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Water quality in Albania: An overview of sources of contamination and controlling factors

SULEJMAN SULÇE[1*], EVAN RROCO[1], JAMARBËR MALLTEZI[1], SEIT SHALLARI[1], ZAMIR LIBOHOVA[2], SOKRAT SINAJ[3], NIKOLLA P. QAFOKU[4]

[1]Agriculture University of Tirana, Kodër -Kamëz, Agronomy Building no 7, 1019 Tirana, Albania.

[2]USDA-NRCS National Soil Survey Center, 100 Centennial Mall North, Federal Building, Room 152. Lincoln, NE USA 68508.

[3]Agroscope, Institute for Plant Production Sciences (IPS), Route de Duillier 50, P.O. Box 1012, 1260 Nyon, Switzerland.

[4]Pacific Northwest National Laboratory, Richland, WA 99352, USA

*Corresponding author; E-mail: sulejmansulce@yahoo.com

Abstract

Albania is a country rich in freshwater resources, both surface and ground waters, but the water quality has deteriorated significantly over the last several decades. The objective of this paper is to present a general overview of the issues related to the surface and ground water quality in Albania and discuss about sources and controlling processes. The sources of metal and organic contaminants are: i.) Many oil industry severely contaminated, abandoned or operating sites; ii.) Cr, Ni and Cu mines, mainly in the north; and iii.) Old processing factories. The sources that contribute to the high concentrations of N and P are: i.) A growing number of fertilizer and pesticide storage facilities (ten of them are considered “hot spots” and significant sources of N and P); ii.) Other identified point sources, industrial or urban; and iii.) Urban liquid and solid waste; the vast majority of residential areas with more than 5,000 inhabitants have no wastewater treatment plants, and the waste waters are directly discharged into rivers or the Adriatic and Ionian Seas. It is estimated that these sources supply up to 20% of the N and P transported to water collection basins. Another important contributing factor to pollution of waters in Albania is erosion. The erosion rate, varying from 1 to 30 t ha^{-1} yr^{-1}, is the highest in the southeast Europe. The high erosion rates are mainly due to the lack of soil vegetative cover and poor natural resources management practices. Especially over the last two decades, the soil vegetative cover has been removed due to massive uncontrolled deforestation, mainly the result of lack of enforcing forest protection laws and policies. In addition, abandoned agricultural lands and overgrazed pastures at higher elevations have rare vegetation and the agricultural land-use management practices are outdated. In conclusion, we propose that systematic research efforts should be conducted to: i.) Document all sources of water contamination and types of organic and inorganic contaminants; ii.) Quantify amounts and fluxes of contaminants from sources to surface and ground waters; and, iii.) Determine the best research based remedial strategies to remove contaminants from waters and decrease risks to humans and wild life. In addition, adequate rigorous and continuous monitoring to determine potential risks to aquatic ecosystems should be established and implemented throughout the Albanian territory. Monitoring plans for integrated transboundary waters should be regularly updated and a comprehensive database on water pollution should be created and maintained.

Keywords: Water quality; water pollution; surface water; groundwater; Albania; erosion; erosion rate.

1. Introduction

Albania is a rich country in freshwater resources, but the quality of this water has deteriorated significantly especially over the last several decades. The factors that have caused this deterioration are numerous and of different nature. Probably, the most important one is that there have been significant social changes in Albania in recent years, such as the change of the political regime from a one party communist system to a democratic system, and the severe downturn in economy prior to the fall of communism. Other important natural and anthropogenic factors are climate, hydrology, vegetation coverage, land use, geology, and topographical characteristics, which have contributed in different ways to the deterioration of the water quality in Albania.

In Albania, there are approximately 150 streams and rivers flowing from east to west, including relatively big rivers such as Drini, Shkumbini, Devolli, Osumi, Semani, Vjosa, and Bistrica (Kabo, 1990) (Figure 1). The water of the rivers is used in urban areas, agriculture, aquaculture, recreation, hydropower, and industry. The upper reaches of major rivers flow through steep terrain contributing significantly to erosion in the eastern highland areas and alluvium deposits in the western flat areas.

There are a number of deltas, lagoons and wetlands in western Albania, which are critical because of both their tremendous biodiversity and their function as wildlife habitats. For this reason, the wetlands have both national and international protection status. However, the transport of contaminants and colloids from the eastern part of the country has deleteriously affected these transitional bodies of water at the interface of rivers and seas.

Pollution from mobile aqueous species of nitrogen (N) and phosphorus (P) is one of the most pressing environmental issues associated with degrading of the water quality because it often results in eutrophication (Viličić et al., 2010). Nitrogen and P are mostly associated with agricultural activities and are considered nonpoint source pollutants. However, they can have impacts similar to those of other soluble substances transported with colloid and sediment particles from point source pollutions, which are monitored in specific areas and are relatively easy to manage.

Ammonium (NH_4^+), nitrite (NO_2^-), and nitrate (NO_3^-) are the main inorganic ionic species of N in aquatic systems (Wetzel, 2001; Kopáèek et al., 2004; Rabalais, 2010). These inorganic N aqueous species are transported via surface runoff and subsurface groundwater. In addition, dissolution of N-rich geological deposits, soil erosion, and biological mineralization of organic matter contribute to increasing concentration of N aqueous species in surface waters and groundwater.

Anthropogenic N and P can enter in ecosystems via point and nonpoint sources. Phosphorus is found in all soils in different forms: soluble, adsorbed, precipitated, and organic (Frossard et al., 2000). The mechanisms involved in soluble P transport include initial desorption or dissolution of P bound to soil particles, followed by transport to streams or rivers (Haygarthand Jarvis, 1999). The inorganic P in surface waters is in the form of PO_4^{3-}, HPO_4^{2-} and $H_2PO_4^-$ (Pierzinski et al., 2000).

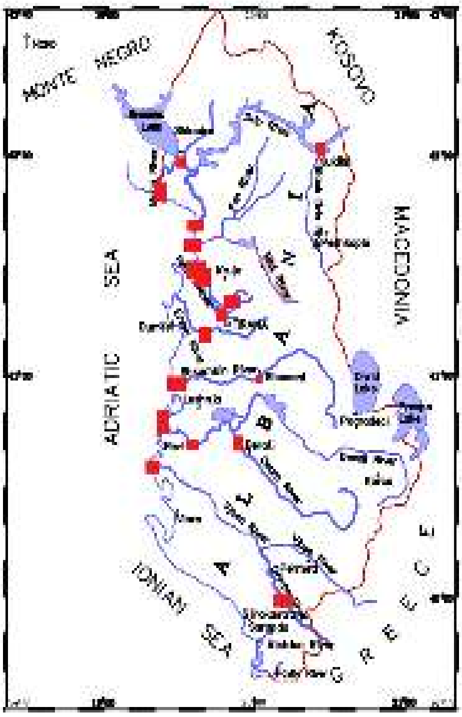

Figure 1. Hydrologic map of Albania showing major rivers and permanent water monitoring stations (represented by red squares and rectangles) (from *Institute of Hydrometeorology, modified by Albanian National Agency of Environment*).

