AQUA
Water Infrastructure, Ecosystems and Society

 AQUA — Water Infrastructure, Ecosystems and Society Vol 71 No 10, 1159 doi: 10.2166/aqua.2022.084

Preliminary data on water quality using benthic macroinvertebrates as quality indicators: a case study in the Drin River Basin, Albania

Erjola Keci[a,*], Bledar Pepa[b], Anila Paparisto[c] and Pranvera Lazo[c]
[a] Faculty of Professional Studies, 'Aleksander Moisiu' University, Durres, Albania
[b] Faculty of Technical Sciences, 'Ismail Qemali' University, Vlora, Albania
[c] Faculty of Natural Sciences, Tirana University, Tirana, Albania
*Corresponding author. E-mail: erjolakeci@yahoo.it

EK, 0000-0002-2563-1728

ABSTRACT

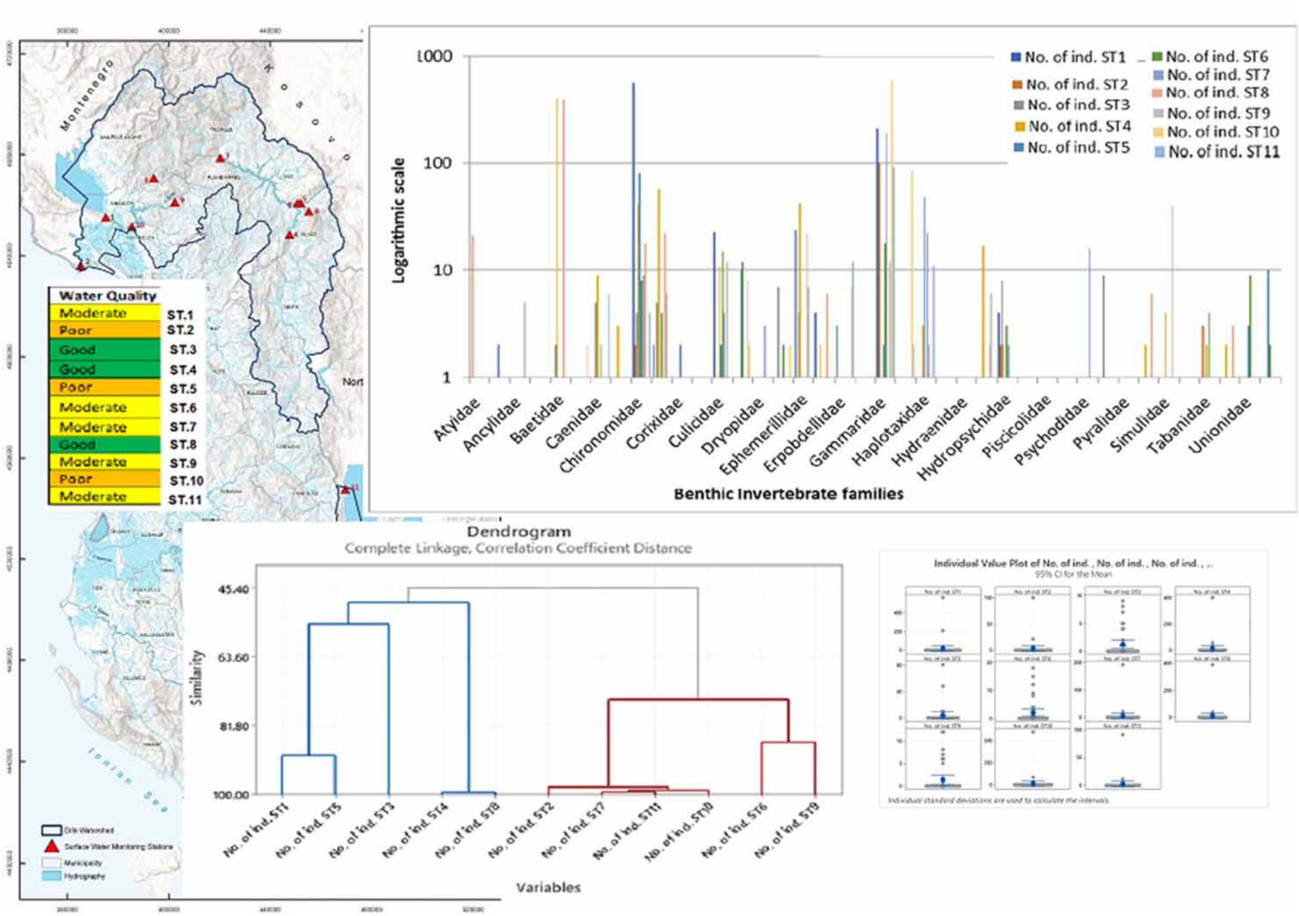
Compliance with the Water Framework Directive has not yet been met by Albania, and further efforts are needed to achieve this goal, including the implementation of an extensive programme of monitoring of surface and groundwater bodies. Benthic macroinvertebrates are an integrated element of this monitoring programme whose results are being used to assess the achievement of the Water Framework Directive objectives. This study has been carried out strictly following protocols and methodologies of the Water Framework Directive. The biological assessment took place in 2017 at 11 monitoring stations along the Drin River in Albania. Sampled specimens have been used to assess the water quality along the Drin River Basin through a set of indices' calculations per each group of indicators. A total of 41 benthic invertebrate taxa were used to calculate the biotic indices, finding out only 3 monitoring stations with a good status of water out of 11 monitoring stations assessed in our study; water quality in 8 monitoring stations is classified as a moderate or poor status. Statistical analysis has been carried out to identify the trend of benthic invertebrates from one sampling point to another and the factors influencing the similarity between monitoring stations and benthic invertebrate families.

