The environmental state of important aquatic habitats in Albania based on algal assessment - a review

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Abstract

Albania is rich in aquatic resources with high natural and biological values. Nevertheless, the waters still continue to be endangered, especially in western Adriatic Lowland areas. The structure of microscopic algae may give a better idea of water quality than traditional indicators. Systematic control of water quality will help to develop new strategies of wastewater management. It will allow Albania to reach international standards in environmental protection.

Keywords: Albanian waters, microscopic algae, biomonitoring, eutrophication, trophic index, saprobic index.

Introduction

Albania possesses many water resources with high natural and biological values, i.e. the Ohrid, Prespa and Shkodra lakes, glacial lakes, river valleys, coastal lagoons, etc. An overview of aquatic ecosystems and the related human impact is given by Cullaj *et al.* (2005) and by UNEP (2000). The water resources still continue to be endangered, especially the in western Adriatic Lowland areas through which most of the rivers run, and where the most densely inhabited and industrial areas lie, together with the areas most affected by intense agriculture and tourism.

The microscopic structure of periphyton or phytoplankton may give a better idea of water quality than the traditional chemical approach. The biological communities summarize the response of the biota to a range of pollutants occurring in waters over time (Sládeãek, 1986; Hofmann, 1994; Rott *et al.*, 1997; 1999; Passy and Bode, 2004).

After the 1990s, Albanian experts started to consider biological data as an important tool to evaluate the quality of waters, in rivers (Cake 1996; Miho *et al.*, 2005a and b; Kupe, 2006), lakes (Miho and Lange-Bertalot, 2001; 2003; Rakaj, 2002) and lagoons (Miho, 1994; Miho and Mitrushi, 1999; Dedej, 2006). A review of the most important aspects of these studies is reported here, focusing on the water quality of the related habitats, also highlighting diatom-based monitoring as a new experience in Albania.

Materials and methods

The biological studies of water quality cover almost the most representative habitats, as shown in the map in figure 1. They started with the study of macrophyte algae along the coast by Kashta (1986). The phytoplankton of Butrinti lagoon was studied during the period 1987-1991 (Miho, 1994); net and/or bottle samples in

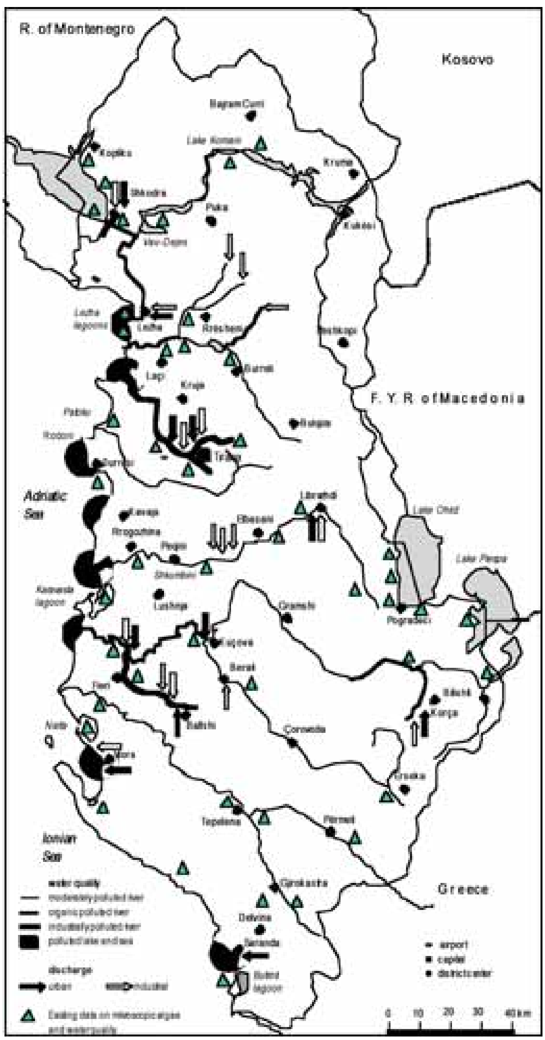

Figure 1 - Hydrological map of Albania showing pollution sources as described by UNEP (2000), modified by Miho et al. (2005b). The aquatic habitats for which data on microscopic algae and water quality are available are shown with a triangle.

six stations in the lagoon and the sea were examined. Other sporadic studies continued along the coast (Miho and Mitrushi, 1999; Dedej, 2006), covering the period 1987-2005, and almost all the important lagoons, including Butrinti, Narta, Lezha (Ceka and Merxhani) and Karavasta. Meanwhile, other studies in lagoons still continue (Miho and Xhulaj, 2005).