Total concentrations of N > 50 mg NO_3- N L^{-1} and P > 100 mg P L^{-1} may cause eutrophication. The main anthropogenic sources of N and P are listed in Table 1 (Carpenter et al.,1998; Pierzinski et al., 2000; Howarth et al., 2000; Smith, 2003;Galloway and Cowling, 2002).

As a candidate for the European Union (EU), Albania has redesigned the environmental protection laws. The 2011 environmental law and, especially, the standards for fresh waters are very similar to those of other EU countries (Water Framework Directive 2000/60/EEC). The major goal is to attain the same water quality indicators as EU by 2020 (Inter Sectorial Strategy for Environmental Protection, 2015-2020). However, major challenges related to implementation and enforcement of the law still remain, and, unfortunately, water quality issues do not currently constitute an emergency for the Albanian government.

Table 1. Major anthropogenic sources of inorganic N and P in aquatic ecosystems.

Point sources
• Liquid waste from cities near water flow (mainly rivers)
• Waste water from livestock and farming (cattle, pigs, and chickens)
• Industrial wastewater effluents
• Runoff and infiltration from waste disposal sites
• Runoff from operational mines, oilfields, and unsewered industrial sites
• Overflow from combined storm and sanitary sewers
Nonpoint sources
• Use of animal manure and inorganic N fertilizers and the subsequent runoff from agriculture
• Runoff from burned forests and grasslands
• Runoff from N-rich forests and grasslands
• Urban runoff from unsewered and sewered areas
• Septic leachate and runoff from failed septic systems
• Runoff from construction sites and abandoned mines
• N loadings to ground water and subsequently to receiving surface waters (rivers, lakes, estuaries, and coastal zones)
• Emissions into the atmosphere of reduced (from volatilization of manure and fertilizers) and oxidized (from combustion of fossil fuels) N compounds and the subsequent atmospheric (wet and dry) deposition over surface waters
• Other activities that can mobilize nitrogen and phosphorus, such as wetland drainage

The objective of this paper is to present a general overview of surface and ground water quality in Albania and analyze sources and related controlling processes. Specific objectives are to: (i) identify and assess contributions of point and non-point sources to water pollution; (ii) determine the role of the transport of soluble and/or colloid bound forms of contaminants (mainly macronutrients, such as N and P) in water pollution and quality; (iii) assess the influence of macronutrients transported via streams and rivers on lagoon and coastal wetland ecosystems of Albania; and (iv) identify adequate measures for the protection of these ecosystems.

2. General overview

2.1. Geology

Geology and parent material control to a considerable degree the physical and chemical properties of soils. The adsorption and release of contaminants depend on the mineralogical composition of the parent material or rocks from which the soil is formed. The geology of Albania is composed mainly of three rock formations: (i) sedimentary rock in the south and western plains; (ii) conglomerates in central part of the country, and (iii) magmatic rock in the east and north-east.

The major rock formations influencing the soil properties in the most important watersheds include: (i) calcareous rock; (ii) ultra-basic and basic ophiolitic rocks (diabasic composition); (iii) flysch (including sand and limestone); (iv) the Virgla Formation (limestone); and (v) sediment (“alluvions”).

There are no geological formations rich in N in Albania. However, in the south, phosphate minerals originating from sedimentary rocks have a relatively high P concentration (up to 11% P in the apatite mineral). In the north-central part of Albania, which is dominated by magmatic rocks, there are large areas with geochemically high levels of potential contaminants such as Cu (>2000 mg/kg soils), Cr (>5000 mg kg^{-1} soil), and Ni (>8000 mg kg^{-1} soil), which serve as sources for these contaminants.

2.2 Physiographic Regions and Soils

One of the major factors determining physiographic divisions in Albania is the sharp orographic gradient that cuts through diverse geology. This leads to a dense hydrographic network in which precipitation is quickly dispersed. The major physiographic regions areshown in Figure 2.

