1

ENVIRONMENTAL ANALYSES OF BOVILLA WATERSHED (ALBANIA) – AN OVERVIEW

ANALIZË MJEDISORE E PELLGUT UJËMBLEDHËS TË BOVILLËS (SHQIPËRI) – NJË PËRMBLEDHJE

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Abstract

The Bovilla Reservoir is one of the largest hydro-technical constructions in Albania, built to deliver sufficient drinking water to the capital Tirana. Since 1999 water is transferred continuously from the Reservoir to the newly built Treatment Plant. The catchment area is mountainous and belongs to the upper part of the Terkuza River. The vegetation forms distinct vertical belts dominated either by Mediterranean evergreen shrubs, oak trees, beech and pine forests. Eight villages are located in the catchment area on steep slopes, a few are close to the lakeshore. Livestock farming, traditional agriculture and forestry are the principal activities of the local inhabitants. Besides, some income is generated from the trade of medical plants. The water quality of the Reservoir is directly related to the state of the catchment and the human activities within. Intense erosion due to large deforestations followed by increasing nutrient run-off from cultivated land has led to eutrophication of the aquatic system. Additionally, the river Terkuza is continuously filled with gravel which is subsequently deposited in the Bovilla Reservoir. Up to now, no substantial measures have been taken for the proper management of the catchment area and for the protection of the drinking water quality. As a consequence, a continuous monitoring of the Bovilla Reservoir and its surrounding catchment area in addition to a new watershed management strategy is urgently needed. Moreover, keeping the Reservoir in a natural state will prevent costly water treatment measures and guarantee Tirana town the access to drinking water of high quality.

Keywords: Bovilla catchment, vegetation cover, erosion, drinking water quality

1.1. Foreword

The first biological approach in Bovilla Reservoir was carried on before its waters were used for human consumption; preliminary assesment of the phytoplankton (*see* Koni *et al., this volume*) and the zooplankton (*see* Shumka & Nikleka, *this volume*) was carried on in September 1998. But our interest in the Bovilla Reservoir was a response to the overall concerns related taste-and-odor outbreaks in drinking water, detected first in September 2001; additional assessment of phytoplankton was carried at that time in cooperation with Water Treatment Plant, Tirana. The region was also visited and a Round Table was organized in Tirana, in 27 September 2002, with interested representatives from Tirana and from the region, facilitated from the Albanian NGO – Preservation and Protection of Natural Environment in Albania (PPNEA); moreover a special issue of the PPNEA journal 'Ne dhe Mjedisi' was dedicated to Bovilla (Bozo, 2002; Miho, 2002; Emiri, 2002; Kodra, 2002; Murati, 2002). The ideas of the present study were presented previously by Macchia & Miho (2002) in the 5th CEI Summit Economic Forum ... Investing in European co-operation, 13-15 November 2002, Skopje, Macedonia.

Environmental analyzes of the Bovilla Reservoir and its watershed will be discussed in an overview of the integrated study on Bovilla watershed, carried out during the years 2005 to 2008 within the joint research project SCOPES 2005-2008 (nr. IB7320-111032). The purpose of the present book is to present the complete data, aiming to collect sufficient baseline quality data which allow to determine the current limnological state of the Reservoir and to provide a first quantitative basis for the future water quality protection and monitoring.

The Bovilla Reservoir is the main drinking water supply of the Tirana region including a population of about 850'000 inhabitants. Detailed discussions are developed by different working groups, on the chemistry, on the phytoplankton, on the zooplankton, and on the microbiology of the lake water. Other papers deal with the trophic state of the lake, with the particle composition in the water, with the odor problems, the benthic diatoms in aquatic habitats in the surrounding watershed, about the present Tirana drinking water treatment and quality. As comparison and reference the drinking water supply of the town of Zurich (Switzerland) is described. Since most of these texts are in Albanian, an overview in English is given at the beginning to facilitate the understanding for the non Albanian readers.

1.2. Geographical description of Bovilla watershed

The Bovilla watershed extends in northeast of Tirana (Fig. 1-1), between 41^{o}30' N and 41^{o}15' S, and 19^{o}50' W and 20^{o}05' E. The territory belongs to two municipalities, Zall Bastari (Tirana district) with an area of 52.2 km^{2} and

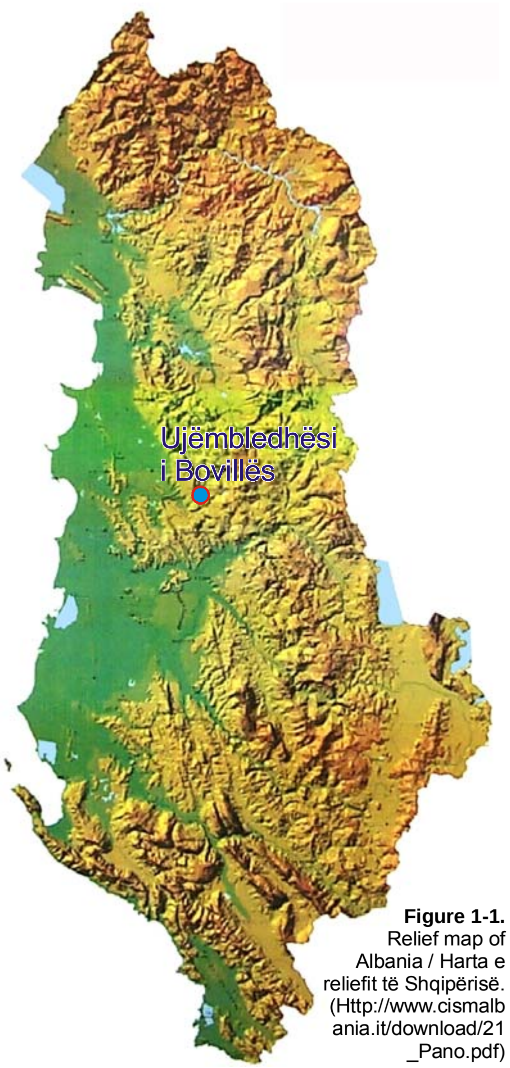


Figure 1-1. Relief map of Albania / Harta e reliefit të Shqipërisë. (Http://www.cismalbania.it/download/21_Pano.pdf)

Culli (Kruja district), with only three villages (Fig. 1-2; *see* also Tab. 12-8 and Fig. 12-16 in Mersinllari *et al.,* Nr. 12 *this volume*). The road network is not well developed. Only few gravelled roads cross the territory. Besides the main road that links the two municipalities, there are only footpaths which are not suitable for cars.

The region can be reached through different roads; the dam is ca. 15 km far from Tirana, through Zall Herri village; from there it is possible to reach the villages of Kruja district, Rranza, Culli and also Qafeshtama. This part can be reached also from Kruja town (Fig. 1-2). The most important part of the region is Zall Bastari, ca. 20 km far from Tirana, which can be reached through Tujani pass, along Tirana river valley; from there different villages can be visited, like Bastari, Mneri, Vileza, etc. Another gravel road continue from Tirana to Murriza pass (1'500-1'800 m a.s.l.), behind Dajti Mountain, where the most eastern mountainous part (Mali me Gropa) can be visited.

The geologic formations in the watershed belong mainly to flyshes (clayey, sandy, alevrolithes). Limestones of Cretaceous II build up the lateral frames (Kabo, 1990-91), mainly the high relief of the mountain chains of Kruja-Dajti and Skenderbeu-Mali me Gropa. Only the formations in the higher parts seem to be resistant to the erosion. The lower part is hilly, built up of flysh cliffs, frequent with eroded slopes, especially around the Mneri village (Fig. 1-2).

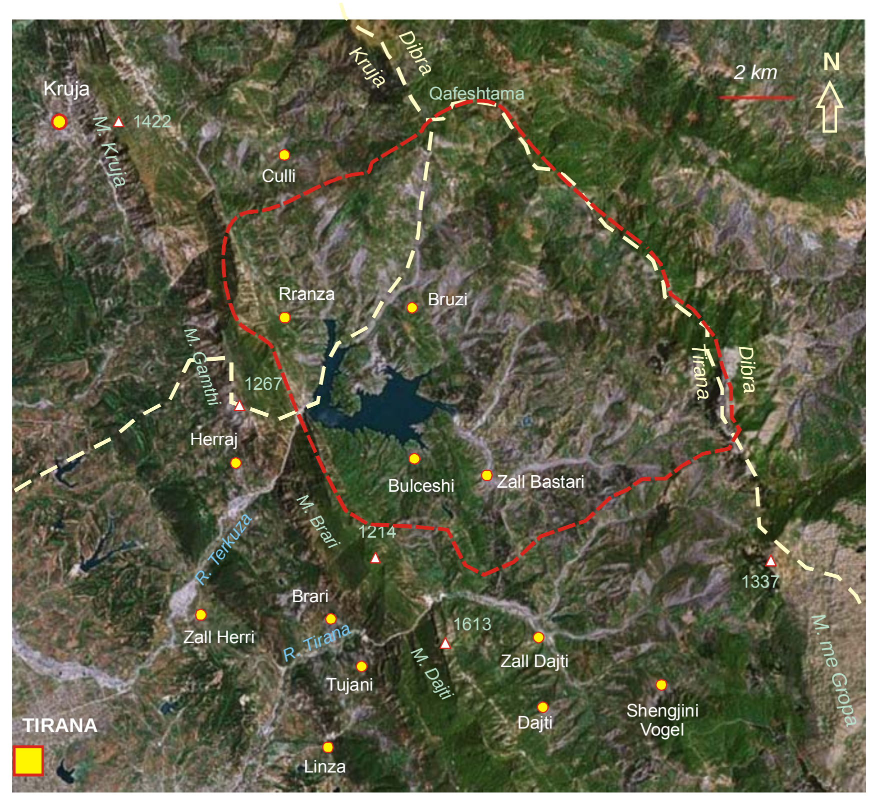


Figure 1-2. Satellite view of the Bovilla region, with the main administrative (*white*) and watershed (*red*) boundaries. / Pamje satelitore e rajonit të Bovillës me kufijtë kryesorë administrativë dhe të Qarqeve (bardhë) dhe të pellgut ujëmbledhës (kuq) (Image © Terremetrics, Europe Technologies and Digital Globe, Google Earth 2008).

The Bovilla catchments belongs to the subhilly Mediterranean climate, where two climate sub-zones are distinguished mainly: **hilly Mediterranean** (up to 700-800 m a.s.l.) and **pre-mountainous Mediterranean** (in higher altitudes). The **mountainous Mediterranean** climate is present only in higher peaks, too (Figs. 1-16). The zone is characterized by the heavy precipitations (pluriannual average of 1'200-1'300 mm yr^{-1}) mainly during the end of winter and end of autumn (Kabo, 1990-91). In hilly zone the rainfall dominate, distributed in two peaks, autumn and winter, while the mountainous peaks are often covered with snow during the winter. During the study period the average monthly temperatures oscillated from a minimum 3.7 (January 2006) to 24.5˚C (July 2007). The total rainfall was about 2'027 mm in the year 2006, 1’740 mm in the year 2007 and 1’154 mm in the year 2008 (*see* Tab. 12-1 and Fig. 12-3, in Mersinllari *et al*., *this volume*). The higher precipitation may be a sign of the global warming.