During sporadic campaigns in the period 1993-2000, littoral benthic and plankton samples were evaluated in the Albanian part of the cross-border lakes of Ohrid (Driloni, Tushemishti, Pogradeci, Guri-Kuq, Lini) and Prespa (Macro and Micro Prespas) (Miho and Lange-Bertalot, 2003). In July 1993, net samples were collected from 15 glacial lakes of Lura, Ballgjaj and Dhoksi, situated in the mountainous central part of Albania (over 1500-1700 m a.s.l.). Rakaj (2002) reports data on the phytoplankton of Lake Shkodra (Albanian part). Net plankton samples were collected in 8 stations (Zogaj, Shirokë, Peshkimi, Bishti-Qenisë, Grizhë, Stërbeq, Kamicë, Shegan), during the period 1997-99. The fish of the River Shkumbini were studied by Cake (1996), in the period 1988-93. In addition, the digestive apparatus of barbells (*Barbus meridionalis*) was used to evaluate the diatoms and trophic level of different stretches of the river (Miho *et al.*, 2005a). The first attempt to extend biomonitoring in Albania to assess water quality based on benthic diatoms was carried out during the period May 2002 - March 2004 (Miho *et al.*, 2005b; Kupe, 2006). Seven trips, in 13 stations in the most impacted rivers of the Adriatic Lowlands: the Mati (Shkopeti, Miloti), with its tributary Fani (Rubiku); the Ishmi (Fushe-Kruja), with its tributaries Tirana (Brari) and Lana (Kashari); the Shkumbini (Labinoti, Paperi, Rrogozhina); the Semani (Mbrostari) with its tributary Gjanica (Fieri); and the Osumi (Berati, Ura-Vajgurore). It involved cooperation of the sections of Analytical Chemistry and Botany of Tirana University, and the Department of Agronomy, Tirana

Agricultural University, under the qualified assistance of experts from the Institute of Plant Biology, Institute of Environmental Sciences and the Limnological Station, University of Zurich, supported by the Swiss National Foundation for Research, within the joint project called SCOPES: Scientific Co-operation between Eastern Europe and Switzerland.

The study, performed through the SCOPES Program, was intended firstly to assess heavy metals (Pb, Cd, Cu, Zn, Mn, Fe, Cr, Ni and Hg) in waters, sediments and algae from the most impacted rivers of the Adriatic Lowlands. Additional parameters were measured, including conductivity, dissolved matter, pH, temperature, oxygen, suspended solids, nitrates, nitrites, ammonium and phosphates. Moreover, microscopic algae (diatoms - *Bacillariophyta*) were examined, and the trophic state and saprobic state were calculated. More information is given in Cullaj *et al.* (2003; 2005), Miho *et al.* (2005b; 2006), Miho and Kupe (2005), Kupe (2006) and on the website of the Faculty of Natural Sciences, UT: www.fshn.edu.al.

Generally, the periphyton was sampled often by scrubbing the top surface of selected rocks, or collection of thalli of *Cladophora*, or other submersed biota. Samples were often preserved in 4% formaldehyde or in Lugol. Diatom frustules were cleaned from organic and inorganic materials by boiling in HClcc, followed by boiling in H_2SO_4cc, adding a few crystals of KNO_3. Permanent slides were prepared using Naphrax as a medium. In a diatom-based approach, more than 400 valves were counted. Identification of diatoms, as well other steps, were based mainly on Krammer and Lange-Bertalot (1986-2001). The trophic diatom index (TI_{DIA}) and saprobic index (SI) for the diatoms were calculated using the formula of Zelinka and Marvan (1961). Trophic classes were based on Rott *et al.*, 1997; 1999). Often the diversity index of Shannon and Weaver (1949) was also calculated.

Results and discussions

Studies on Albanian algae started only after the 1990s, by the working groups in Tirana University and other universities (Shkodra, Elbasani) or research institutions.