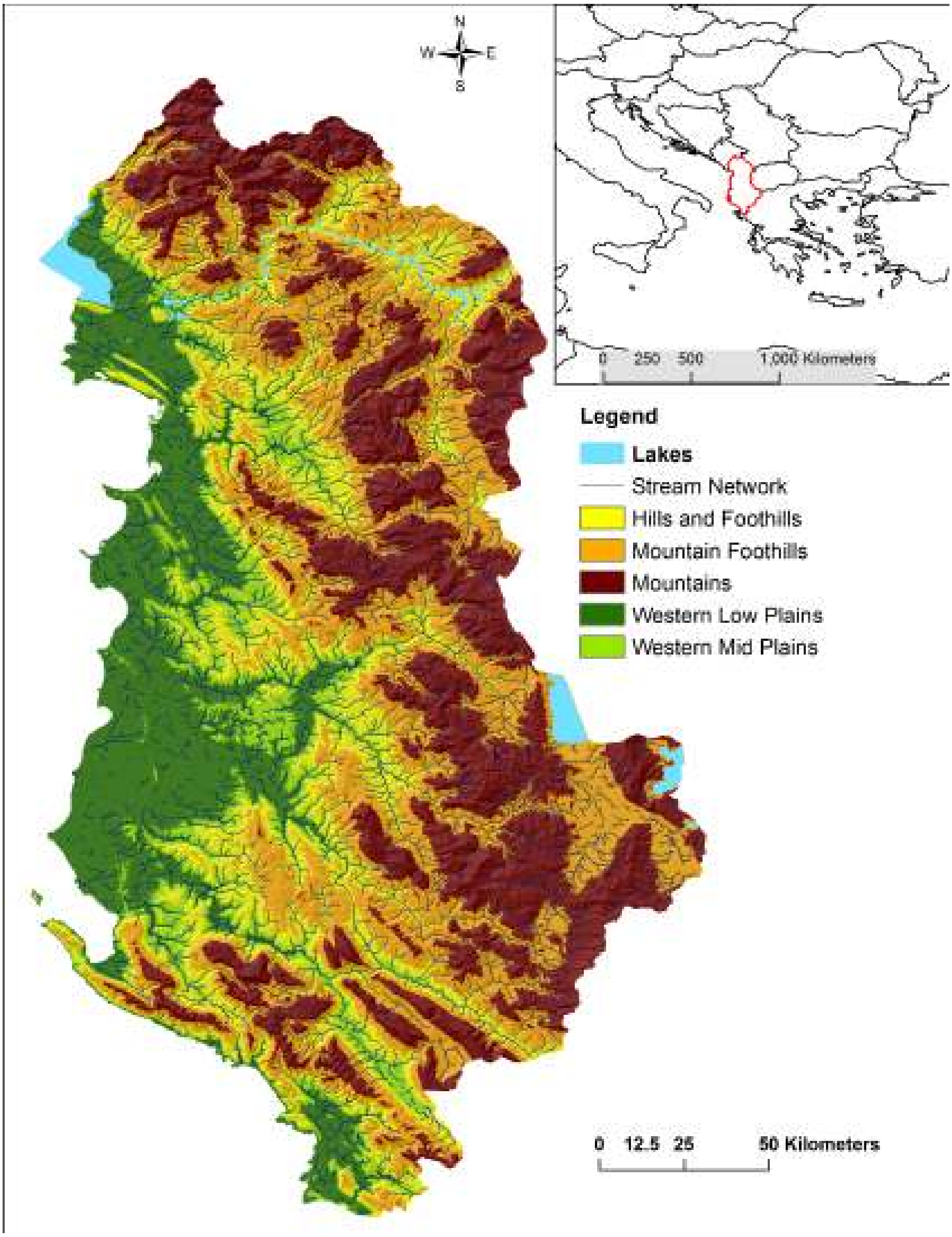

Figure 2. The main physiographic regions and stream network of Albania.

According to the National Soil Classification System (NSCS), which is based on soil-forming factors (climate, vegetation, geology, topography/relief) and physical and chemical soil properties, soils are divided into four broad vertical regions (Veshi and Spaho, 1988). According to the FAO classification, there are six major soils types/orders: (i) Cambisols (30.6%); (ii) Luvisols (25.3%);(iii) Regosols (13.2%); (iv) Phaeozems (10.5%);(v) Leptosols (8.8%), and in the western coastal areas, (vi) Fluvisols (5.5%) (SSI, 2002, Figure 3).

Figure 3. Major soil types of Albania (from *Soil Science Institute, 2002*).

The Soil Science Institute of Albania conducted an assessment in 1988 of the potential *capability* and *suitability* classes of soils (based on soil fertility indicators such as macronutrients and soil organic carbon) and grouped soils into 10 major classes. The presence of macronutrients in arable lands (Table 2) indicates that soils are moderately rich in N (63% of the total surface layer) and P (67%) and rich in potassium (K). The arable lands are dominated by loamy soils (50%), followed by clayey soils (30%) and sandy soils (20%).

Table 2. Concentration of humus, N, P, and K in arable soil (Soils Science Institute, 1988).

No.	Level	Humus (%)		Total-N ($g\ kg^{-1}$)		Available-P ($mg\ kg^{-1}$)		Available-K ($mg\ kg^{-1}$)	
		Arable land (%)	Range	Arable land (%)	Range	Arable land (%)	Range	Arable land (%)	Range
1	Low	44.6	<1.5	36.9	<1.0	33.0	<10	8.2	<80
2	Medium	45.6	1.5-3	41.9	1-1.5	41.6	10-20	43.7	80-
3	High	9.8	>3.0	21.2	>1.5	25.4	>20	48.1	>150

2.3. Land Use and Environment Impacts

Albania has a surface area of 2,874,800 hectares; 24.4% of the total surface area is agricultural land (699,500 ha); 36.9% is covered by forests (1,062,770 ha); 14.4% is used as pastures and meadows (414,517 ha); and 24.3% of total area is comprised by urban areas, lakes, and reservoirs (699,013 ha).

Importantly, the land use in Albania has changed drastically since the beginning of 90'when the political regime changed. Arable land has decreased by 34%, from 630,000 ha in the 1990to approximately 420,000 ha in 2012. A large part of the remaining agricultural land, however, has been abandoned (approximately 15%) and thus has become susceptible to significant and, in some areas, dramatic erosion.

Currently, the main crops grown in Albania are forage (approximately 40%), cereals (approximately 35%), and fruit trees and vegetables (approximately 25%) (INSTAT, 2013). Before the 1990s, approximately 50% of all agriculture land was used for grazing or was part of forests or wetlands. The rest almost 25% was cultivated with cereals, 10% with forage crops, 7% with industrial crops and almost 8% with fruits and vegetables. Steep lands (>15% slopes) once used for grazing and later cultivated, regardless of their poor fertility and limited economic returns, are currently abandoned and prone to degradation and high rate and extent of erosion.

The root-cause for the environmental concerns associated with soils and land use in Albania, specifically with regard to soluble and/or solid-phase associated forms of plant macronutrients (i.e., N and P) and their subsequent transport from the upstream watersheds to coastal areas, can be related to: (i) severe erosion from steep sloping areas that leads to the removal of solid-phase associated N and P via colloidal transport in surface waters, streams and rivers, (ii)leaching and percolation of soluble forms of N and P via surface water and groundwater and their subsequent transport to streams, rivers and lakes; (iii) increasing uncultivated fallow areas of abandoned agricultural lands that significantly and/or dramatically contribute to surface runoff, erosion, and transport of N and P to streams, and (iv) current cultivation and management practices (e.g. fertilization and irrigation)for forage and cereals, e.g., alfalfa, maize and wheat are outdated and substantially contribute to the release of N and P into the aqueous phase and subsequent removal.

2.4. Climate and Vegetation

The climate of Albania is Mediterranean on the coast (with mild, rainy winters and hot, dry summers), while it becomes slightly more continental in the interior, with mild summers (owing to the high elevations) and cold winters. The rainfall varies from 1300 mm/year in the south to 2000 mm/year in the north and increases from west to east. Rainfall distribution during the year is irregular: 5-10% in summer, ~40% in winter and ~32% in spring. High-intensity, short-duration rainfall events account for more than 15% of the total rainfall. The mean winter temperature is about 7° C in the western coastal areas. The mean summer temperature is about 24 °C but can reach 30° C in south (Albanian Academy of Sciences 1988).

The Albanian vegetation is different in the two climatic zones; in the western and southern part of the country the vegetation is predominated by Mediterranean maquis, whereas in the eastern and northern part is characterized by the presence of coniferous and beech forests. Due to the high elevation [almost 70% of the territory is more than 200 meters above sea level (asl), while the average altitude is about 708 m asl, or almost double the European altitude] and relatively steep slopes, Albania has very diverse micro-zones with different climates, which enable a rich biodiversity (Miho et al., 2013). The terrestrial ecosystems, in addition to the Mediterranean evergreen and deciduous shrubs and pine forests, include alpine and sub-alpine pastures and meadows. Forests and pastures cover approximately 36% and 15%, respectively, of the terrestrial ecosystem, and most of them are alpine or sub-alpine in character.