The catchments is split into a diverse hydrographic network (Fig. 1-2) consisting of many brooks, torrents and tributaries of the Terkuza River, of some springs with moderate or small flow, and of some reservoirs. The main torrents originate from the Zall Bastari and Zall Mneri villages, the first transports high amounts of solid materials. Other brooks show also a strong torrential character, after rainfall events the water level suddenly rises which leads to massive erosion. Erosion, logging, desertification, and intense rainfall have amplified such clayey torrents, erosion spots, and landslides. Due to the lack of artificial sedimentation basins, the eroded solid matter is deposited in the lake resulting in a sedimentation rate of approximately 1 to 1.3 meter per year (Fig. 1-20; *see* also the Figs. 12-18, in Mersinllari *et al*., *this volume*).

The whole territory extended between mountains of Kruja and Mali me Gropa (Fig. 1-2), comprising the Bovilla watershed, is well known for the freshwater springs, often with oligo-mineral waters, with scarce content of calcium and magnesium salts. Most of them are collected in Bovilla Reservoir. Two big springs, Selita and Shenmeria (total flow 300-700 L/s each one), situated in Zall Dajti and Mali me Gropa, since the year 1957 were the principal drinking water supplier of Tirana (*see* Tab. 10-2, Emiri *et al.,* this volume); their waters cross the Dajti Mountain through a tunnel, and through a hydro-electrical power station in Dajti foot, continues even nowadays to supply Tirana with drinking water, together with waters from Bovilla Reservoir. The Qafeshtama springs are also famous for their curative values. Some of those waters are nowadays bottled as drinking mineral water. (*see* Tab. 12-2 in Mersinllari *et al*., *this volume*).

1.3. Methods of the study

Water quality data have been collected bimonthly from May 2006 to September 2008. Depth profiles (1m, 3m, 5m, 10m, 15m, 20m, 30m, 40m) were obtained using a Ruttner bottle (2 L) with a hand-winch mounted on the boat (*see* Fig. 3-1 in Koni *et al., this volume*); samples were taken the first year at three sites and later only at the main site near the dam, as the differences between the three stations were negligible. For the positions of the three sampling stations (*see* Fig. 2-3 in Çullaj *et al., this volume*).

The chemistry group measured the main **physico-chemical parameters**: water temperature, pH, conductivity, dissolved oxygen, alkalinity, total dissolved solids, turbidity, permanganate index, UV absorbance, transparency; **nutrients** (phosphorus, nitrate, nitrite, ammonium), and the **photosynthetic pigments** (chlorophylls a, b, c and pheophytins) (*see* Çullaj *et al., this volume*) (Tab. 1-1).

Table 1-1. Physical-chemical parameters measured in Bovilla. / Parametrat fiziko-kimikë të matur në Bovillë (Çullaj *et al*., Nr. 2 this volume).

Parameter	Methods	Instrument
Temperature	Thermometry	Multi-Parameter Meter HACH
pH	Potentiometry	
Conductivity & TDS	Conductometry	
Dissolved Oxygen (DO)	Winkler Method and Electrometry	
DO%		
TSS	Filtration with membranes 0.45μm and drying at 105°C	Filtering Unit
NO_3 -N	Spectrophotometer UV-VIS	SF UV-VIS Shimadzu 2401PC
NO_2 -N		
NH_4 -N	Spectrophotometer UV-VIS (Indophenol blue method)	
PO_4 -P	Spectrophotometer UV-VIS (method of the reduction of molybdenum blue)	
Chlorophyll (a, b, c and pheophytin)	Spectrophotometry UV-VIS	
Fe, Zn	Atomic Absorption in air-acetylene flame	SAA Varian SpektrAA 10+
Transparency	Secchi disk, 20 cm in diameter	

Biological data obtained covered qualitatively and quantitatively the **phytoplankton** (cells/ml, Utermöhl, 1958) by inverse microscopy (*see* Koni *et al.,* Nr. 3 *in this volume*) as well as the **zooplankton** with an assessment of the trophic state using the standard Pantle-Buck method (1955) based on the qualitative and relative quantitative composition of *Rotifera, Cladocera* and *Copepoda* species (*see* Shumka & Nikleka, Nr. 4 *in this volume*). The **microbiological** assessment covered total coli bacteria, fecal coli bacteria and fecal streptococci using the membrane filter technique (pore size 0.45 µm), the cultivation in three different media at controlled temperatures (APHA, 1998) following also the criteria of the EU Directive 75/440 on the quality required of surface water intended for the abstraction of drinking water (*see* Hoxha & Emiri, Nr. 6 *in this volume*).

Moreover, besides the 14 sampling expeditions on the Lake, several field trips were done to terrestric parts of the Bovilla catchment. The following aspects were studied and discussed (*see* Mersinllari *et al., this volume*), **flora and vegetation**, and **environmental conditions,** like the state of the belt around the water systems as well as natural areas, inflowing rivers, erosion and transport of solids by the rivers, evaluation of the sedimentation rate in the Reservoir, the **human activities** (agriculture, forestry and use of medicinal plants) and the **impact of humans on water quality** with an estimation of pollution from diffuse and point sources.

1.4. The drinking water supply in Albania and for Tirana

Albania is a country rich in water. Its overall renewable resources amount for 41.7 x 10^9 m^3 or 13.3 x 10^3 m^3 per capita, out of which about 65% are generated within Albania and the rest originates from neighboring countries. The major water resource is surface water, most important are the rivers of Drini, Mati, Ishmi, Erzeni, Shkumbini, Semani, Vjosa and Bistrica (Çullaj *et al.*, 2005). According to data reported by UNICEF (2001), about 97% of the Albanian population has access to clean drinking water, about 80% of the water originate from groundwater, the remaining 20% from surface water. About 85% of the water is produced by public systems, in urban areas available directly at home, but in rural areas often only at public taps and standpipes. The estimated drinking water consumption is about 20 – 50 L $person^{-1}$ day^{-1} at the taps, but 120 L $person^{-1}$ day^{-1} at the source, meaning that about 50-70% of the water is lost due to an obsolete and old infrastructure of the distribution system, poor maintenance, and mismanagement (Floqi, 2007, *see* also Fig. 10-2 in Emiri *et al., in this volume*).

The region of Tirana possesses wide natural geological features that offer abundant water resources of good quality. Drinking water supply for the capital area is estimated to be about 83.7 x 10^6 m^3 $year^{-1}$, with an average daily flow of around 2.8 m^3 sec^{-1} obtained from three different water sources: surface water (Bovilla Reservoir), natural underground springs, and artesian pumped wells. About 50 – 57 x 10^6 m^3 are obtained from Bovilla Reservoir (*see* also Table 10-2 in Emiri *et al., in this volume*). The water is collected in storage reservoirs with a total capacity of about 67'600 m^3 which are located at different points around the city. Each one can be furnished from two or three different sources (Floqi, 2007).

After 1990 Tirana experienced a drastic population growth and development. It is estimated that actually more than 850'000 inhabitants live in the Tirana region, which is equal to more than three times the population as in 1990. Therefore, the construction of the Bovilla Reservoir in 1998 was crucial to solve the drinking water demand of the rapidly growing capital. On the basis of a population of 850'000 inhabitants the drinking water use in Tirana amounts for 270 L day^{-1} $person^{-1}$ (see Tab. 10-2 in Emiri *et al.,* Nr. 10 *this volume*), a number higher than the respective value for the United Kingdom (*Anonymous*, 2005). Although we have to admit that the water distribution may be not continuous and often shows problems.

1.5. Bovilla Reservoir

The Bovilla Reservoir is a man-made lake and one of the largest hydro-technical constructions in Albania intended to ensure the drinking water supply for Tirana. After the World Commission on Dams (2000), dams with a height of more than 15 m or with a water volume of 10^6 m^3 are defined as "large dams'. Considering these limits there are more than 300 large dams in Albania, constructed for hydropower generation, irrigation and water supply. Bovilla dam belongs to the largest ones (Figs. 1-3 to 1.5 and 1-12; Zagonjolli *et al.,* 2005).

The dam is 91 m high and has a crown length of about 130 m at an elevation of 321 m a.s.l.. The material volume used was about 650'000 m^3 (SC, 1995), composed of gravel-sandy conglomerates, taken from alluvial remains in the Terkuza River, upstream of the dam.

The main hydrotechnical works in Bovilla includes a deviation tunnel (starting at 255 m a.s.l.), the discharging plant and water withdrawal for irrigation purposes in agriculture (from 275 m a.s.l.), the raw water outlet for drinking water (at 275 m a.s.l.), and the tunnels of drinking water withdrawal from the springs below the dam. The most important installations are situated on carbonic rocks of the upper Cretaceous, rocks of earlier origin and of the middle Paleocene, mainly from dolomite micro-crystalline organogenic limestone. These rocks form the base of the valley and the site of the dam, rising up over the maximal level of the Reservoir on both sides (Fig. 1-3, 1-7).

The dam (Fig. 1-3, 1-5, 1-7, 1-12) was built in a steep and narrow gorge of the Terkuza River at the Zall Herri pass (Fig. 1-4). It is situated about 15 km North-East of Tirana city, and is reached by a road from Kamza (Tirana) and Zall Herri. The hydrotechnical work started in February 1988 based on funds from the Albanian government, but was interrupted several times because of economic and social problems. It was resumed again in October 1993 and finally completed in 1996, by the Albanian company ALBINFRASTRUCTURE L.t.d. founded by the Italian company ITALSTRADE S.p.A. of the State Group IRI FINTECNA and from N.A.R.R., an Albanian State Enterprise financed by the Italian government (Gjata, 1997).

The Reservoir was filled during 1998 and 1999 and Bovilla water started to be used as the main drinking water source for the city of Tirana. In parallel, the Drinking Water Treatment Plant in Kodra Kuqe (Tirana) (elevation 217 m a.s.l.) was completed, through another soft loan from the Italian government (*see* Figs. 10-6 to 10-8, in Emiri *et al*., *this volume*). A steel pressure line of about 10 km length and 0.9 m in diameter delivers continuously about 1.8 m^3 sec^{-1} of water from the Reservoir to the Treatment Plant in Tirana.

Figure 1-3. View of the working process of the hydrotechnical area. / Pamje e zonës hidroteknike gjatë fazës së punimeve (*Anonymous*, 1996).