The most complete study of macrophyte algae along the coast was carried out by Kashta (1986), which is also a taxonomic and ecological work. About 136 species were described along the coast and its wetlands, where species from *Rhodophyta* were dominant. About 70% of species were found on rocky substrates, most of them on the Ionian coast, including 8 species of Cystoseira, as well as *Padina pavonica, Acetabularia acetabulum, Laurenzia obtusa, Corallina elongata, Haliomeda tune, Cladophora proliphera*, etc. The sandy substrate of the infra-littoral, mainly along the Adriatic, was inhabited by the seagrasses, *Posidonia oceanica* and *Cymodocea nodosa*, together with *Caulerpa proliphera*, *Bangia fuscopurpurea, Nemalion heminthoides, Porphyra leucosticte*, etc. In a recent study of the distribution of *Posidonia oceanica* along the Albanian coast, Kashta *et al.* (2005) confirm that habitats of this sensitive seagrass (endemic to the Mediterranean Sea) are seriously disturbed along the Adriatic. It is almost absent from Velipoja to Rodoni Promontory, and from Durresi to Vlora, probably as a consequence of the impact from the Buna, Drini, Mati and Ishmi rivers, in the former stretch, and the Semani and Vjosa rivers, in the latter. In those zones, *Posidonia* seems to be substituted by the other marine grass, *Cymodocea nodosa*, considered less tolerant of ecological factors and substrate, but which never grows in dense meadows.

Nevertheless, the Albanian coast still conserves interesting and important wetlands, characterized by a high diversity of microscopic algae. About 440 taxa of diatoms were already known in different coastal habitats, where Butrinti, Armura, Karavasta, Lalzi and Merxhani are particularly important (Miho and Witkowski, 2005; Dedej, 2006). Butrinti (Fig. 2) contains typically meromictic habitats; therefore, phytobenthos only grows intensively in limited areas of the shorelines, dominated by *Enteromorpha* prolifera (Miho, 1994). The rest of the bottom is anaerobic, characterized by strong sedimentation of organisms in decomposition. According to Miho (1994), the phytoplankton of the upper layers (up to 5-7 m of depth) is the main primary producer. However, this is dominated (often more than 90%) by one or two species of centrics: *Ch. cf. wighamii* and *Cyclotella cf. choctawhatcheeana*. The phytoplankton showed seasonal dynamics, with a high peak in spring and another lower one in autumn. The decrease in phytoplankton in summer was accompanied by a relative increase of peridinieae. During April-June 1987, an abnormal bloom was observed: *Pseudonitzschia seriata* followed by *Prorocentrum micans* and *P. minimum*, the last one mentioned as toxic.

In the period 1992-93, about 75 species of diatoms were found in the Orikumi wetland, where pennatae dominate (Dedej, 2006). Here too, centrics of *Chaetoceros* and *Cyclotella* were abundant, with a similar structure as in Butrinti, but with lower quantity; peridinieae increased during summer, too. Miho and Mitrushi (1999), in July 1996 observed relatively high diversity of microscopic algae in Merxhani lagoon (Lezha). In Ceka, an algal bloom was observed, dominated by *Nitzschia reversa*, *Peridinium spp., Goniaulax monacantha* and

Figure 2 - View of Butrinti lagoon (Saranda) (Photo: L. Shuka)

Prorocentrum minimum. In Kenalla, a relatively deep pond, close to the shallow lagoon of Merxhani, a centric diatom, *Chaetoceros muelleri* was found to be very abundant. There were also abundant filamentous colonies of blue-green algae, i.e. *Anabaenopsis circularis*, Oscillatoria sp. and a small peridinieae, Gimnodinium sp. Other preliminary examinations were also carried out in other Albanian wetlands, i.e. Karavasta, Patoku, Viluni, Butrinti, Armura, Saranda and Durresi harbours; more detailed discussion from the ecological point of view is given in Dedej (2006). High species diversity was observed in Armura, Butrinti and Karavasta. In November 2004, blooming of filamentous cyanobacteria were observed in Narta lagoon, close to the wastewater discharge from Narta village (Miho and Xhulaj, 2005).