2.5. Water Resources

The Albanian territory covers approximately 65% (43,905 km^2) of the total watershed area of the rivers that drains to the west coast (Cullaj et al., 2005), the rest 35% is part of the territory of Republic of Kosovo and FYROM. The mean annual rate of discharge by all rivers in Albania combined is approximately1308 m^3 s^{-1}and varies from 649 to 2164 m^3 s^{-1} during the year. Rivers contribute to approximately 70% of the total water discharge whereas groundwater contributes the remaining 30%. The annual groundwater volume is about 13,000

m^3 $capita^{-1}$ $year^{-1}$ (Stanners and Bourdeau, 1995). There are approximately 247 natural lakes throughout the country, and most of them are karstic or glacial in origin andvery small (~1 ha).

2.6. Erosion

Soil colloids with substantial amounts of sorbed N, P, trace metals, and organic matter of different types, may be transported to rivers, lakes and seas. Usually, the surface soil A and AB horizons, which are rich in macronutrients and organic matter, are eroded the most. Erosion is influenced by several factors, such as climate, rainfall intensity and distribution, geology, morphology, land cover, and slope characteristics (Wischmeier and Smith, 1978; Nearing et al., 1999). The calculated slope length and LS factor derived from the NASA Shuttle Radar Topographic Mission (SRTM) elevation data (Jarvis et al., 2008) is as high as 160, especially for the hills and foothills, mountains foothills, and mountains physiographic regions (Figure 4).This indicates a high potential for soil loss through erosion. The long-term evidence on erosion rates during the last two decades in Albania is based on limited surveys and is sporadic and fragmented (MOEF, 2012-2014). Erosion data from other sources for the Mediterranean regions are often incomplete and contradictory. The lack of vegetative cover is identified as one of the major drivers for the higher erosion rates (Kosmas et al., 1997).

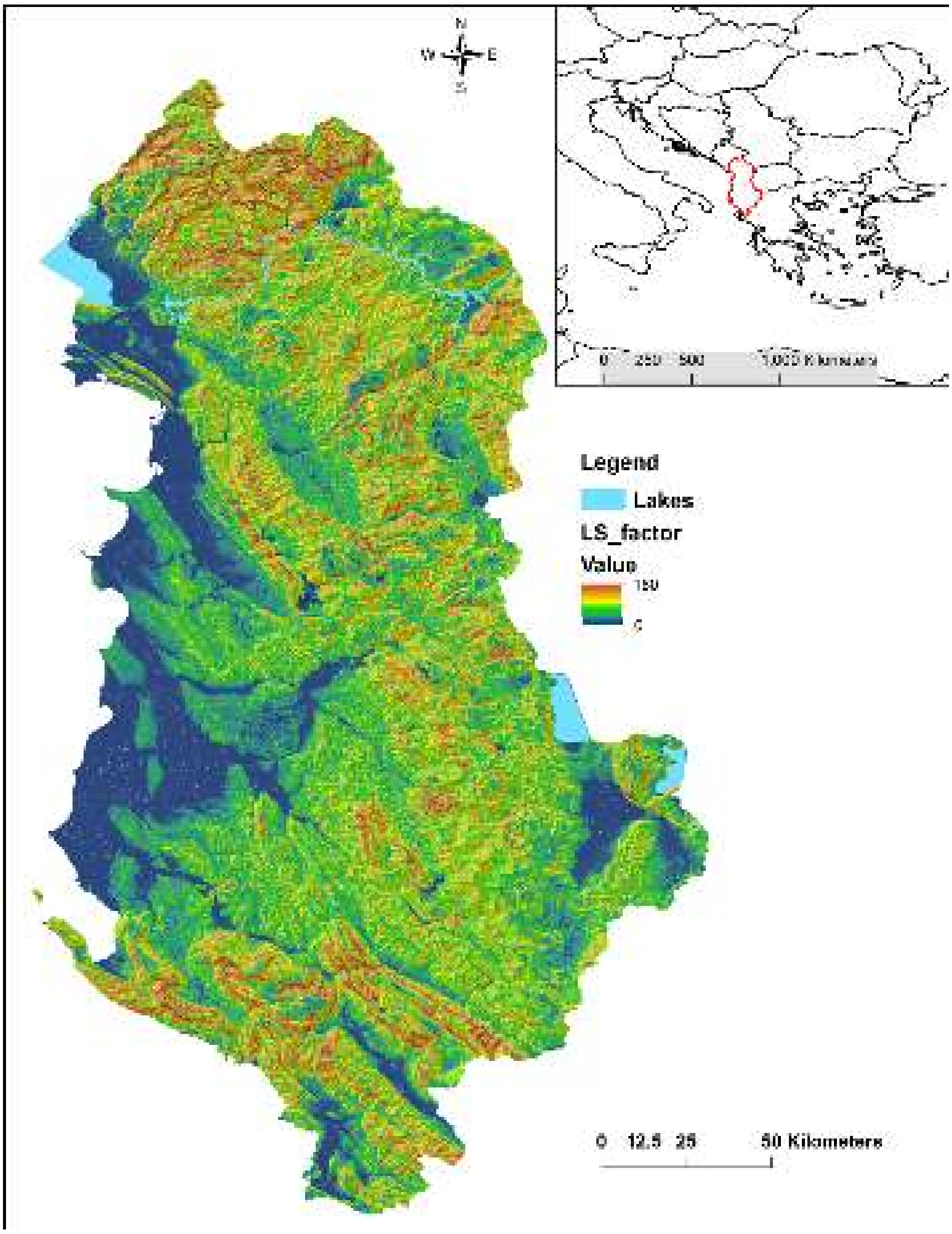

Figure 4. Universal Soil Loss Equation (USLE) LS factor for Albania calculated based on SRTM elevation data (Grazhdani and Shumka 2007).

The erosion rates in Albania are expected to be much higher than in other European countries due to the higher degree of deforestation, overgrazing, high-intensity use of biomass, and cultivation of steeply sloping areas. The reported erosion rates in different studies conducted in Albania are inconsistent. On one hand, according to the study by Grazhdani and Shumka (2007), the average erosion rate is greater than 10 t ha^{-1} y^{-1}; in some areas in south, the rate can reach 100 t $ha^{-1}y^{-1}$. On the other hand, as stated in the monitoring reports of the Albanian Ministry of the Environment (MOEF, 2010-2012), the erosion rate in Albania varies from 3.6 t ha^{-1} y^{-1}in pastures to 18.3 t $ha^{-1}y^{-1}$in corn cultivated areas (AKM report, 2012). These rates are similar to those reported by Cerdan et al.(2010), which were determined in experiments conducted in 81 sites (a total of 2741 plots) located in 19 European countries. It should be emphasized, however, that in areas prone to high erosion, as described by Grazhdani and Shumka (2007), there was no vegetative cover for10 to 20% of the time during the year and the intensity of rainfall was twice as high as that in the central part of the country.