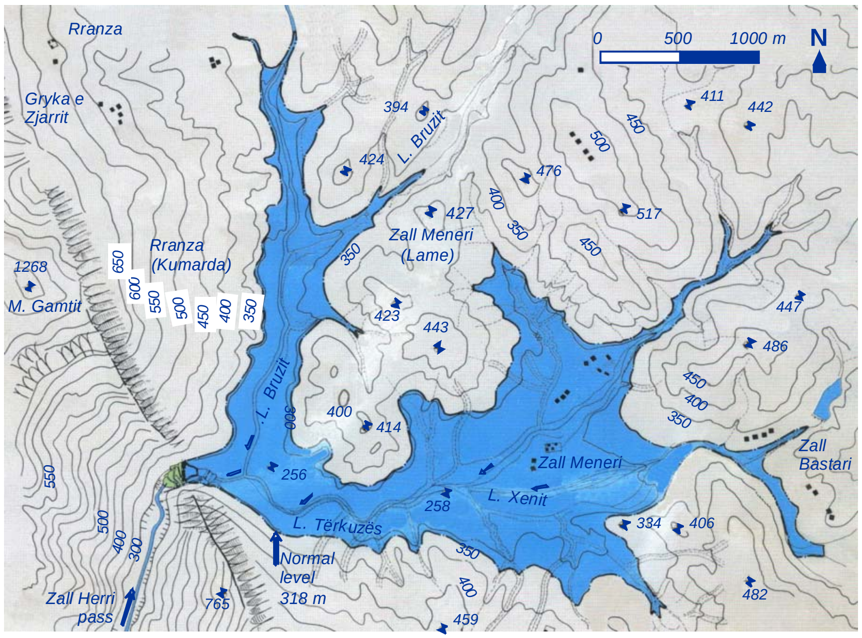


Figure 1-4. Topographic map of the Bovilla reservoir / Hartë topografike e ujëmbledhësit të Bovillës (1:25'000; *Anonymous*, 1996)

Figure 1-5. Satellite view of the Bovilla dam. / Pamje satelitore e digës së Bovillës (Image © Terremetrics, Europe Technologies and Digital Globe, Google Earth 2008).

Figure 1-7. View of the Bovilla lake close to the dam (from sampling station S1). / Pamje e liqenit të Bovillës shumë afër digës (stacioni kryesor S1 për marrjen e mostrave) (Photo: Miho).

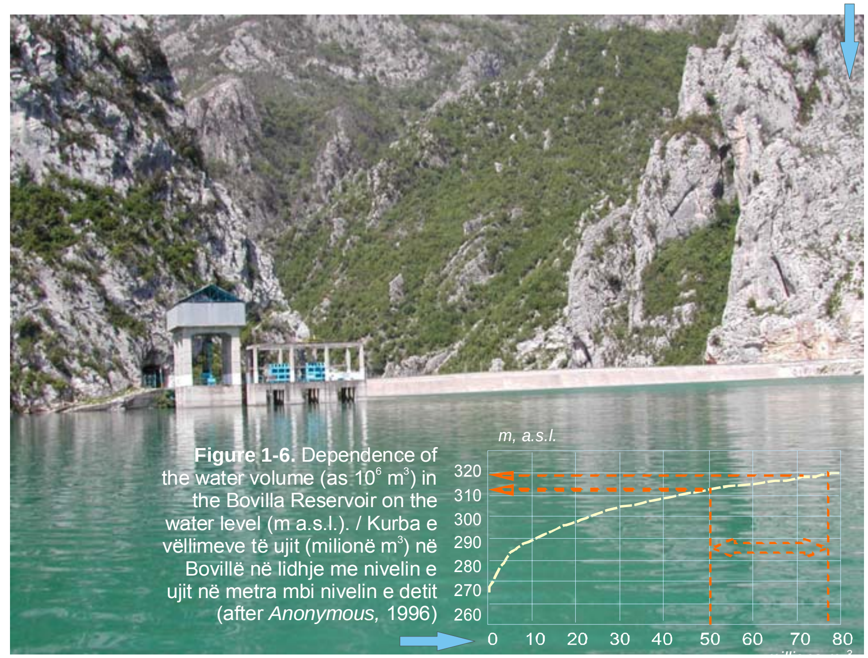


Figure 1-6. Dependence of the water volume (as 10^6 m^3) in the Bovilla Reservoir on the water level (m a.s.l.). / Kurba e vëllimeve të ujit (milionë m^3) në Bovillë në lidhje me nivelin e ujit në metra mbi nivelin e detit (after *Anonymous*, 1996)

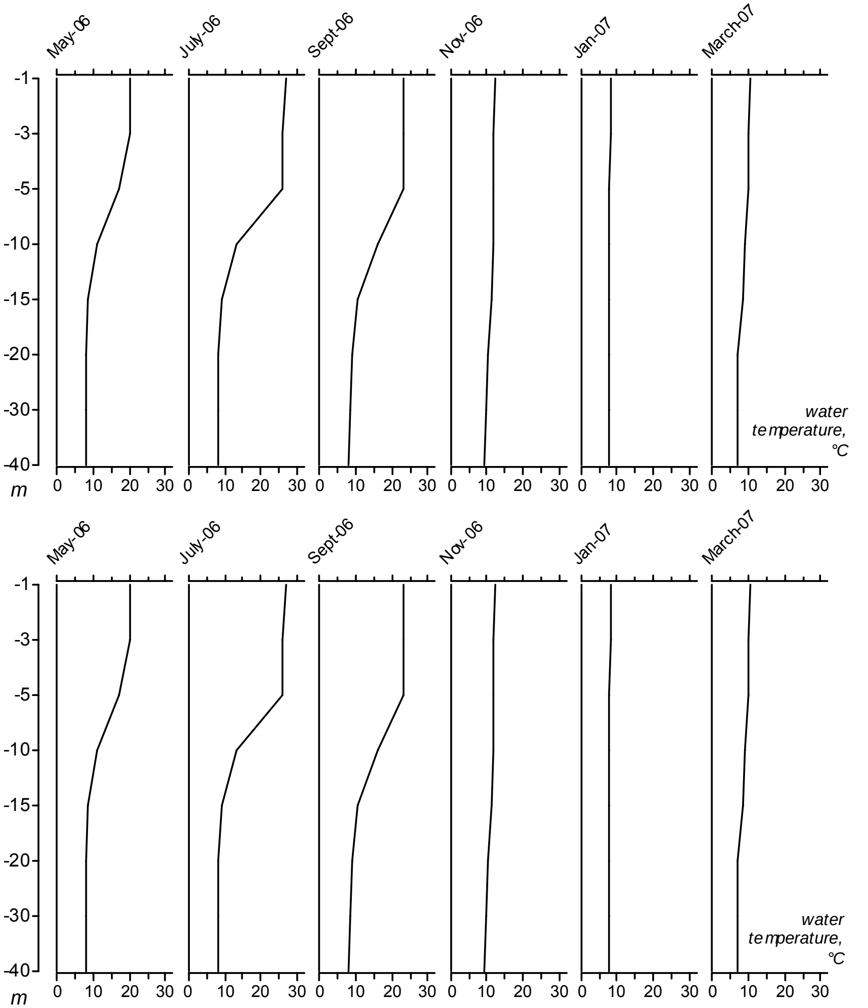


Figure 1-8. Changes of the water temperature (˚C) profile in the water column (depth, m) in the main station (S1) of Bovilla. / Ecuria e temperaturës (˚C) në kolonën e ujit (thellësinë, m) tek stacioni kryesor (S1) i Bovillës.

The drainage area of the Bovilla Reservoir covers approximately 98 km^2 (Fig. 1-2); the river Terkuza is the main source with an estimated average annual volume of 105 x 10^6 m^3. The maximum capacity of Bovilla Reservoir is about 80 x 10^6 m^3 at the normal level, quoted at 318 m a.s.l. The mean annual water consumption from Bovilla Reservoir is about 78 x 10^6 cubic meters which

corresponds to an average flow of 2.5 m^3 sec^{-1}. The change of the capacity at varying water levels is given in Fig. 1-6. About 50 x 10^6 m^3 are used for drinking supply and the rest for irrigation. The surface of the Reservoir amounts of 4.6 km^2; its average depth is 18 m. The original maximal depth was 53 m, the difference between the quotes of 265 m to 318 m a.s.l. (normal water level) found near the dam (Station 1, Fig. 1-7). During our study the maximal depth observed at station S1 was often about 45 m, about 30 m in its right arm (S2) and 20 m in its left arm (S3). It is assumed that the depth of less than 45 m is due to the sediments brought in by the Terkuza River. The residence time of the water is about 1 year.

The Bovilla Reservoir is a **warm monomictic water body** (Wetzel, 2001), as shown in the temperature profiles (Fig. 1-8), that never freezes and stratifies with high stability during the summer season. The **epilimnion** extends from 0 to 10 m of depth, the **thermocline** is located between 10 to 15 m and the water in the **hypolimnion** below 15 m is nearly isothermic with temperatures between 7.6 to 11.2°C. During winter the water is totally mixed, with respective temperatures of 8°C (13/1/2007), 11°C (25/11/2007) and 7.6°C (18/1/2008) within the whole water column.

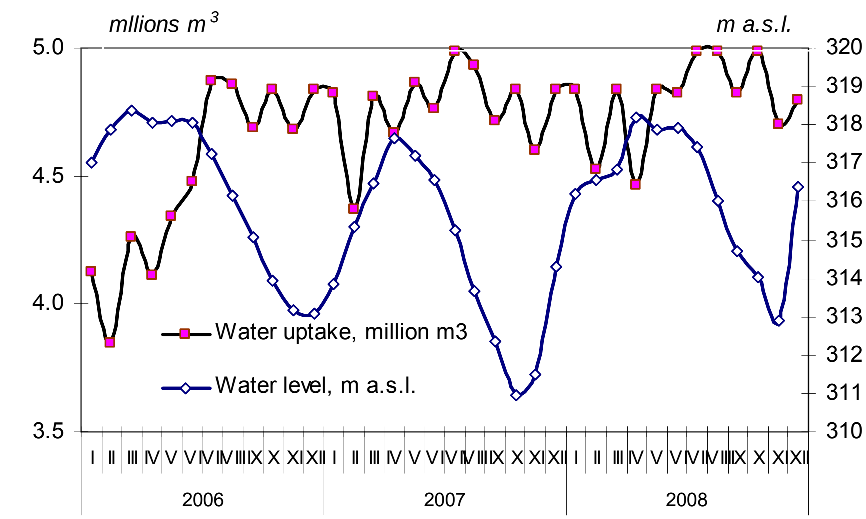
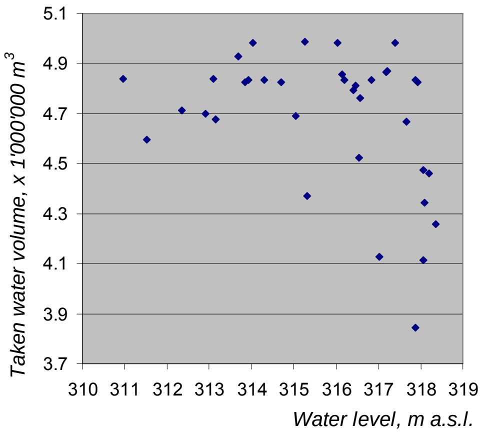


Figure 1-9. Dynamics of average values of lake water level (m a.s.l.) and the volume of water uptake from the Treatment Plant (in 10^6 m^3) during the years 2006 to 2008. / Ecuria e vlerave mesatare të nivelit të ujit të liqenit (m mbi nivelin e detit) dhe e vëllimit të ujit që është përpunuar nga Impianti (milionë m^3) gjatë periudhës 2006-08.