Rakaj (2002) gives data on the phytoplankton of Shkodra Lake (Albanian part) (Fig. 3). About 468 species of microscopic algae were reported, the areas of Kamica and Shegani (Kopliku) having the highest diversity. Generally, the phytoplankton was dominated by oligo-mesotraphentic species, i.e. *Cyclotella ocellata, Asterionella formosa, Fragilaria capucina,* etc, often accompanied by tolerant or eutraphentic species, such as *Fragilaria ulna, F. construens, Gyomphonema acuminata, Navicula capitatoradiata, N. reichardtiana var. crassa, N. trivialis, N. cryptotenella, N. menisculus var. grunowii, Nitzschia*

Figure 3 - Sunset in Shiroka, Shkodra Lake. (Photo: L. Shuka)

recta, etc. The density of eutraphentic species increases during summer, as seen in the Buna outflow and along the western shoreline of the lake (Shiroka and Zogaj).

More than 430 species diatoms were found in 15 glacial lakes of Lura, Ballgjaj and Dhoksi, where more than 100 belong to the red list of Europe (Miho and Lange-Bertalot, 2001). The most common species were *Cyclotella cyclopuncta, Achnanthes minutissima gr., Cymbella sylesiaca, C. cesatii, C. microcephala fo. minores, Fragilaria construens, F. nanana, Nitzschia denticula* etc. The Lura lakes represent rare habitats, where Lake Flowers can be distinguished; about 200 species of diatoms were found in one sample only. They are mostly oligotraphentic species, dominated by *A. minutissima* (fo. *gracillima*) and *C. cesatii*, characteristic of very clean waters with scarce nutrients. Allamani Lake can be also considered interesting in that it contains rare and even new species. New species for science have already been described by Miho and Krammer and Miho and Lange-Bertalot, including *Cymbella (Cymbopleura) albanica, C. lura, C. lata var. lura, Navicula pseudoppugnata* (Lange-Bertalot, 2001; Krammer, 2003). Still others are of taxonomic interest, too, e.g. *Geissleria sp., Sellaphora sp.,* etc. Lake Black in the Dhoksi region is distinguished not only by its interesting floristic values but also by its special and attractive drainage basin.

Microscopic algae are also interesting in Lake Ohrid. More than 350 diatoms were found in littoral samples in the Albanian part of Lake Ohrid (Miho and Lange-Bertalot, 2003). About 1/4 of taxa are rare or endemic. More than 15 taxa are considered interesting or new for science. Six of them, *Aneumastus albanicus, A. rosettae, A. humboltianus, Navicula pseudoppugnata, N. parahasta and N. hastatula*, were described by Lange-Bertalot and Miho as new taxa (Lange-Bertalot, 2001). Miho and Lange-Bertalot (2005), in a recent publication related to the diversity of the genus Placoneis in Lake Ohrid, describe two additional new species: *Placoneis juriljii* and *Placoneis neoexigua.*

Most of the species observed in Ohrid were oligotraphentic, growing only in clean waters with quite low nutrients. However, in littoral habitats, especially nearby Pogradeci town, tolerant species that dominate in eutrophic waters were observed. Some poly-hypertrophic species of diatoms and high presence of *Cyanophytes* were also observed in plankton samples. The trophic diatom index varied from 1.5 to 2.5, changing from oligo-mesotrophic to eutrophic, showing worse water quality near the shore than in the deeper waters. The worst state was in Driloni, a sensitive spring wetland, where the trophic value was very high (2.5, eutrophic), probably caused by the high nutrient loading from urban settlements and agriculture (Miho and Lange-Bertalot, 2003).

Cake (1996) evaluates the distribution of fish along the Shkumbini River; about 17 fish species were reported, *Cyprinids* being dominant. The upper and middle mountainous flow was richer, mainly with *Alburnus bipunctatus, Barbus meridionalis* and *Nemachilus barbatulus ssp. sturanyi.* Barbell (*B. meridionalis ssp. peteny*) and mountain trout (*Salmo trutta ssp. macrostigma*) were found only in the upper part, showing a good natural state. Fish were scarce downstream of Elbasani Town; before 1992, especially in nearby Paperi, fish were almost absent, due to waste discharge from the industrial complex in Elbasani plain; a slight increase in fish species was observed after summer 1992, the period when the steelworks was closed. During this study, the digestive apparatus of barbells (*Barbus meridionalis*) from different parts of the Shkumbini (Fig. 4) was studied to assess the diatoms. Miho et al. (2005a) report more than 95 species of diatoms (mainly pennatae), mostly of benthic origin. The most common and abundant species were: *Diatoma moniliformis* (up to 84%: Paperi and Proptishti), *Achnanthes minutissima, Fragilaria capucina, Fragilaria ulna*, etc. TIDIA varied from 1.6 (mesotrophic) to 3.4 (polytrophic). High trophic values were found

Figure 4 - Shkumbini River in Labinot - Fushe (Elbasani) (Photo: L. Shuka)

in the plain part of the river (Paperi and Peqini), showing heavy inorganic pollution, probably caused by Elbasani town and its industrial activities; the lowest values were found in the upstream parts: Labinot-Fushe and Proptishti.