Earlier studies have estimated the nutrient losses due to erosion in Albania to 100,000 t y^{-1} for N, 60,000 t y^{-1} for P and 16,000 ty^{-1} for K (Kovaci et al., 1996). Other authors (Gjoka and Cara,1996) estimated that annual losses are approximately 70,000 ty^{-1}, 40,000 ty^{-1}, and 6,400 ty^{-1} for N, P, and K, respectively. In a more recent study, Binaj et al., (2014), found that the N and P losses were respectively around 40 000 and 24 000 tons. Although the data provided by Binaj et al. (2014) were significantly smaller than those presented in previous studies, they also stated that erosion is the main factor of soil degradation which contributes to the removal of substantial amounts of plant macronutrients. Practically, 90% of the N added into arable lands with fertilizers is used to replace N losses from erosion, whereas the amounts of P added with fertilizers are much lower than the losses through erosion.

3. Status and characteristics of major water bodies

3.1 Nutrient load and sources and transportation of solids

Supplemental amounts of plant nutrients are usually added to soils through inorganic and organic (mainly animal manure) fertilizers to achieve high yields for most of the crops. The rate of N and P fertilizers application in Albania (122 and 66 kg $ha^{-1}y^{-1}$, respectively) is comparable to that of other European countries (INSTAT, 2013; EUROSTAT, 2014). The rate of fertilizer application has changed over the last two decades. For example, approximately 121 kg ha^{-1}N, 21 kg ha^{-1}P, and 1.5 kg $ha^{-1}$of K (a total of 125.5 kg ha^{-1} N,P,K) was used in 2012, as opposed to a total of 150.4 kg ha^{-1} in 1990 (INSTAT, 1990 and 2013). Of particular interest is the high ratio of N: P (6:1), which affects water quality. The total amount of animal manure applied in arable land in 2012 was about 6 million tons, or 8.9 t ha^{-1} y^{-1} (INSTAT, 2013). However, not all nutrients added into soils with organic and inorganic fertilizers are taken up by crops. For example, it is estimated that only 40 to 60% of the amount of N applied is taken up by crops, and this depends on the plant type, soil properties, management practices, temperature and rainfall (Soil Science Institute, 1996).

Data from long-term experiments conducted in Albania in different soil types and under various management practices showed that the nitrogen rate of uptake (NRU) by plants was, in average, not higher than 55% for different crops. Thus, at least 45% (or more) of applied N is subject to leaching, volatilization, denitrification, and sorption (when is applied as NH_4^+). Studies have shown that almost 10% of the applied N was found in the soil after harvesting (Baumgärtel et al., 1989), most likely due to root exudation, which for wheat has been quantified to be 29 kg ha^{-1} (Rroço and Mengel, 2000).

Long-term measurements of the amount of nutrients leached at the field and country scale are lacking in Albania because of the difficulties associated with such large scale measurements (Sulce, 1996). In the regions around the Mediterranean Sea, N leaching is in the range between 99 and 289 kg N ha^{-1} y^{-1} (Ramos et al., 2002; De Paz et al., 2009), although other authors have reported moderate, such as 50 kg N ha^{-1} y^{-1}, or even lower amounts (Romic et al., 2003; Costandin et al., 2010; Sanchez-Martin et al., 2010). Recent preliminary data from a study conducted in Albania showed that N leaching can reach 50 kg N ha^{-1} y^{-1} (Beqaj et al. 2016).

Phosphorus leaching and accumulation in the groundwater have rarely been considered important due to the relatively low P mobility in soils. However, a few studies have shown an environmentally significant export of P in some agricultural drainage (e.g., deep sandy soils, soils high in organic matter, and soils with high P concentrations from long-term over-fertilization and/or excessive use of organic waste) (Sims et al., 1998). The amount of P leached from irrigated soils, mainly sandy soils, is reported to be approximately 2-3 kg ha^{-1} (Erickson et al., 2005; Sinaj et al., 2002), whereas it does not exceed 1 kg ha^{-1}in soils with lower sand content (Aronsson et al.,2011; Sinaj et al.,2002). Recent ongoing lysimeter studies in two Albanian soils with different sand contents under irrigation showed P leaching of less than 0.1 kg $ha^{-1}year^{-1}$ (Rroço, 2016, personal communication), demonstrating again low P mobility.

The release of P from soils to surface waters is controlled by a variety of factors, such as soil properties, crop type, management practices, surface runoff, erosion, and preferential flow in the subsurface (McDowell et al., 2001). In areas with soils that have been degraded as a result of significant erosion and/or poor management practices, P removal via runoff is significant. Studies in Albania have shown that the <2μm size fraction separated from soils was the main sink of water-soluble P (as phosphate), and the P released and transported into surrounding rivers and lakes increased significantly when soil aggregates became unstable (Sinaj et al., 1997).

The most common method of calculating the losses of nutrients via erosion is based on the amount of the soil particles transported with surface waters and the average contents of nutrients in these particles; however, this method provides only estimates of nutrient losses, which may or may not be accurate (Joneset al., 2003). According to the World Bank estimates (WB, 2007) approximately 350,000 ha, or close to 60% of the agricultural land in Albania are subject to significant erosion, with a loss of soil estimated at approximately 25 million t y^{-1}. Studies conducted in recent years, have demonstrated that the annual amount of soil and nutrient loss from the most important watersheds in Albania are considerable and highly variable (Table 3). Pano (2008) reported that the rivers of Albania deposit, on average, approximately 53.2×10^6 t y^{-1}into the sea.

Table 3.Hydrographic data (Kabo, 1990–91), average solids and nutrient values of the principal Albanian rivers (AKM, 2010-2011; Abazi [Ishmi River], 2014 Malltezi and Sulce [Mati River], 2013-2014; Pano, 2008; Cullaj et al., 2005).