Figure 1-10. Scatering of Lake water level (m a.s.l.) and volume of water withdrawal from Treatment Plant (in 10^6, m^3) during the years 2006 to 2008. / Shpërndarja midis nivelit të ujit të liqenit (m mbi nivelin e detit) dhe e vëllimit të ujit që është përpunuar nga Impianti (milionë m^3) gjatë periudhës 2006-08.



Typical for reservoirs, the water level in Bovilla oscillates drastically over the seasons; during the study period 2006 to 2008, the water level varied up to 7 m (Fig. 1-9) between the quote 311 m to 318 m a.s.l. (= normal maximal level). As in every year the maximum level was observed during the wet period (February-April), due to the abundant inflow from the catchment, the minimum was observed in late summer-autumn (October to November) as a result of the scarce rainfall and a rather excessive use of water for drinking purpose. There is a significant correlation between water uptake and lake level (Fig. 1-10). The massive decrease of the water level in the Reservoir has probably some effects on the water quality; it must be taken into consideration by the Drinking Water Enterprise, for the proper management of its water resources. For the discharge five gates are used for the water consumption (Fig. 1-11), they are situated between ca. 8 m to 34 m of depth depending on the water level. The Treatment Plant collects the water at the maximal level (wet season) from the thermocline layer (10-15 m of depth) through gate 2 (304.1 m) and at minimal level through gate 3 (297.4 m).

Figure 1-11. Front view of water withdrawal and discharge tower. / Pamje ballore e kullave të marrjes se ujit dhe të shkarkimit (*Anonymous*, 1996).

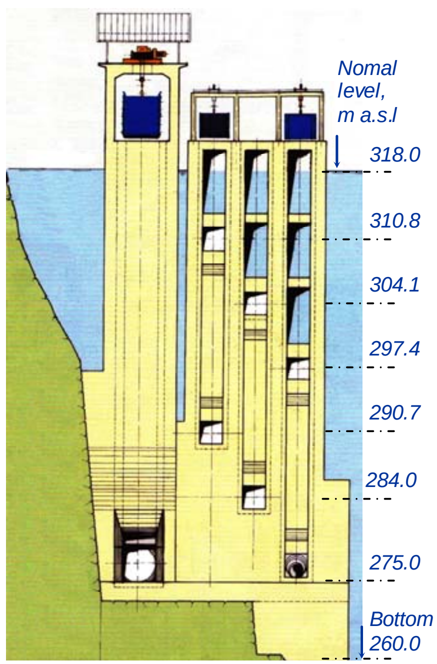
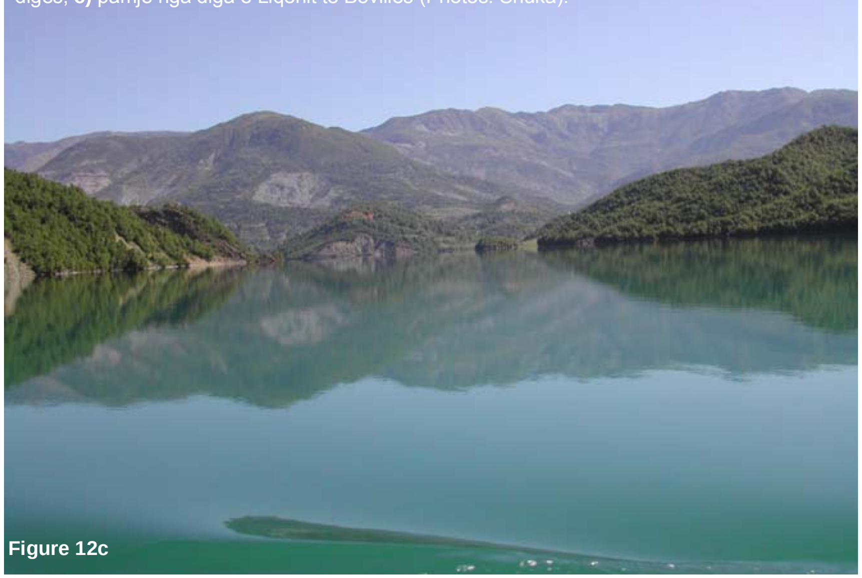


Figure 1-12. a) The Bovilla withdrawal and discharge tower; **b)** View of the dam; **c)** View from the dam on the Lake. / **a)** Pamje e kullës së shkarkimit dhe marrjes së ujit; **b)** pamje e digës; **c)** pamje nga diga e Liqenit të Bovillës (Photos: Shuka).



1.6. The Drinking Water Treatment Plant

The Drinking Water Treatment Plant is situated in Kodra Kuqe (quote 217 m a.s.l.), near Tirana. A steel pipeline transports up to 1'800 L s^{-1} (more 50-57 million m^3 $year^{-1}$) from the Reservoir to the Treatment Plant (*see* Tab. 10-3, in Emiri *et al.,* Nr. 10 *this volume*). The water is treated using the steps prechlorination, coagulation, flocculation, decantation, filtration, and disinfection (final chlorination). In cases of unpleasant smell an adsorption step by activated carbon is added (frequently from October to April). The treatment process is regularly monitored and automatically controlled. After the treatment process the quality of the drinking water quality achieves the required values set up by the Albanian Standard STASH 3904:1997 for drinking water and the EU Directive 80/778.

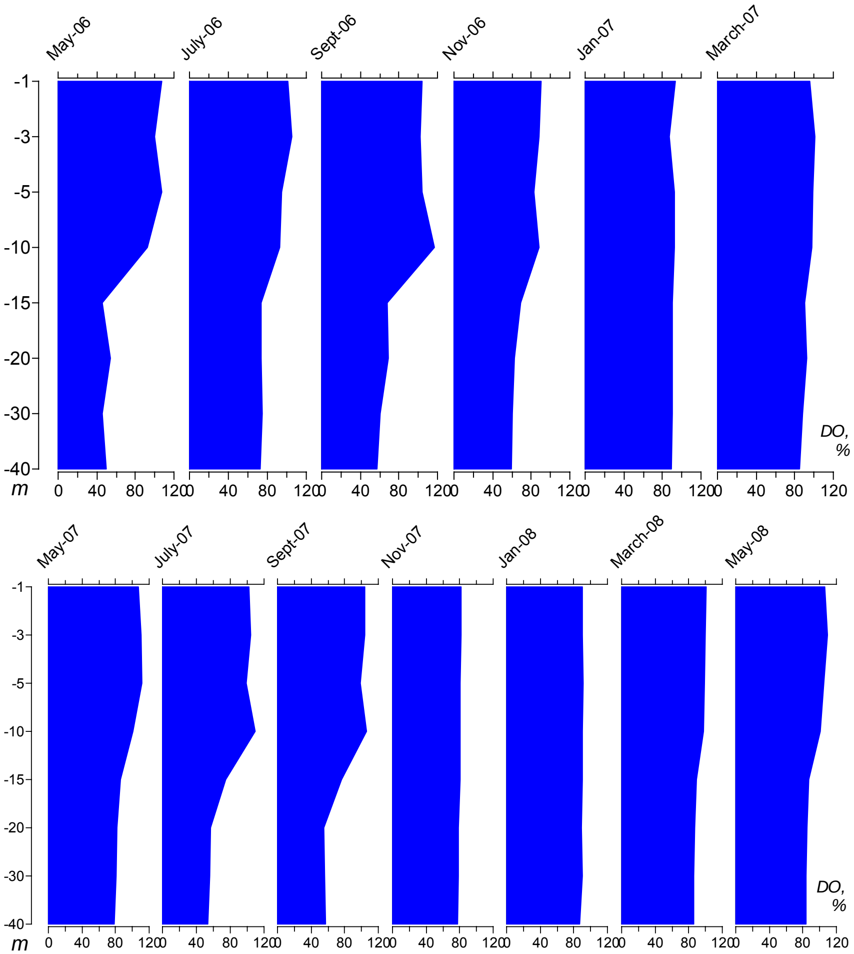


Figure 1-13. Changes of the dissolved oxygen (%) profiles in the water column (depth, m) at the station S1 of Bovilla Lake. / Ecuria e oksigjenit të tretur (%) në kolonën e ujit (thellësia, m) tek stacioni kryesor (S1) i Bovillës.

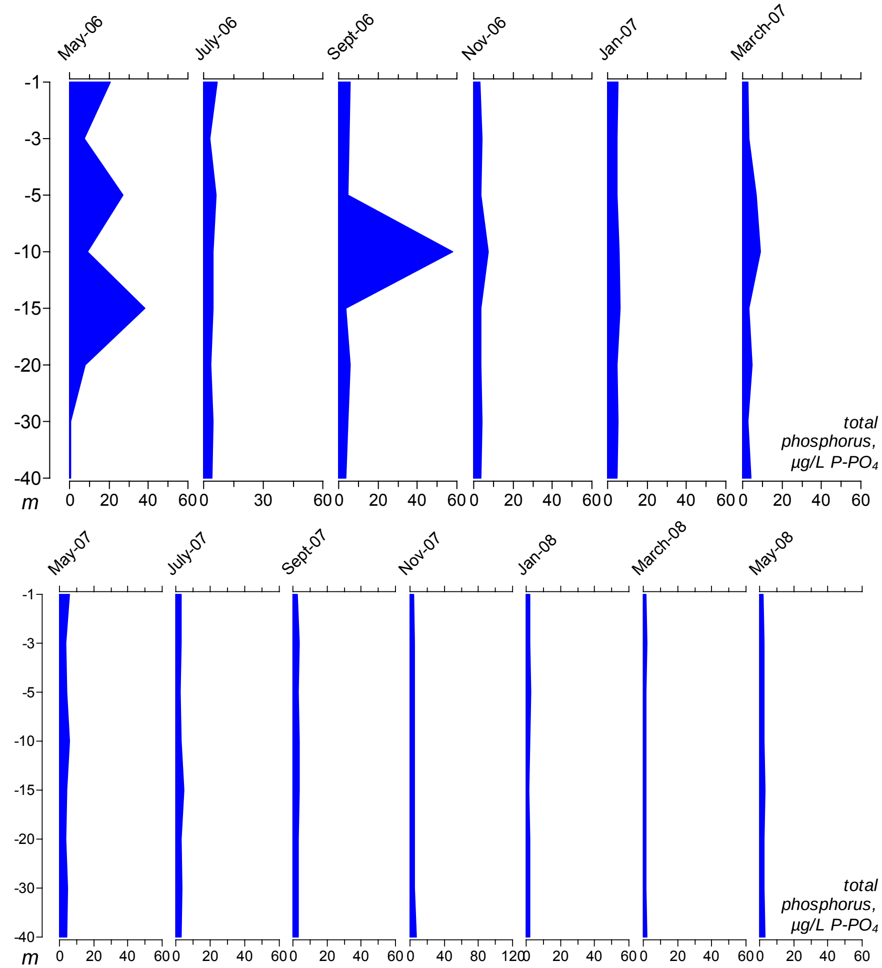


Figure 1-14. Changes of total phosphorus (µg L^{-1} P-PO_4) profiles in the water column (depth, m) at the main station S1 of Bovilla Lake. / Ecuria e fosforit të përgjithshëm (µg L^{-1} P-PO_4) në kolonën e ujit (thellësia, m) tek stacioni kryesor (S1) i Bovillës.