Except for *Cladophora glomerata*, macroscopic algae were not usually found along the rivers in the coastal lowlands. This might be due to the increased turbidity with high content of solid matter and, in some cases, even the high organic pollution, e.g. in the Ishmi, Lana, Gjanica and Osumi rivers. The SCOPES study showed that metal accumulation by macroscopic algae is not a suitable tool to measure the annual fluctuations of heavy metals in the rivers of the region (*Miho et al.*, 2005b; 2006; Kupe, 2006). However, the quantity of heavy metals in the water and the biota was unexpectedly low; therefore, their effect on water quality seems to be negligible today, as a consequence of the closure of the mining industry.

More than 250 species of diatoms were found in periphyton samples, of which only 15 were centrics (Miho *et al.*, 2005b; Kupe, 2006). *Achnanthes minutissima, Amphora pediculus, Cocconeis pediculus, Diatoma moniliformis, Fragilaria capucina, Gomphonema tergestinum* and *Nitzschia dissipata* dominated in the Mati (all stations), in upstream stretches of the Tirana, Shumbini and Osumi; a relatively high number of species and high diversity were found too. In the Lana, Ishmi and Gjanica rivers, the diatom structure was dominated by saprotrophic or tolerant species, such as *Nitzschia palea, N. incospicua, Gomphonema parvulum, G. olivaceum, Navicula accomoda, N. veneta* and *N. saprophila.* The diversity index was mainly between 2.5 and 3.5; it was higher (more than 3.5) in the Shkumbini (mainly in Paperi and Rrogozhina), as well as in the Osumi and Semani. In the Semani (Mbrostar) the diversity index reached 4.53 (May 02) and in Shkumbini (Paperi) it reached 4.30. The lowest diversity values were found at Lana and Ishmi stations (as low as 0.32). Most of the species were common and not taxonomically interesting; nevertheless, *Caloneis* sp., probably a new species, was often found in the less polluted parts of the rivers, as an epiphyte on *Chadophora*.

Miho *et al.* (2005b) report that the TIDIA varied from 1.6 (mesotrophic,) in the Mati to 3.4 (polytrophic), in the Ishmi, Lana and Gjanica. High values were observed in the Lana and Ishmi, and in downstream parts of the Shkumbini (from Elbasani to Rrogozhina) and the Gjanica; it showed strong inorganic pollution of urban origin, from the discharge of untreated wastewaters from the towns of Tirana, Elbasani and Fieri. Compared with the TIDIA values calculated by Miho and Cake (2005) for the Shkumbini river, it seems that pollution from inorganic nutrients (nitrogen and phosphorus) is unchanged today. In mountainous parts, the rivers can be considered only slightly polluted, as observed in Bushkashi (1.4, oligo-mesotrophic). The mean SI values oscillate from 1.7 (oligo- to beta-mesosaprobic), in the Mati, to 2.8 (alfa-mesosaprobic), in the Ishmi. The Lana and Ishmi rivers always have high saprobic values, also showing high organic pollution.

Not only in the Lana and Ishmi rivers (Tirana region) and the Gjanica (Fieri), but also in the Mati, downstream stretches of the Shkumbini (Elbasani, Rrogozhina) and the Osumi (Berati), nutrients were higher than the EC guideline quality values for fresh waters for Cyprinid waters (EC Directive 78/659: BMZ, 1995): nitrite and ammonium values reached 4.047 mg NO_2/l in the Lana (November 03), 42.05 mg NH_4/l in the Lana (November 02). Furthermore, the O_2 values were below the BE limits in those rivers, too (Miho *et al.*, 2005b). Correlations performed with SigmaPlot 8.0, considering the mean TI_{DIA} values and the mean values for phosphates, nitrites, nitrates and ammonium, show a hyperbolic trend, with a saturated level, characteristic in relations of nutrient level to biota (Kupe, 2006). This means that there is a certain critical value where the trophic index reaches the maximum. To decrease the trophic values, hence decrease the pollution, the level of nutrients must be below the critical value. There is also a linear positive correlation between the two trophic indexes, TI_{DIA} and SI (99.9%).