River	Length (km)	Drainage basin (km^2)	Average flow ($m^3 s^{-1}$)	Mean value of sediments ($g m^{-3}$)	Total solids transported per year ($10^3 Mg y^{-1}$)	Mean NO_3 ($mg l^{-1}$)	Mean PO_4^{3-} ($\mu g l^{-1}$)
Drini	285	11756	352	1250	13860	0.95	17
Buna	1.5	5187	320	Nd	Nd	0.77	32
Mati	115	2441	103	590	2020	1.21	114
Ishmi	74	673	20.9	3070	2020	20.4	1316
Erzeni	109	760	18.1	5640	3180	0.56	58
Shkumbini	181	2444	61.5	3040	5790	18.2	914
Devolli	196	3130	49.5	5580	8690	2.9	327
Osumi	161	2073	32.5	3510	3590	3.3	144
Semani	281	5649	95.7	2340	13200	14.6	1090
Vjosa	272	6706	195	1000	6710	0.41	27

The monitoring of the water quality of rivers in Albania is conducted by the National Environment Agency, which has different stations located throughout Albania. Due to the limited amounts of $NH_4^+$and NO_3^- and very large seasonal variations, nitrate concentrations are reported based on the annual average calculated from data collected in multiple years. The water quality based on average concentrations of N (as nitrate) and P for the Drini, Buna, Vjosa, Osum, Devolli, and Erzeni Rivers is classified in the classes I and II pursuant WFD, and poor to bad for the Ishmi, Shkumbini, and Semani Rivers (classes III, IV,and V). Based on the EU guidelines (EU: 78/659/EEC & FWD, 2008) for water quality (limit of 50 mg l^{-1} for nitrates and 0.5 mg l^{-1} for orthophosphates), only the Drini, Buna, and Vjosa Rivers are classified as "high-quality" waters.

The rivers with poor or bad water quality flow through major urban centers, that contribute even more to the increase of the concentration of N and P through their wastewater releases. Various industries, untreated solid urban waste and waste waters play a major role in deteriorating water quality. The Drini and Mati Rivers have hydropower dams and reservoirs where solid and total suspended particles (TSS) are deposited, and hence, their downstream flows are cleaner. Meanwhile, the Devolli, Erzeni, and Ishmi Rivers flow, in large part, through sandy soils that are easily erodible contributing to the poor water quality of these rivers.

3.2. Anthropogenic sources

Solid urban waste, wastewaters and land industrial discharges are a growing concern in Albania. There are approximately 30 degraded industrial sites with high potential risk for pollution. These industries include oil, metallurgy, metal processing, and mining for Cr, Ni, and Cu as well as enrichment factories and pesticide storage units located throughout the country. Ten of the sites are considered "hot spots." These sources contaminate waters with trace metal elements and pesticides with high toxicity as persistent organic polyphenols (POPs), Hg, Cr, and other heavy metals (Zn, Cu, Ni, and Pb). Wastewaters are major contributors to nutrient leaching. To date, there are six wastewater treatment plants operating in the country, namely in Vlorë, Korcë, Pogradec, Sarandë, Kavajë, and Shirokë. In addition, there is currently a plan to build wastewater treatment plants in all other major urban centers in the country that currently discharge their wastewaters directly into the rivers.

Effluent discharges have the potential to significantly alter many different aspects of aquatic systems, including nutrient uptake efficiency (Haggard et al., 2001; Marti et al., 2004), organic carbon content (McConnell, 1980), and bacterial levels (Petersen et al., 2005). The contamination of rivers is directly linked to human activities, including the discharge of domestic and industrial waste water (Richard et al., 2009). Albania has only recently been building adequate wastewater treatment plants (WWTP) for the major cities. Although approximately 55% of the Albanian population lives in urban areas, only approximately 20% lives in major cities being served by WWTPs (Figure 5).

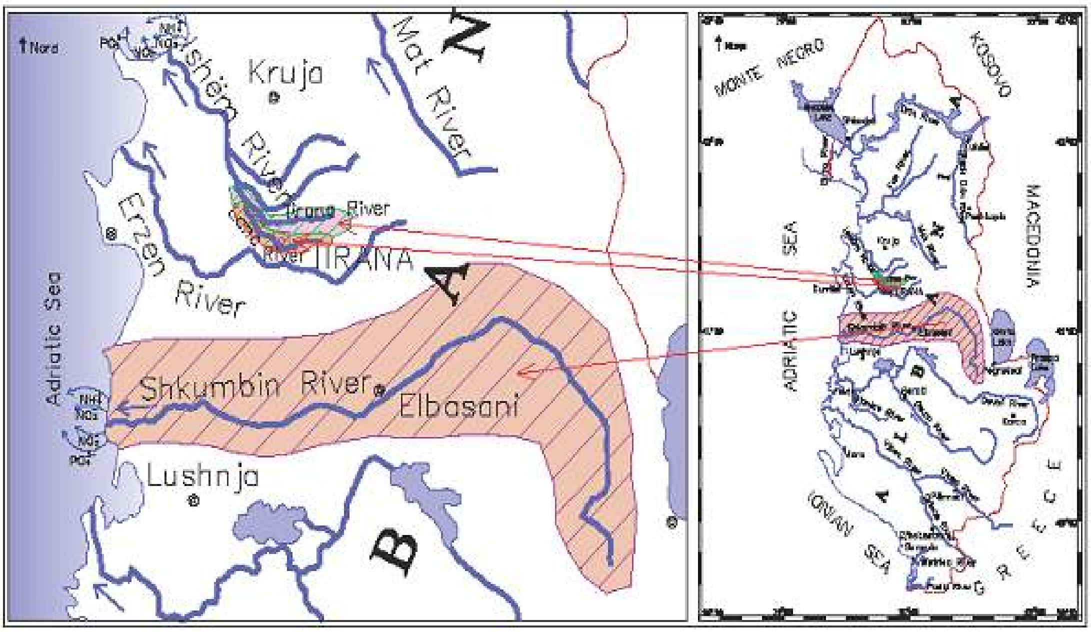

Figure 5. The watershed most impacted by direct wastewater discharge (from Abazi, 2003).

In general, streams in agricultural areas are polluted predominantly by nonpoint sources of nutrients (Carpenter et al., 1998). In urban areas, in particular, point sources of pollution, such as municipal and industrial wastewaters, contribute significant nutrient loads (Haggard et al., 2005).

Table 4 provides estimates of N and P concentrations in the main rivers in Albania, based on the average N and P concentrations in wastewaters, (Tchobanoglous et al., 2003). In the central part of the country, the Ishmi River watershed includes the City of Tirana and its suburbs wiith a population of approximately 1 million inhabitants, which is the major contributor to N and P pollution, with 876 and 153 tons per year, respectively. These data are also suggested by previous surveys. According to Abazi (2003), for example, the point sources generally account for 80% of nutrient inputs to the Ishmi River in central Albania, where population density is higher. The point sources account for 10%, 15%, and 23% of N and P inputs in other rivers such as Buna, Semani, and Shkumbini.

