 12.8	–	–
Mati (Miloti) (Cullaj et al., 2003)	**0.2–0.6**	0.7–8.9	0.01–0.03	15–**41**
Mati (Miloti) (KMM, 1995–1996)	**0.084**	0.45	0.005	6
Osumi (Berati and Kucova) (Cullaj et al., 2003)	**0.2–1.6**	0.9–3.8	0.02–0.30	**35–280**
Osumi (Kucova) (KMM, 1995–1996)	**0.13**	0.5	**0.07**	**45**
Semani (Fieri) (Cullaj et al., 2003)	**0.9/0.2**	4.5/**31.1**	0.03/0.02	**436/55**
Semani (Fieri) (KMM, 1995–1996)	**0.05**	0.52	0.01	**36**
Shkumbini (Labinoti, Paperi, Rrogozhina) (Cullaj et al., 2003)	**0.2–1.0**	3.1–**204.6**	0.01–**0.2**	**31–328**
Shkumbini (Labinoti, Paperi, Rrogozhina) (KMM, 1995–1996)	**0.05–0.30**	0.7–1.2	0.01–**0.05**	**136–456**
Tirana (Brari) (Cullaj et al., 2003)	**0.7/0.9**	2.2/**26.3**	0.01/**0.36**	**50/54**
Tirana (Brari) (KMM, 1995–1996)	**0.14–3.35**	0.45–1.2	0.003–**0.31**	**35–60**
EC guide values after EC Desig: 78/659, dt. 18.07.78 (after BMZ, 1995)	**<0.04/<0.2**	**25**	**<0.01/<0.03**	**25**

Nitrogen is in mg N l^{-1}; –, no value available; TSS, total suspended solids, mg l^{-1}; bold numbers indicate values that exceed the EC regulations.
The ranges indicate minimal–maximal values; two numbers separated by a slash give the two values from May and November 2002, respectively; the values originating from the KMM report represent mean values, but do not specify the number of stations and the time period. The EC guide values for high quality fresh water correspond to Salmonid/Cyprinid waters, respectively.

4.4. Nonsustainable land use and erosion

Large investments were made in agriculture during the past 50 years, towards reclamation, irrigation and land fertilization. The extension of agriculture into mountain areas, aiming to get new cropland, demanded vast deforestations. The WB report (1997) confirmed that from 1950 to 1995, the naturally forested area in Albania decreased from 46% to 35%; moreover, the present forest area is overused and became substantially degraded. Such forest mismanagement gave rise to erosion, another increasing problem.

Erosion is not only favored by the mountainous relief and climate, but also by unfriendly human activities, like overuse of the catchment areas to obtain construction materials, woodcutting, overgrazing or firing (Fig. 8). The mean altitude of river basins ranges from 357 (Ishmi) to 1132 m a.s.l. (White Drini), which is typical for mountain rivers (Table 2). Suspended solids (TSS) often exceeded by severalfold the value of 50 mg l^{-1}, the third class limit on the quality of fresh water needing protection or improvement in order to support fish life given by the EC Directive 78/659 (BMZ, 1995). High rates of erosion in their watershed are found for the rivers Devolli, Gjanica, Ishmi, Lana, Osumi, Semani, Shkumbini and Tirana (Table 3; Fig. 9).

4.5. Loss of biodiversity

Despite admittedly scarce knowledge, Albania is considered to have a rich biodiversity (NEA, 1999). About 3200 species of vascular plants have been described, of which about 160 are only found in the region and more than 30 are recorded as endemic. According to altitude, vegetation grows up in well-expressed belts, like Mediterranean shrubs and forests, oak, beech, pastures and alpine meadows. A rich fauna is sheltered there, among mammals wolfs, brown bears, wild goats, and wild boars.

Aquatic biota contain more than 310 species of fish, six of them endemic, about 520 species of mollusks with 54 endemic, 15 amphibians and 37 reptiles. Along the coast and its wetlands, 46 echinoderms, 115 crustaceans, and more than 70 species of waterbirds have been determined. Furthermore, about 136 species of macroscopic algae and 440 diatoms, about 70% found on rocky substrates at the Ionian Riviera, have been counted. Marine grasses, *Posidonia oceanica* and *Cymodocea nodosa* inhabit the sandy substrate along the Adriatic coast, forming large submerged pastures (Kashta, 1986). More than 1200 species of diatoms were determined totally in Albanian fresh water (Miho, unpublished data), trans-boundary lakes included. Of this inventory 21 mammals, 17 birds, 5 reptiles, 27 fishes, and 17 insects are considered globally threatened (NEA, 1999).