1.7. The chemistry of Bovilla water

Based on the regular data taken from the Bovilla Treatment Plant (*see* Tab. X-1; Annex X in Emiri *et al.*, Nr. 10 *this volume*), and from this study (Çullaj *et al.*, Nr. 2 *in this volume*), Bovilla water can by judged into category A_1 of EU Standard 75/440 for surface waters intended for the abstraction of drinking water, especially for the physico-chemical parameters pH, BOD_5, conductivity, the nutrients nitrogen and phosphorous. Below the thermocline, the water temperature is always fresh at 6-11°C (Fig. 1-8), oxygen saturation is between 50 to 100% depending on the season (equal to categories A_1-A_2), as shown in the oxygen profiles (Fig. 1-13).

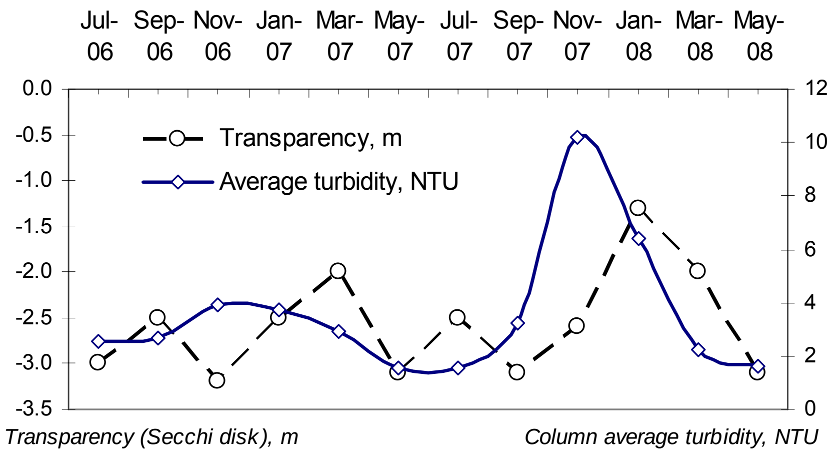


Figure 1-15. Changes of the Secchi disk transparency (m) and column average value of turbidity (NTU) in main station (S1) of Bovilla Lake. / Ecuria e tejpamjes (m) dhe mesatares së turbullisë (NTU) në kolonën e ujit tek stacioni kryesor (S1) i Liqenit të Bovillës.

Nitrogen and phosphorus were generally low in the whole water column; total phosphorus was with few exceptions below 10 µg L^{-1} P-PO_4, (May 2006 with 38.2 µg L^{-1} at 5 m depth and September 2008 with 57.8 µg L^{-1} at 10 m), when relatively high values were observed especially in the thermocline (Fig. 1-14). A high content of suspended solids was found, that several times exceeded 25 mg L^{-1}, a relatively high turbidity and a low transparency (2.5 - 3 m) of the water (equal to category A_2, Fig. 1-15). This was especially during the rainfall seasons, with a high rate of erosion in the watershed and relatively high concentrations of iron and nitrates. For some other parameters the water quality worsened during the period of stratification (May to September), such as the dissolved oxygen in the hypolimnon (categories A_2 and A_3) or ammonium (*see* Çullaj & Miho, Nr. 9 *this volume*).

Starting in autumn 2001, an unpleasant smell was observed in the drinking water from Bovilla of which the source is not known, the phenomenon is discussed later (*see* Çullaj & Bachofen, Nr. 8 *in this volume*). The adsorption process with active carbon was introduced by the Treatment Plant to eliminate the nuisance (*see* Emiri *et al.,* Nr. 10 *in this volume*).

Table 1-2. Total phytoplankton (cells/ml) in the Bovilla Lake at different depths, from May 2006 to September 2008. / Fitoplanktoni i përgjithshëm (qeliza/ml) në Liqenin e Bovillës gjatë periudhës maj 2006 - shtator 2008.

Period / Depth, m	-1	-3	-5	-10	-15	-20	-30	-40
S1-20/05/06	564	786	614	165	49	64	21	27
S2-20/05/06	821	525	798	279		25	16	
S3-20/05/06	745	827	214	356		28		
S1-15/07/06	1500	1104	1113	5618	1481	931	295	157
S2-15/07/06	1119	716	1818	2185		374	271	
S3-15/07/06	1521	1186	3513	3302		522		
S1-16/09/06	1008	646	613	6302	1346	506	89	54
S2-16/09/06	543	401	421	232		750	117	
S3-16/09/06	642	684	484	7355		185		
S1-18/11/06	1610	1799	1563	1709	785	1115	806	465
S2-18/11/06	1468	1459	2330	1623		685	573	
S3-18/11/06	1529	1659	1541	1488		473		
S1-13/01/07	154	147	85	188	154	91	88	89
S2-13/01/07	125	128	119	100		136	95	
S3-13/01/07	98	98	92	67		58		
S1-17/03/07	2021	2060	2006	1857	447	150	112	72
S2-17/03/07	2080	2371	1885	841		138	87	
S3-17/03/07	2672	1966	2325	2421		121		
S1-12/05/07	9689	9300	9341	5004	4521	3328	239	170
S1-23/07/07	1605	1526	908	3370	993	474	198	141
S1-16/09/07	848	875	1462	453	1564	418	212	108
S1-17/11/07	108	130	116	106	111	83	45	30
S1-19/01/08	330	306	345	338	333	157	23	2
S1-15/03/08	80	97	81	128	175	99	72	23
S1-17/05/08	555	412	483	243	193	86	101	22
S1-28/09/08	3034	3037	1688	1728	713	405	340	246

1.8. Biological aspects of Bovilla water

A low photosynthetic productivity was observed in Bovilla Reservoir as the biomass, phytoplankton and zooplankton, was scarce, as was expected for the mainly oligotrophic state of the water (first class water quality). Only in few cases, i.e. in May and September 2007 a strong growth of the phytoplankton was observed with up to 9'000 cells ml^{-1} in the epilimnion (May 2007), which corresponds to mesotrophic conditions (second class water quality).

The numbers for the phytoplankton (Table 1-2) indicate that the epilimnion was the most productive layer during thermal stratification (March to November), with peaks in May and July. The phytoplankton was dominated by the species of the genus *Cyclotella*, a species known to develop in oligotrophic water (Håkansson, 1989) with a low nutrient concentrations. More than 150 phytoplankton algal species were found in the Bovilla Reservoir (*see* Tab. III-3 in Annex III, Koni *et al., this volume*). The centric diatom *Cyclotella commensis* dominated with up to 98% of the phytoplankton. Other groups occurred scarcely or even only occasionally, such as *Dinophyceae, Chlorophyceae, Cryptophyceae, Chrysophyceae* and *Cyanophyceae*. Cryptomonads were the most abundant of these, especially during winter, they were represented mainly by species of *Cryptomonas* sp*. diverse* and *Rhodomonas minuta*. Dinoflagellates were present during the whole year, represented typically by *Ceratium hirundinella,* and various species of *Peridinium*, they were most abundant during the maximal growth of phytoplankton in summer.

About 39 zooplankton species were found, belonging to *Cladocera* (21 species), *Rotatoria* (11) and *Copepoda* (7). *Brachionus angularis, Keratella cochlearis, Trichocerca capucina, Polyarthra trygla and Pompholyx sulcata* were most widespread among the *Rotatoria, Bosmina longirostris* f*. typical* from the *Cladocera,* and *Cyclops vicinus* and *Mesosclops leuckarti* from the *Copepoda.* Overall the Copepods, especially *Cyclops vicinus,* were dominant, mostly the larval and copepodid stage. The most widespread and abundant was *Bosmina longirostris* f. *typical* with up to 1000 individuals L^{-1} in September 2006. The Bovilla ecosystem does not seem to have reached an equilibrium state concerning a defined number and composition of zooplankton species compared to other lakes in the region (*see* Shumka & Nikleka, *this volume*).

This low zooplankton density sustains only a small fish population. Fish community is thus to be rather poor, dominated by *Alburnoides* sp. and *Barbus* sp.; the Silver carp (*Hypophthalmichthys molitrix*) was also observed (*see* Fig. 5-1 in Shumka, *this volume*); it was introduced several times by the authorities of Ministry of Environment, Forests and Water Administration (MOE) (Bardhi, 2007), in order to improve the water quality of Bovilla Lake. The possibility of utilizing biomanipulation to improve the water quality of a drinking water reservoir is a known practice. But it is very important important that before undertaking any biomanipulation activities in Bovilla Lake, a specific study of ecosystem control should be initiated. An empirical experiment is not sufficient to reach a good water quality control and maintenance (*see* Shumka, *this volume*).

Total coliforms were generally lower than 50 colonies 100 ml^{-1}, indicating water of the category A of the EU Directive 75/440 for the quality of surface waters intended for the abstraction of drinking water in the EU States. Only in September 2006 the water from all three stations had numbers higher than 50 colonies 100 ml^{-1} (= A_2) The highest values (90 -110 colonies 100 ml^{-1}) were

observed in the hypolimnion at the station near the dam (S1) in 30 - 40 m depth. In contrast fecal coliforms exceeded often the limit of 20 colonies 100 ml^{-1} (= A_1). The highest values were observed in November 2006, oscillating between 60 and 80 colonies 100 ml^{-1} (= A_1) especially in the hypolimnon of all three stations. Fecal *Streptococci* were often found to be more than 20 colonies 100 ml^{-1} (= A_1), notably during May 2007 to January 2008 with maxima in November 2007 and January 2008 with up to 90 colonies 100 ml^{-1} (= A_2). During rainfall the numbers of coliforms and fecal *Streptococci* were usually increased (*see* Hoxha & Emiri, *this volume*).