The contribution of nonpoint and point sources varies according to the size of the watershed, population, and agricultural activities. Not well documented point source pollution areas are also very important in Albania due to the fact that housing units have been illegally built in agricultural lands. Official municipality data indicate that approximately 480,000 private housing units have been built outside urban or rural areas. Because these units have no or failing septic systems, they all serve as important sources of N and P. Their contributions, however, remain unquantified or unaccounted for. In a study conducted in Devolli River, samples were taken before and after the irrigation season at three different points of the river to assess the impact of a population of almost 22,000 and that of the agricultural activities conducted at the area (Beqaj et al., 2015). The results indicated a clear increase in the N and P concentrations in the river water as it flowed through the populated area clearly demonstrating the deteriorating impact of human activity although the concentrations of both N and P were still low enough that the water could be used for irrigation (Beqaj et al., 2015).

Table 4. The average total concentrations of N and P of the typical composition of untreated domestic waste water and respective inhabitants for each watershed that discharges waste water directly into a river.

Watersheds	Population	Average Dissolved Inorganic Nitrogen (total N)	Average Phosphorus (total P)	Total N (t y^{-1})	Total P (t y^{-1})
Ishem	1000000	40*	7*	876	153
Seman	220000	40	7	192	33
Vjose	45500	40	7	39	6
Buna	272000	40	7	238	41
Shkumbin	188000	40	7	164	28
Total				1511	264

* The values are the typical composition of untreated wastewater in Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy, Inc., 4th ed., revised by George Tchobanoglous et al., 2003)

Figure 6. The most important lagoons and lakes of Albania (from *Shallari, 2013*)

3.3. Lagoon characteristics

A large portion of soil particles, especially suspended solids and colloids, have been and still are deposited in transitional waters (wetlands and lagoons) (Figure 6). The mountainous and hilly areas of Albania to the east and the relatively flat areas to the west resemble a natural amphitheater. The western parts of Albania have very high values of the topographic wetness index (Beven and Kirkby, 1979) indicating areas of accumulating water, while the eastern part has low values indicating areas of water runoff due to steep slopes (Figure 7).

The lagoons in the western part of the country are located near the river deltas (Butrinti Lagoon is near the Pavllo River; Narta Lagoon is near the Vjosa River; Karavsta Lagoon is near the Shkumbini River delta in the north and Semani River delta in the south; Patok Lagoon is near the Mati River delta in the north and Ishmi River delta in the south; Kune-Vain Lagoon is near the Drini River delta in the north and Mati River delta in the south).

Currently, the rivers have deviated from lagoons either naturally (e.g., the Vjosa, Shkumbini, and Semani Rivers), or because of the construction of hydropower plants, which trapped sediment (the Drini Rover),or other land reclamation activities. The soil particles deposited in the lagoons are similar to the suspended colloids carried out by rivers (Pano, 2008). The solids of organic origin are subject to biochemical changes, including mineralization and the release of high amounts of soluble N and P in the water column (Jonsson, 1997; Selig, 2003) which then increases the risk of eutrophication.

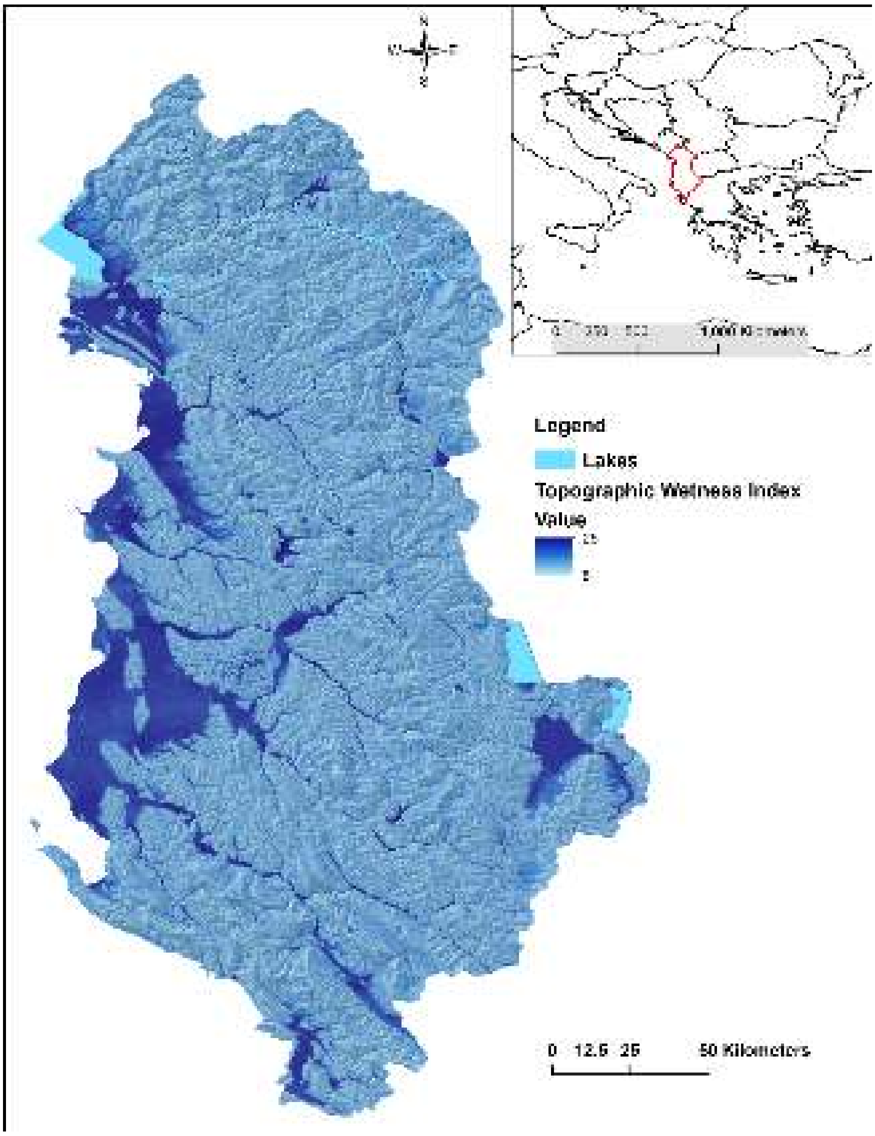

Figure 7. Topographic wetness index showing high values for the wet areas to the west, where the majority of wetlands and lagoons are located.

The data included in Table 5 shows that the four lagoons that were subject of recent studies have soluble N and P at levels that are moderate and comparable with other Mediterranean lagoons. The status of the Butrint and Narta Lagoons is mainly oligotrophic most of the year, and that of the Patok and Narta Lagoons is transitory.
Lagoons, together with wetlands, are part of coastal areas and important for the economy and tourism industry. They serve as a buffer zone between the sea and the agricultural areas. One of the most important, although "invisible," functions of lagoons and wetlands is the biological filtering of nutrients and heavy metal overloads through the vegetation.