The diversity of species and their habitats are continuously endangered by human impact, high rate of erosion, ongoing deforestation, and increasing pollution of water, air and soil. The intensive land reclamation during the former socialist regime (1945 to 1991) led to a decrease or even extinction of some of the most sensitive habitats, like

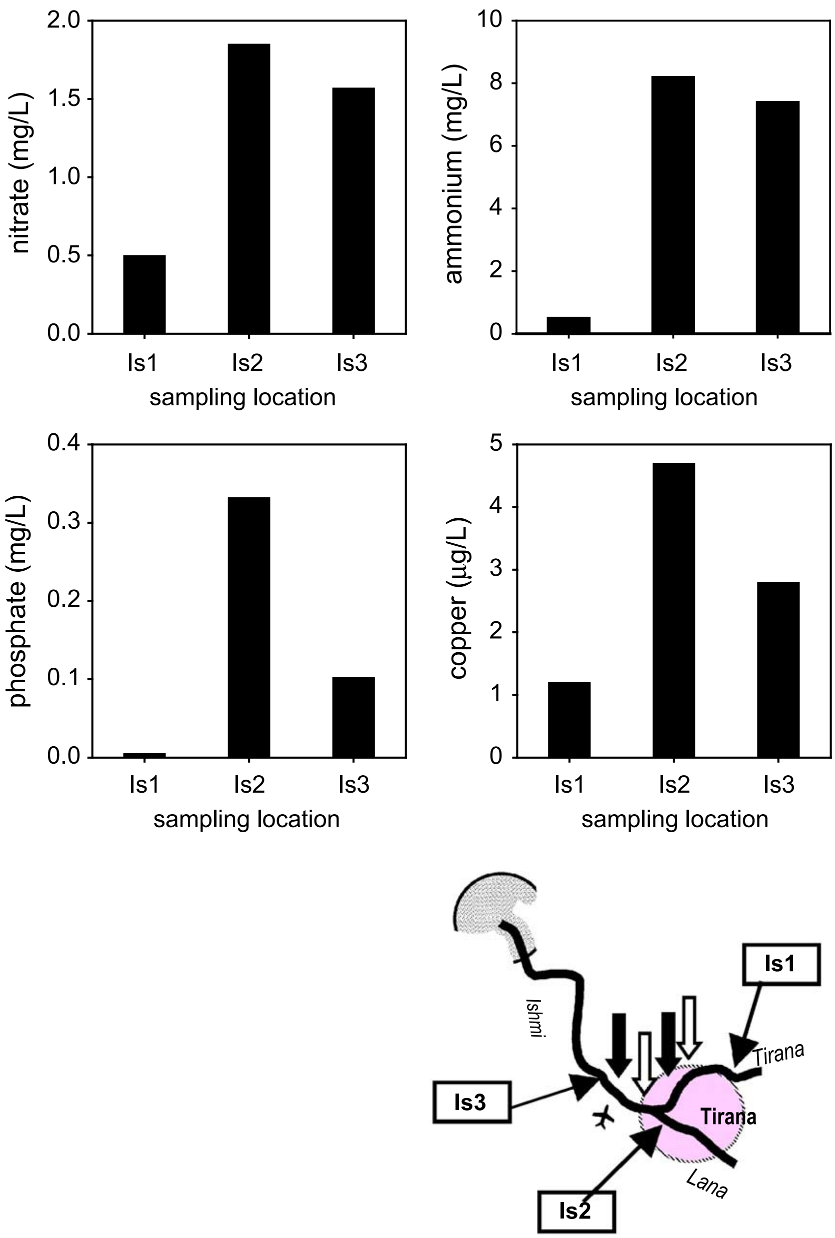

Fig. 7. Impact of urban wastewater on water quality of river Ishmi and its tributaries that cross through Tirana town. Is1 is located upstream of Tirana town, Is2 and Is3 downstream. Waste water discharge: black arrows = urban origin, open arrows = industrial origin (May 02).

coastal lagoons and other wetlands. Not even rare ecosystems of international value, like Micro Prespa and Lura lakes, were protected at that time. Illegal and uncontrolled hunting or fishing, overgrazing and uncontrolled trade of medical plants still continue and, thus, still endanger biodiversity.