According to published data from other lakes none of the phytoplankton species found in Bovilla Reservoir seems to release compounds causing bad odors and tastes, such as the well known geosmin and 2- MIB. Cyanobacteria, known to produce these volatile compounds, are only rarely present. The most abundant species, *Cyclotella commensis*, is not recognized so far to deteriorate the quality of the water. Nevertheless, a better knowledge about those taxa known to produce volatile compounds, e.g. benthic cyanobacteria and diatoms, organisms that are or may be present in Bovilla Reservoir, is needed. Aerobic filamentous actinobacteria with the actinomycetes (*Streptomyces*) are well known to cause taste-and-odor outbreaks in drinking water, they should be studied in the Bovilla ecosystem. A more detailed discussion about these undesirable smell and taste compounds in Bovilla water is discussed by Çullaj & Bachofen (*this volume*).

1.9. Terrestrial flora and vegetation

The vegetation in the Bovilla catchments belongs to the phytoclimate zones of **Mediterranean shrubs and forests, oaks, beech** and **pre-mountainous pastures** (*see* Mersinllari *et al.*, *this volume*). From the back of Zall Dajti to the slopes of Zall Bastari, Vileza-Gurra, Vileza-Liqe, Mneri-Siperm (Pjeci, Dedaj) and down in Bregu-Dishit, the hills are covered with oaks extending into the upper belt; Mediterranean shrubs and elements of maquis are found mainly in the lower parts (Fig. 1-16). On the fertile soils in the plains, the farmers grow cereals, forage and fruits. The mountain peaks are naturally covered with beech forests; mountainous pastures grow on the high crests (at elevations of 1’500-1’800 m), typically around Mali me Gropa. Rare but economically important plant species are often sheltered in karstic structures, dolines, holes and wells.

The most abundant plant associations that grow in the catchment area were the **deciduous forests and shrubs** (*Carpino–Pistacetum terebinthii*), with *Carpinus orientalis, Ostria carpinifolia, Pistacia terebinthii***, the Mediterranean maquis and evergreen shrubs** (*Myrto–Quercetum ilicis* and *Arbuto–Quercetum ilicis*), with *Myrtus communis, Arbutus unedo, Erica arborea, Phyllirea latifolia, Fraxinus ornus, Cistus spp.,* **thermophyllic deciduous**

forests of oaks (*Querco–Carpinetum submediterraneum* and *Quercetum frainetto-cerris*), with *Carpinus orientalis, Quercus cerris, Q. frainetto, Melitis melisophyllum, Lathyrus niger, Potentilla micrantha, Galium lucidum,* etc*.,* **the Mediterranean mesophyllic mountainous beech forests** (*Ostryo–Fagetum* and *Luzulo-Fagetum*), with *Ostrya carpinifolia, Fagus sylvatica, Fraxinus ornus, Carpinus betulus, Acer* spp*.,* etc. (*see* tab. 12-6 in Mersinllari *et al.*, *this volume*). According to the EUNIS habitat categories (Davies & Moss, 1997), the plant communities cited above correspond to: **I) the Mediterranean Grasslands, Matorral, Maquis and Forests**, and **K) the Temperate Wood and Fringe, Scrub and Broadleaf Forests**.

Degraded oaks forests grow in waste areas, represented by *Prunus spinosa, Crataegus monogyna, Dorycnium hirsutum, Teucrium pollium, Paliurus spina-christi,* etc*.,* mainly close to inhabited parts and abandoned lands, some of them in an irreversible state. The degraded processes in the ecosystem are quite evident, due to logging, overgrazing and fires (Figs. 1-16 and 1-18).

Some other more or less isolated plant formations are also of interest, like **plane trees**, with *Platanus orientalis, Juglans regia, Tamarix parviflora* and *Crataegus monogyna,* along the riverbeds and torrent beds; this riverbank vegetation is important to restrict the strength of erosion. Some associations were rare, like the **deciduous pre-mountainous forests**, with *Castanea sativa, Quercus petraea* and *Juniperus communis***,** the **coniferous forests**, with *Fagus sylvatica, Pinus heldreichii* and *Abies alba,* etc.

Grasslands grow up in open forests or in **mountainous pastures**, higher than 1'500 m, represented mainly by the plant species of *Agrostis capillaris, Bromus erectus, Cynosurus crystatus, Festuca* sp*. diverse*, *Thymus* sp*. diverse, Trifolium spp., Phleum alpinum*, *Poa* sp. diverse, *Koeleria splendens, Asphodelus albus, Narcisus poeticus, Nardus stricta,* etc*.* (Dumishllari & Buzo, 2008); the most common were the **dry stony mountainous pastures**, with *Festuco-Brometum, Teucrium montanum-Stipetum pengata, Festucetum bosniaca-Thymus cherlerioides, Saturetum montona,* etc. **Semi-arid meadows**, with *Pteridio-Agristietum capillaries* and Thymus striatus-Agrostietum capillaries, and **true meadows**, with *Poa media-Festucetum panciciana, Cynosuro-Trifolietum pratense, Phleum alpinum-Koleretum splendens, Asphodelus albus-Narcisus poeticus,* represent an important part, too. **Cold mesophyllic meadows**, with *Poa media-Nardetum* grow up here and there, in the northern slopes or fresh holes.

Despite the human impact and the degradation of the vegetation cover, the catchment area of Bovilla can be considered rich in plant species, many of these economically important or even rare and endangered. The checklist of more than 860 taxa of higher plant species was recorded in the Bovilla catchment, together with the area of Dajti-Mali me Gropa, which are ecologically closely related, and form actually a complex protected zone, (Dumishllari, 2006; Kalajnxhiu, 2006; *see* also Tab. XII-1, in Annex 12,

Mersinllari *et al., this volume*). About 670 taxa belong to dicots, 170 to monocots, 8 gymnosperms and 19 species to ferns. The most abundant families were *Fabaceae* (99 taxa) *Asteraceae* (87), *Poaceae* (76) and *Lamiaceae* (55). Dominant life forms were hemicryptophytes (37%), therophytes (28%) and geophytes (17%), which grow in the open parts and high scale of degradation of shrubby and forest canopy. The dominance of Eurimediterranean and Mediterranean species is a consequence of the climate characteristics for the region, with a long drought period in summer and high temperatures in spring and summer. The European species were found mainly in the high altitude Eastern part of the Bovilla catchment, where the vegetation is dominated by broadleaves and herbaceous plants. There, the vegetation cover decreases during winter when the rainfall rate increases and the erosion is enhanced.

About 60 plant species are cited in the Red Book of the Albanian Flora (*Anonymous*, 2008) (*see* Figs 12-9 to 12-11, in Mersinllari *et al., this volume*); 18 species belong to the strictly protected Red List (Urdhër 146, 2007), such as the Gymnosperms *Pinus sylvestris* and *Taxus baccata*, and Angiosperms like *Halascya sendtneri, Orchis provincialis, Oxytropis purpurea, Saxifraga grisebachii (sensu* Hayek*), Cerastium grandiflorum, Fritillaria macedonica* and *Ramonda serbica*. Five species are considered as endemics, *Aster albanicus (Asteraceae), Colchicum pieperanum (Liliaceae), Forsythia uropaea (Oleaceae), Gymnospermium shqipetarum (Berberidaceae) and Pinguicula hirtiflora* var*. louisii (Lentibulariaceae),* 8 others as subendemics*, Orchis albanica (Orchidaceae), Cerastium grandiflorum (Caryophyllaceae), Chamaecytisus tommasinii (Leguminosae), Colchicum lingulatum (Liliaceae), Sesleria robusta* ssp*. scanderbeggii (Gramineae), Solenanthus scardicus (Boraginaceae), Teucrium arduini (Labiatae)* and *Vincetoximum huteri (Asclepidaceae).*

The zone is known for the diversity of medicinal plant species, like *Ceterach officinarum*, *Juniperus communis, J. oxycedrus, Crataegus monogyna, Digitalis* lanata*, Hypericum* perforatum*., Rosa* canina*, Orchis spp., Origanum vulgare, Salvia officinalis, Satureja montana, Teucrium* chamaedrys, etc.

1.10. Human activity and human impact in the zone

The Bovilla region is inhabited since the 6th century AC as confirmed by archeological remains. About 9 villages of more than 5'600 inhabitants, in 1'600 households are spread out in steeply slopes of Bovilla catchments area. Three villages belong to Culli municipality (Kruja district): Bruzi Mal, Bruzi Zalli and Rranxe, with about 1'800 inhabitants (Murati, 2002), and the rest belong to Zall Bastari municipality (Tirana district) (Zguraj, Vileza, Mal Vileza, Zall Bastari, Bastari Mesem, Zall Mneri) (Fig. 1-2; *see* also Tab. 12-8 and Figs. 12-16, in Mersinllari *et al., this volume*). During the construction of the Reservoir some families have been transferred from the flooded part to the suburbs of Tirana; however, some sites close to the lakeshore are still inhabited. The local population lives at a low living standard, although they are geographically close to Tirana city, the most developed part of Albania. The infrastructure is far away from any modest daily requirements and some villages are completely isolated. Education reaches the level of middle school; furthermore, there are some public institutions operating, such as public health and State administration.

The municipality of Zall-Bastari counts about 750 ha of agricultural land and 4'500 ha of pastures. As livestock and forestry are the main activities the damage of the vegetation cover, not only of the shrubby belt but also of the true forests, cannot be overlooked. Logging is the dominant activity due to the high demand of wood by the booming construction sector in Kruja and Tirana (Fig. 1-22). Livestock move around freely within the watershed, counting 1100 cows, 800 horses and mules and more than 1000 domestic sheep and goats. Unofficial data mention about 12'000 domestic animals, mainly goats. In addition to forestry and agriculture, the collection of medical plants is another activity as the area is considered rich in plant diversity. Plants collected include *Salvia officinalis, Origanum vulgare, Thymus* sp., *Hypericum perforatum, Crataegus monogyna, Rosa canina* and others.

The human impact on the Northern and Eastern slopes is pronounced and apparent (Fig. 1-17 and 1-19). Changes in land cover and land use affect the ecological landscape functions and processes (Papastergiadou *et al*., 2007). The high frequencies of *Juniperus oxycedrus, Crataegus monogyna, Dorycnium hirsutum, Putoria calabrica, Staehelina uniflosculosa, Saponaria calabrica, Rubus ulmifolius, Rosa sempervirens, Pyrus amygdaliformis, Pteridium aquilinum, Ononis spinosa, Paliurus spina-christi* indicate the beginning of a degradation, caused mainly by uncontrolled woodcutting and overgrazing, furthermore favoured by the sandy-clay soil texture and the low level of nutrients.