Table 5. Data on nutrients, chlorophyll and trophic states for transitional waters.

Transitional waters	Protection	Surface (km^2)	Dissolved N ($\mu mol\ l^{-1}$)	Dissolved P ($\mu mol\ l^{-1}$)	Chlorophyll ($\mu gram\ dm^{-3}$)	Status based on N and P concentration	References
Butrinti	a	16.0	3.51±2.7 (*n=14*)	0.055±0.04	1.8±0.47	Mostly oligotrophic	Sulce and Bani (2011)
Narta	c	29.90	3.3±4.5 (*n=7*)	0.06±0.084	2.38±5.62	Mesotrophic-oligotrophic	Bino et al. (2004), Cako et al. (2014)
Karavasta	a	43.3	4.8±6.6 (*n=9*)	0,079±0.03	0.33±0.35	Oligotrophic – mesotrophic	Babani et al. (2012)
Patok	b, c	7.10	2.4 ± 7.7 (*n=18*)	0.043±0.09	2.1 -9.6	Mostly mesotrophic	Avdolli (2012), KociKalfa et al. (2014)
Kune Vain Lagoons	b, c	11.45	6.4±2.2 (n=12)	0.088±0.06 2	4.3±3.6	Mostly mesotrophic-	Koci Kalfa et al. (2014), Kokali (2014)

The protection actions are classified as a = Ramsar site; b = Nature 2000 site; c = Local protection plans (classification by Barbone et al., 2012).

The protection status of the lagoons is based on their international, national, or local importance. For example, the Butrinti and Karavasta Lagoons have the highest status (category "a" or Ramsar site), while the Patok and Narta Lagoons have a lower status. The status is also related to the pressure exercised on the lagoons and their surroundings by different natural and anthropogenic factors. The overall pressure varies according to the different functions and activities of a lagoon (Table 6).

Table 6. The pressure evaluation on the list of the transitional water ecosystems considered. The intensity of every pressure type was evaluated using a scale of values ranging from 0 to 4 (0 = absent; 1 = very low; 2 = low; 3 = moderate; and 4 = high) according to an expert evaluation based on existing knowledge as reported in a TW Reference Net report. A = organic load; B = nutrient load; C = hazard substances; D = fishing; E = alien species; F = navigation; G = physical modification; H = average pressure; I_a = net pressure. *The data and evaluation in this table are from Barbone et al. (2012), except for the data and evaluation of the Butrinti and Kune Vain Lagoons.*

Lagoons	**Pressures**								**References**
	A	B	C	D	E	F	G	H	I_a	

Butrinti	2	2	-	4	1	-	2	1.4	1.1	Bino et al. (2004), Bego et al. (2009), Sulce and Bani (2011)
Narta	2	2	-	3	-	-	4	2.7	2.6	Cullaj et al. (2005), Xhullaj and Miho (2008), Cako et al. (2014)
Karavasta	1	1	-	4	1	1	3	1.8	1.4	Cullaj et al. (2005), Xhullaj and Miho (2008), Bani (2014)
Patok	-	-	-	2	1	-	1	1.3	1.0	Cullaj et al. (2005), Xhullaj and Miho (2008), Avdolli (2012)
Kune Vain	-	-	-	3	2	-	1	3.0	2.8	KociKalfa et al. (2014)

The Butrint and Patok Lagoons have an overall pressure close to 1, which is considered low, whereas Karavsta has a pressure level close to 1.4, which is mainly caused by physical modifications of the lagoon and other factors in the surrounding area, such as the contributions from deltas of the Shkumbini and Seman Rivers. The Narta Lagoon has a higher pressure level than other lagoons due to the physical influences and presence of hazardous chemical substances in the vicinity (industrial "hot spots").

4. Conclusions

- Surface waters in Albania are heavily influenced by N and P through nonpoint and point source pollution. Rivers transport considerable amounts of macronutrients that impact water quality. The Semani, Shkumbini, and Ishem Rivers are the most polluted with macronutrients and are classified as category IV or V. These rivers flow through the central regions of Albania, where agricultural activities and untreated waste water from urban areas increase considerably the concentration of macronutrients and the microbial activity. Similar patterns of deterioration of the chemical, physical, and biological properties of the waters lagoons and on the seashore are also observed. Their waters show a clear tendency toward degradation, and their functions are restricted due to direct human pressure. The lagoons considered in this study are characterized as having:(i) oligotrophic water quality and low human pressure (Butrinti Lagoon); (ii) oligotrophic-mesotrophic water quality and medium human pressure (Karavasta Lagoon);(iii) mesotrophic-oligotrophic water quality and high human pressure (Narta Lagoon); and (iv) mostly mesotrophic water quality and very high human pressure (Patok and Kune-Vain Lagoons). The lagoons with high human pressure risk the deterioration of their trophic status. In addition, the quality of coastal waters is deteriorated, especially in estuaries and in the waters connected with lagoons.
- In Albania, the amount of N and P transported through rivers to the sea is very high. Apart from serious economic loss, erosion causes pollution of surface and transitional waters and, in particular, affects the quality of surface water and drinking water by leading to reduced filtration or purification.
- The soil erosion rates in Albania are much higher than other countries in the region. There are two main causes for these high rates: (i) lack of a vegetative cover and (ii) inappropriate natural resource management practices. In the last two decades, vegetation in Albania has decreased drastically because of massive deforestation, the result of lack of targeted policies and protection from illegal logging.
- Vegetation is highly degraded on abandoned land, while most pastures are overgrazed. Agricultural practices are outdated and associated with the misuse of natural resources, particularlywater and soil. They have resulted in groundwater pollution, especially with N.
- Pollution from identified sources, industrial or urban, contributes to the degradation of water quality in rivers and lagoons. These pollution sources comprise up to 20% of the contribution of N and P to water collection basins. For the vast majority of residential areas with more than 5,000 inhabitants, there are no wastewater

treatment plants and wastewater is disposed directly into rivers or the sea. A lack of investment and inappropriate policies have resulted in serious pollution problems and increased threats to all water bodies, transitional waters, and coastal waters, including those with protective status.

- Short - and mid-term investments need to be focused on building wastewater treatment plants in urban centers with populations greater than 10,000, especially those near coastal areas and major rivers. In addition, watershed management plans and best management agricultural practices are some short-term measurements that could reduce the negative impacts on water quality.
- A national monitoring network should be established, and adequate monitoring plans that identify pollutant sources and quantitative transport of contaminants in aquatic ecosystems should be enacted. Monitoring plans for integrated transboundary water, which are compiled pursuant to bilateral or multilateral agreements, should be funded to establish a solid database for water pollution.

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