The high content of suspended solids in the waters was a striking aspect observed during the monitoring of rivers in the Adriatic Lowlands (Miho *et al.*, 2005b). Except for the Mati, suspended solids often exceeded by many times the value of 25 mg/l, established by EC Directive 78/659 for the third class limit on the quality of fresh water needing protection or improvement in order to support fish life (BMZ, 1995). It was observed not only during the wet season in autumn, but also in late spring at low water level. It highlights the high rate of soil erosion, caused probably by the large deforestation in the respective drainage basins; it leads to massive deposition of solid material in the coastal areas, especially in the coastal lagoons. It also results in unfavourable conditions for aquatic life in rivers and on the marine coast, as mentioned previously for *Posidonia* (Kashta *et al.*, 2005). Related activities, such as agriculture, fishing and tourism are also seriously disturbed, with economic consequences.

In the period 1993-2004, sporadic periphyton samples were examined, collected in the Vjosa (Kelcyra, fig. 5, and Mifoli), Shalsi (Germenj, a Vjosa tributary), Devolli

(Zvezda), Tirana (Brari), and Shkumbini (Librazhdi) rivers, and in the springs of Kelcyra, Ujit të Ftohtë (Tepelena), Syri i Kaltër (Bistrica), Shalsi (Gërmenj), Sotira (Gjirokastra) and Borshi (Saranda). About 96 species of diatoms were found in these rivers and springs (Kupe, 2006). The TI_{DIA} oscillated from 2.51 (Shalsi-Germenj) to 3.29 (Kelcyra), the lowest value being observed in Novosela (1.9). The trophic state in these habitats varies form oligo-mesotrophic (Novosela) to mesotrophic in Germenj and Kelcyra (Kupe, 2006). The most common species found in those rivers were: *Achnanthes minutissima* (up to 40.5% in Germenj), *Diatoma moniliformis, Fragilaria biceps, Cocconeis placentula, Gomphonema tergestinum*. The most abundant species in the springs were: *Achnanthes minutissima*, *Cocconeis placentula, Diatoma moniliformis, D. mesodon, Fragilaria ulna,* etc. *A. minutissima* reached up to 92.9% of the diatom community in all stations, followed by *F. ulna* and *D. moniliformis* (up to 78.6%). The TI_{DIA} in the springs oscillates from mesotrophic to polytrophic (Syri i Kaltër). The SI oscillates from 1.4 (Borshi) to 2.1 (Devollin, Erseke and Kelcyra), from oligo-beta-meso-

Figure 5 - The spring of Ujit të Fhohtë in Keleyra (Përmeti) and Vjosa River

saprobic to alfa-beta-mesosaprobic. Low SI values and high TI_{DIA} values show that the waters suffer from serious inorganic pollution.
There is currently increasing demand for water for drinking, irrigation, aquaculture, hydro-electric power production and tourism in Albania. Therefore, a greater awareness and control of water quality is strongly needed, accompanied by better management and protection of the water resources. After 1990, the industrial impact was reduced, and municipal waste waters became the dominant source of water pollution. In the Western Lowlands (mainly close to Tirana and Durresi), the increased and uncontrolled discharge of domestic wastewater, and of solid waste as well, visible to the naked eye, continuously contaminate the waters of rivers, lagoons and the sea. It is a real risk for the economy and human health, as well. Wastewater treatment and waste disposal management should be of the highest priority. Reforestation activities and sustainable land use of the watershed areas must also be of high priority. The restoration of the rivers of Lana, Tirana and Ishmi would surely decrease the health risks for about 1 million inhabitants. The altered regions will benefit and regain their original beauty, too. Monitoring programs may help to understand better the present environmental state, characterize the main and most dangerous sources of pollution, and set up the basis for policy guidelines to improve the ecological situation; study of the aquatic biodiversity may also provide useful information. Albania is an important supplier of water into the Adriatic and Ionian seas; therefore, sustainable watershed management would guarantee the fulfilment of the obligations stipulated by regional and international agreements and programs.

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