The lowest parts of the catchment area, situated at 700-800 m a.s.l., are the most exploited by agricultural activities and livestock farming, degrading the natural plant biocenoses (Fig. 1-17 and 1-19), i.e. the ones of mixed oaks, pastures and forests, and Mediterranean shrubs. Activities also enhanced erosion and formed large gravel beds along the torrents. The vegetation has changed as resistant but not very useful species, like *Pyrrocantha coccinea, Sparthium junceum*, and others substituted the original vegetation. Some typical former species of river valleys such as *Platanus* or *Salix* species should be protected and restored, as these have a high capacity to reduce the erosion. The vegetation state seems better preserved in the upper part of the beech belt and in the mountainous meadows, but even there over-exploitation of the vegetation is apparent. Oak wood has been used for firewood and as building material, particularly at sites close to villages (Fig. 1-19).

Figure 1-16: Overview of hilly landscape of the Bovilla watershed: **a)** from Rranza village; mountainous chain of Mali me Gropa at the horizon; **b)** from Vileza village. / Pamje e peisazhit kodrinor të pellgut të Bovillës: **a)** nga fshati Rranzë; në horizont duket Mali me Gropa; **b)** nga fshati Vilëz. (Photo. L. Shuka).

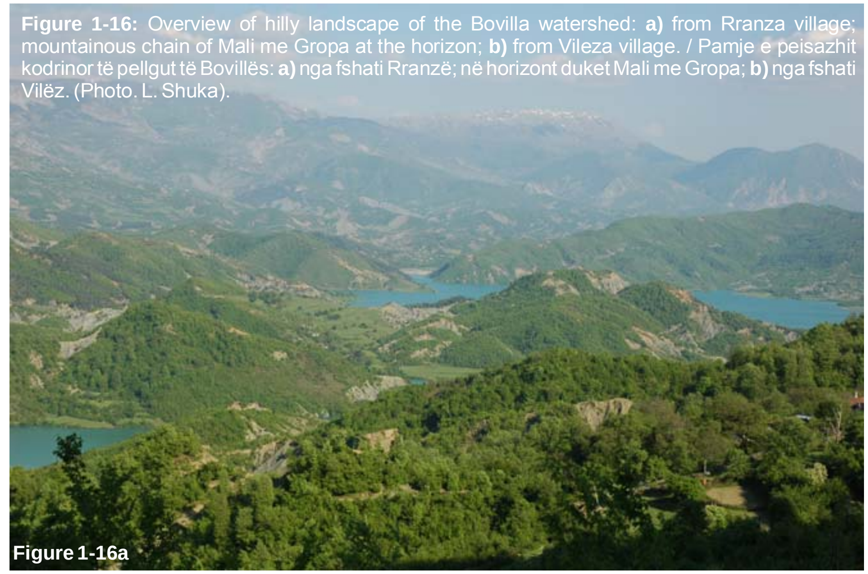


Figure 1-16a

Figure 1-16b

Figure 1-17. Above and below: overview on the Zall-Bastari village, its river and the surrounding eroded landscape. / Sipër dhe poshtë: pamje e përgjithshme e fshatit Zall Bastar, e lumit të tij dhe peisazhit rrethues të gërryer (Photos: Miho; September 2002).

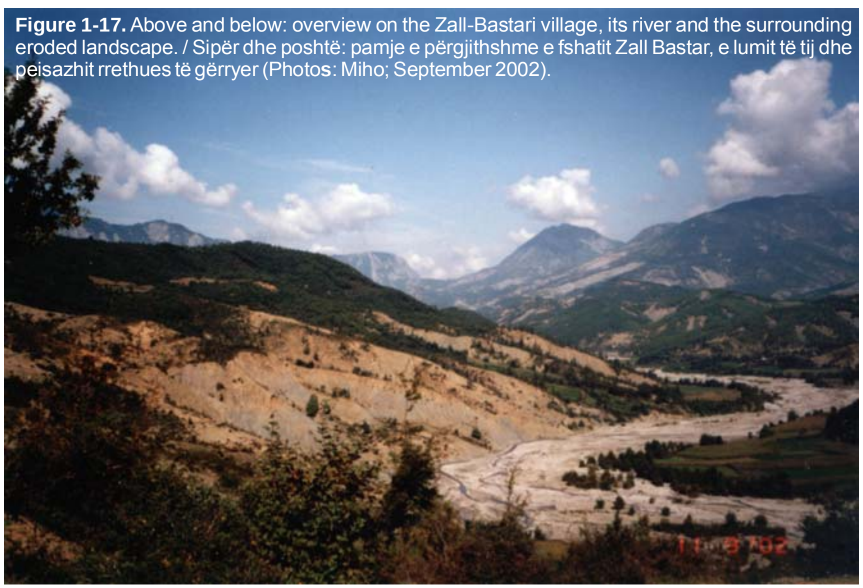


Figure 1-18. Agricultural fields in the Bovilla catchment area. / Toka bujqësore në pellgun e Bovillës (Photos: Shuka; September 2006).

Figure 1-19. Overview of the hilly landscape of the Bovilla catchment area showing the strong erosion areas. / Pamje e peisazhit kodrinor të pellgut të Bovillës me zona me gërryerje të fuqishme (Photos: Shuka; September 2006).

Figure 1-20. Heavy sediment load from Zall Herri (Terkuza) river approaching the Bovilla Lake. / Ngarkesë e rëndë me sedimente nga lumi i Zall Herrit (Tërkuzës) në vendin e shkarkimit në liqenin e Bovillës (Photos: Shuka; September 2006).

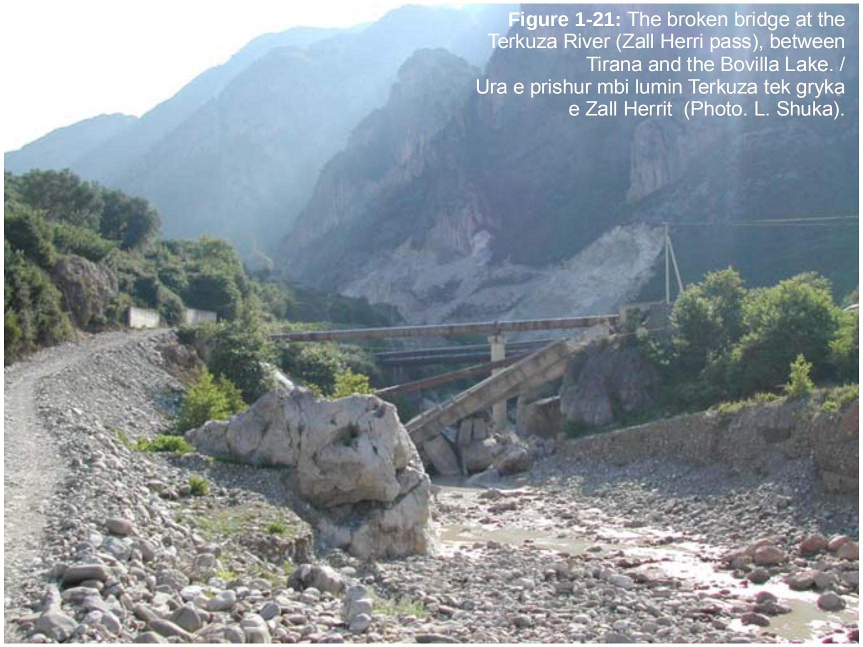


Figure 1-21: The broken bridge at the Terkuza River (Zall Herri pass), between Tirana and the Bovilla Lake. / Ura e prishur mbi lumin Terkuza tek gryka e Zall Herrit (Photo. L. Shuka).

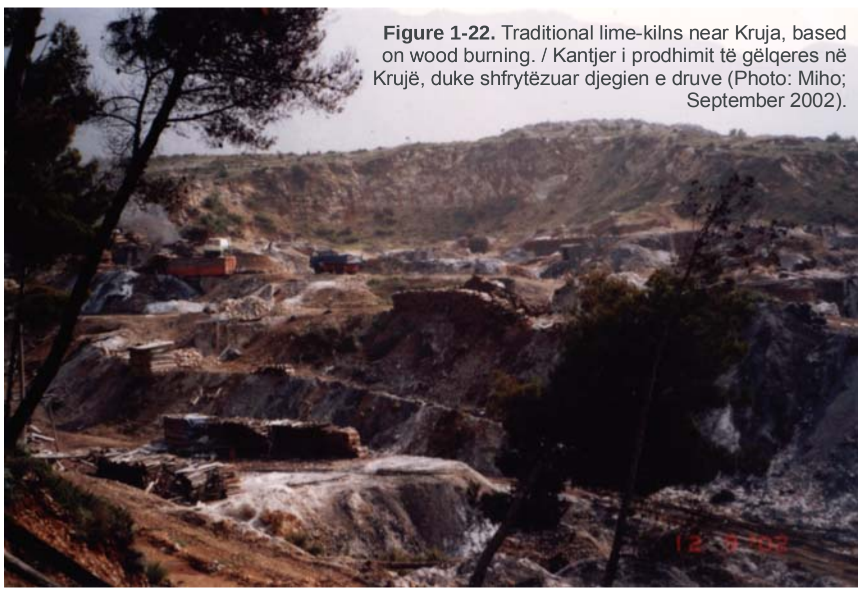


Figure 1-22. Traditional lime-kilns near Kruja, based on wood burning. / Kantjer i prodhimit të gëlqeres në Krujë, duke shfrytëzuar djegien e druve (Photo: Miho; September 2002).

Since 1960, efforts were undertaken to reforest the territory with pine-trees, mainly *P. halepensis*. This has helped to prevent some erosion, but it has also reduced the original plant diversity of the basin. Few erosion dams have been built in the rivers leading to a positive effect. Unfortunately, most restoring activities were abandoned after 1990.

Over-exploitation of forests and shrubs combined with overgrazing is considered to be the main reason for the decrease of vegetation cover within the Bovilla catchment. The degradation of the vegetation cover estimated from satellite images is in the range of 12% to 22% (Fig. 1-17 and 1-19); areas lacking vegetation at all are not rare. This results in a considerable decrease in the retention capacity of water by the land surface. From land denuded by 10 to 20%, the surface water flow is increased by a factor of 2, a denudation of 35 to 40% leads to a three times higher water flow (Michael & Mayer, 2001). This drastically alters the characteristics of the rivers which feed the Reservoir, resulting in large oscillations in the water level during the rainy winter season.