4.6. Efforts to change the situation

Despite economical and social difficulties, efforts to face the environmental problems have been undertaken in Albania. In the new constitution, which has been approved in 1998, the preservation of a healthy environment is the basis for sustainable development. The Committee of Environmental Protection (KMM) was formed as a governmental body in 1991, transformed as National Environmental Agency (NEA/AKM) in 1998, and finally as Ministry of Environment in 2001. The National Action Plan on Environment was approved in 1993, where the monitoring of urban and industrial waters, application of standards, measures to prevent erosion, and restoration of existing 'hot spots' were stated as priority. The Law on Environmental Protection, approved in 1993 and amended in 1998, covers the full spectrum of environmental policy. Based on this Law, the Report on Environmental State was published (KMM, 1995–1996; AKM/NEA, 1997–1998, see also www.grida.no./enrin/htmls/albania/soe/htmls/). The National Strategy and Action Plan of Biodiversity (NEA,

Fig. 8. River Mati near Laci (a), and Bushkashi River (Mati tributary near Burreli, (b) (May 2002, Photo: A. Miho).

1999) was approved in 2000, prepared by a group of experts under the responsibility of NEA. Since 1991, Albania is a party of more than 13 international conventions and agreements dealing with environmental issues. Due to the problems dictated by the low economic level, even the application of existing legislation is often lacking, because of inexperience, low awareness or scarce staff of governmental bodies.

Fig. 9. River Zallbastari (near Tirana), a tributary of river Ishmi. The slopes of mountains and hills show highly eroded areas (September 2002, Photo: A. Miho).

5. Conclusions

In Albania the increasing need for water for drinking, irrigation, aquaculture, hydroelectric power production and tourism requires a greater awareness and a necessity for a strong country-wide control of water quality, as well as a better management of the resources. As industrial production decreased since 1991, municipal wastes became dominant as sources of water pollution. Due to the recent population migration from the mountain regions to the western lowland, mainly to Tirana and Durresi, and the increased and uncontrolled discharge of domestic wastewater, the contamination of surface waters along the Adriatic plain became highly critical.

As sewage treatment plants in large urban centers are lacking, the untreated sewage is discharged directly from the sewer networks into rivers, lakes and finally into the sea. Urban solid wastes are dumped in uncontrolled and unlined areas, often located close to rivers, lakes or seashore. The leaching wastewater from disposal sites is a major source of pollution. In rural areas, waste is not collected at all and dumped uncontrolled. Solid hazardous wastes from mines and industrial plants were disposed earlier in open landfills without stabilization, often close to the rivers. As a result, toxic compounds are continuously leached. The present state of water pollution in Albania is a real risk for the economy and human health. Implementation of wastewater treatment and waste disposal management should be of highest priority for the Albanian government. This holds especially for the cities Tirana and Durresi with the rivers Lana, Tirana, Ishmi (Tirana region), Gjanica (Fieri) that cross these regions.

High values of suspended matter in the rivers are indicative for the high rate of soil erosion, a consequence of the large deforestations in the watershed areas in the upper part of the rivers Shkumbini, Terkuza, Osumi and Gjanica. This leads to massive depositions of solid material in the coastal areas, especially in the coastal lagoons, resulting also in unfavorable conditions for life in rivers, lagoons and marine coast, but also for the related economic activities, such as agriculture, fishing and tourism. Deforestation and agricultural overproduction in watershed areas must be stopped, as they are the main causes of erosion. Reforestation activities, sustainable land use supported by the government, and restoration and protection of the watershed areas are of high priority. This holds especially for the oak belt between 600 and 1000 m above sea level, which is the most overused part of the country with a scarce vegetation cover.

All these demand systematic control and periodical quality monitoring of surface and subterranean waters, as well as of wastewater. Existing data and their interpretation must be available to the public. Additionally, research programs have to be initiated to evaluate the fate of heavy metals in surface waters, their transport behavior during rainfall, and their eco-toxicological impacts. As frequent sampling is often not possible at remote sites, heavy metal accumulation in the biomass of algae and higher aquatic plants may give an estimate of the ecological pressure on aquatic systems. Biodiversity and population structure of the periphyton will give additional information.

Systematic monitoring programs are urgently needed to understand the present environmental state of the Albanian rivers to characterize the main and most important sources of pollution and to set the basis for political guidelines to improve the ecological situation. All institutions concerned with water should form a collaborative network, and only a full exchange of the results between research institutes and governmental agencies will guarantee success. The new knowledge obtained should be published to have a basis for future developments as a consequence of the restoration measures. Due to monetary reasons, Albania will not be able to solve all of the aquatic pollution problems at once. A step-by-step procedure will be necessary, starting with the most efficient measures first. However, this asks for a careful scientific preparation based on data of monitoring programs, which must be done within the next few years.

In summary, Albania is in a lucky situation to have so many water resources, but the responsibility to protect and use them properly must be taken most seriously. Taking the appropriate measures in important and sensitive watershed areas will help to prevent further damage to biodiversity and humans, and finally will aid to regain its original beauty. The Albanian territory is important for water supply to the Eastern Adriatic coast. A sustainable watershed management guarantees the fulfillment of these tasks on regional and international levels.

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