The soil texture regulates the rain infiltration rates and the water retention time. With bare soil the buffer capacity is reduced due to increased surface runoff. This is the major cause of erosion and transport of solids by the rivers and the high sedimentation rate in the reservoir. The high rate of erosion is confirmed also by the high content of suspended solids and the low transparency of the water, in contrast to the low values of chlorophylls (Çullaj *et al.*, *this volume*) and the phytoplankton (Koni *et al., in this volume*). The lower slopes in the Bovilla catchment (400 to 900 m a.s.l.) are mostly eroded, occurring mainly during rainfall in winter. The large riverbed of Terkuza is filled with gravel and enlarges continuously (Fig. 1-20). The erosion is also enforced by the unstable structure of the surrounding hilly areas. The lower parts are the most exploited from by agricultural and livestock activities, degrading natural vegetation (Fig. 1-17 and 1-19), that of mixed oaks, pastures, forests and Mediterranean shrubs. Erosive formations, woodcutting and denuding from vegetation, and intense rainfall have favoured and accelerated clay torrents, erosion of slopes, and landslides, that finally continuously fill the Reservoir.

Troendle (2002) summarized that the principal factors of land degradation in Albania are erosion and sedimentation caused by poor land use practices, deforestation or gravel mining. The situation in the Bovilla watershed is quite typical for that; the pluriannual average (1975-1992) of the Total Suspended Solids (TSS) in the Terkuza River (in Zall Herri, downstream the Bovilla dam) oscillated between 400 to 1'200 mg L^{-1} (*see* Fig. 12-19, in Mersinllari *et al.*, Nr. 12 *this volume*). Miho *et al.* (2005) reported also that the suspended solids in the water of the rivers in the Adriatic Lowland often exceeded 25 mg L^{-1}, the EU Fish Directive 2006/44 of the third class limit on the quality of fresh water needing protection or improvement in order to support fish life.

On the other hand, due to intense gravel mining recently in the Terkuza River between Zall Herri and Kameza close to Tirana, the river bed is lowered down 6 m, which enhances the instability of the river banks and erosion (Fig. 1-21). The first sampling to the Bovilla Reservoir in 2006 could not be realized because the bridge between Tirana and the Bovilla dam was broken after heavy rainfall in spring (Fig. 1-21). The intense gravel mining in the Terkuza river bed and the retention of the solid matter by the Bovilla dam had accelerated the breakdown of the bridge; the new bridge is still under construction.

Erosion and sedimentation can be prevented by an increase of vegetation cover along the tributaries and on naked spots, by planting of broadleave trees such as *Quercus frainetto, Q. cerris, Platanus orientalis, Pyrrocantha coccinea,* or *Salix* sp. Most urgent would be reforestation along the lake shore; an **Ecological Protection Belt** (known in Albania as the **Sanitary Belt)** at 320 to 420 m a.s.l. around the lake must be declared *de jure* as a **Central Zone**, in the related zoning of the new protected area of Dajti NP (extended) (WKM 402, 2006; *see* also Fig. 12-6, in Mersinllari *et al., this volume*); a strictly protected buffer zone around the Reservoir must be enforced, but also properly managed (*de facto*) and protected. It must be an urgent measure to preserve the water quality and to facilitate the retention of soil and organic matter, nutrients, and possibly pesticides from the Bovilla Reservoir (Rosenmeier *et al*., 2002; Austin & Sala, 2002). The vegetation type to be established in the buffer zone depends on the soil characteristics, climate and the rate of precipitations. Buffer or filter strips may be seeded with a mixture of grasses, shrubs, and trees that reduce the rate of water runoff, erosion and the inflow of nutrients (Austin & Sala, 2002; Zhou *et al*., 2002).

The agricultural practice close to the shore is not intense (Fig. 1-18) with only modest use of fertilizers and herbicides. Nevertheless, the water quality is influenced by wastes of people and animal manure that reach the streams and tributaries during precipitation events. The human activity in land use and a relatively dense livestock is reflected also in a rather high concentrations of nitrogen (nitrate and ammonium) in the Bovilla water (Çullaj *et al., this volume*) as well as in the bacterial contamination present (Hoxha & Emiri, *this volume*). The runoff of phosphorus and nitrogen from cultivated land might increase and lead to a more eutrophic situation in the Bovilla Reservoir as it has also been observed in both Ohrid and Prespa lakes (Löffler *et al.,* 1998; Spirkovski *et al*., 2001).

1.11. Awareness concerning the water quality in Tirana

Environmental awareness of the local inhabitants seems minimal. Therefore, any future economic development will conflict with the conservation of water quality. Furthermore, also the responsible institutions in Tirana pay little

attention to the watershed management. In 2006, the government incorporated the whole Bovilla area into the Dajti National Park, but no special regulation was included concerning the Bovilla Reservoir and its catchment area. Moreover, no substantial measures were taken for the protection of the water quality. No barriers hinder the wastewater of the inhabitants and their animals to reach the Bovilla Reservoir. On our field trips, we observed that woodcutting continues unlimitedly and trucks transport the firewood from the Bovilla catchment area to Tirana or Kruja (Fig. 1-22). Logging is not prohibited even in the strictly protected zone of Qafeshtama.

As an open system, the Bovilla Reservoir is directly impacted by the state of the watershed area and the human activities in the region. The main problem that endangers the water quality is the strong erosion. Scarce vegetation cover increases the surface of bare soil, increasing surface water flow and decreasing at the same time both water retention by the soil, and the subterranean water. Therefore, the daily and seasonal water fluctuations are high. The water chemistry is continuously altered by chemicals and solid matter washed out from the catchment area. This leads to nutrient increase in the water enhancing algal growth and inducing algal blooms. Such eutrophication processes may lead even to blooms of cyanophytes, many of them being highly toxic (Cox *et al*., 2005).

A continuous monitoring of both the biology and the chemistry of the Bovilla Reservoir and its surrounding catchment region is strongly needed. Furthermore, it is urgently necessary to develop a catchment area management strategy which should then be applied by all interested parties in Tirana and in the region. Appropriate measures, i.e. controlled forestation, stopping of woodcutting and overgrazing must be enforced to prevent harmful events in the reservoir that will decrease the water quality or even cause irreversible damage. Moreover, this would prevent or at least decrease costly measures concerning the drinking water treatment at the processing plant in Tirana and will ensure the population of Tirana a high quality of drinking water also in future.

1.12. Natural protected areas

Three important protected areas: **the National Park of Dajti (extended)** (Tirana and Kruja districts; WKM 402, 2006), **the National Park of Qafeshtama** (Kruja), and the **Protected Landscapes of Mali me Gropa-Biza-Martaneshi** (Tirana; WKM 49, 2007) form all together a large and complex protected zone. It is furthermore planned that Kruja Mountain – Qafeshtama will be declared as a protected area, too. The Ministry of Environment, Forests and Water Administration and the Ministry of Tourism, Youth and Sports, in cooperation with local administrative institutions, research institutions and business representatives and private stakeholders, were charged to were charged on the application of the related Decisions 402 (2006) and 49 (2007), and to take measures on the preparation and the application of the related management plans, and to review the licenses for economical and social activities within the protected areas.

Dajti National Park (declared in 1960 and in 1966; about 33 km^2) covered originally the Dajti Mountain (1'600 m a.s.l.) which rises up from the Tirana plain, in the southern part of the Bovilla catchment area (Fig. 1-2). In 2006, Dajti NP has been extended to 294 km^2, mainly in the northern part, now known as **Dajti National Park (extended)** (WKM 402, 2006). The whole Bovilla watershed is situated in this new protected zone (*see* Fig. 12-6, in Mersinllari *et al., this volume*).

The original Dajti NP is one of the most visited protected areas in Albania. Situated close to Tirana, it shows a wonderful view of Tirana town, as well as of the most representative Albanian relieves and clear vertical zones of the vegetation. The Dajti Mountain region has a wet and fresh climate with annually 1'200-2'000 mm rain. On its slopes, the vegetation belts are well developed, from Mediterranean shrubs with *Erica, Arbutus, Mirtus*, etc. (until 500 m), oak belt (until 900 to 1'100 m) to beech mixed with conifers (until 1'300-1'400 m). As in the Bovilla catchment, the upper part is composed of limestone of the Cretaceous and Eocene period, while the bottom consists of sand mixed with clay. The Dajti terrace (about 2 km long and 600 to 800 m wide) represents a fragment of the old sea terrace formed by the Helvetian sea waves. The terrace belongs to the checklist of Albanian natural monuments. The zone is also rich in other natural monuments like caverns (in Pullumbasi, Skorana, Shutre, Krraba, etc.), the Tujani Pass, ot the Mneri naked zone.

Qafeshtama National Park (ca. 20 km^2; declared in 1966) is situated about 25 km in the northeast of the Kruja town, near the Qafeshtama pass (Fig. 1-2), in northern part of Bovilla; it can be reached from Kruja town, through the Culli municipality. Qafeshtama is famous for the natural forests, mainly with pines, and the spring, known as Mother Queen Spring; its waters are bottled as natural mineral water (*see* Tab. 12-2, Mersinllari *et al., this volume)*.

Protected Landscape Mali me Gropa-Biza-Martaneshi (ca. 253 km^2) is situated in the south-eastern part of the Bovilla catchment (Fig. 1-2). It is the most recent protected area declared by the Albanian government (VKM 49, 2007). The zone is closely related to the extended Dajti NP, and ecologically connected to the Bovilla watershed and the Qafeshtama NP, in its north-eastern part, in continuous mountain chains. Mali me Gropa (Honey Comb Mountain) is the most typical karst ecosystem in Albania, formed in gentle slopes, and built of limestone at 1'500 – 1'800 m a.s.l. The relief is full of karst valleys, dolines, cones, holes and wells, positioned with a strange regularity, like honey combs (ProGEO, 2002). Mountainous pastures and meadows grow

there, mainly sheltering interesting flora and fauna. This landscape is registered also in the checklist of Albanian natural monuments.

All these new areas protected or intended to become protected in near future, surround the region of the Bovilla catchment, including its reservoir (*see* Fig. 12-6, in Mersinllari *et al., this volume*). Surprisingly, they were focused only on a general protection of natural and biodiversity values, similar to other protected sites (Decision 402; VKM, 2006). No special attention was given to the Bovilla area and to the problem of drinking water quality. Is this another fact of lacking awareness that the relevant and responsible institutions show towards this important strategic watershed? It is worth to protect the biodiversity, but more urgent would be to protect the water quality in the zone. Strong measures of the State administration and a strong management are immediately necessary, focusing directly on restoring the terrestrial situation and avoiding any adverse processes that will endanger water quality and human health for the population of Tirana city. Moreover, in the zoning of the extended Dajti National Park, **the area that belongs to the Ecological Belt along the lakeshores (between 320-420 m a.s.l.) must be declared as strictly protected**. To protect the biodiversity is important, but the protection of the water quality must have priority.

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