Key words: benthic invertebrates, bio-classification, biological assessment, biotic indices, cluster analyses

HIGHLIGHTS

- This paper represents a case study of water quality assessment in Drin River Albania, using benthic invertebrates as quality indicators; the water quality assessment, even though indicative, has been carried out in full accordance with WFD.
- A periodical and long-term water quality monitoring of Drin River should be an integral part of the water quality monitoring programme in Albania.
- Quality monitoring data of Drin River should be continuously shared with the Drin Riparian countries for a better management of Transboundary Water Resources.

GRAPHICAL ABSTRACT



ABBREVIATIONS

ASPT	Average Score per Taxon
BOD_5	Biochemical oxygen demand
BMWP	Biological Monitoring Working Party
FBI	Family Biotic Index
EPT	Ephemeroptera, Plecoptera, Trichoptera Index
TN	total nitrogen
TP	total phosphorus
WFD	Water Framework Directive
WSS	Water Sanitary Systems

INTRODUCTION

One of the key elements for the Integrated Water Resources Management according to the Water Framework Directive is the assessment of the status of surface water and groundwater. In this regard, monitoring is required to cover several quality elements relevant to the assessment of the ecological or chemical status of a water body: hydro-morphological, physicochemical, biological and Water Framework Directive (WFD)-specific priority substances.

For surveillance monitoring, parameters indicative of all the biological, hydro-morphological and all general and specific physicochemical quality elements are required to be monitored. For operational monitoring, the parameters used should be those indicative of the biological and hydro-morphological quality elements most sensitive to the pressures to which the body is subject, and all priority substances discharged and other substances discharged in significant quantities.

The WFD has clearly emphasized the significance of biological parameters in the assessment of the status of aquatic ecosystems. The Directive provides qualitative descriptions for each biological quality element (BQE) in each surface water category and for each ecological status class.

A reference value for a BQE is a value identified from the range of values the quality element may have when subject to no or only very minor alteration as a result of human disturbance (i.e., when it is in a reference, or high status, condition). In accordance with the Annex V of the Water Framework Directive, macroinvertebrates are marked as relevant BQE in the monitoring studies, together with diatoms, macrophytes and fishes.

Benthic macroinvertebrates were included in our monitoring biological campaign as an integrated element of Water Framework Directive monitoring requirements.

Benthic macroinvertebrates are key components of aquatic food webs that link organic matter and nutrient resources (e.g., leaf litter, algae and detritus) with higher trophic levels. These organisms have mostly sedentary habits and are, therefore, representative of site-specific ecological conditions. Benthic macroinvertebrates are small animals that live entirely or partially in water and are highly sensitive to water quality. Thus, assessing the abundance and diversity of benthic macroinvertebrates in a waterbody serves as an indicator of the waterbody's biological condition (..water.wa.gov.au…), demonstrates the effects of environmental conditions on living organisms and the food chain, and provides information on waterbody health. As a result, identifying and assessing benthic taxa in the local region could be used as an additional method of monitoring the water body (..water.wa.gov.au…) and the effects of water quality on living organisms.

Biomonitoring involves the use of indicators, indicator species or indicator communities.

There are various indices used to assess the effects of stressors on (aquatic) populations and communities, the so-called *Biotic indices*. Biotic indices are used to classify the level of pollution taking into consideration the tolerance of an indicator organism to a pollutant. Indicator taxa are assigned scores for their tolerance level. Biotic indices assume that polluted sites or systems will contain fewer species than non-impacted sites or systems and the species that are present will reflect their sensitivity to a pollutant.

In this paper, a case study of water quality biological monitoring along the Drin River Basin, Albania, is presented. A well-known methodology of benthic invertebrates assessment has been used. The study provides an important indication of water quality in the selected monitoring stations of Drin River, Albania, to be applied for future water quality monitoring and trans-boundary cooperation in the field of water resources management.

Benthic invertebrates sampled during July–October 2017 have been used for the calculation of the following biotic indices: *Ephemeroptera, Plecoptera, Trichoptera* (EPT) Index (Plafkin *et al.* 1989), Family Biotic Index (FBI), Biological Monitoring Working Party (BMWP) (Friedrich *et al.* 1996), SWRC – Biotic Index (Schmiedt *et al.* 1998; MC GoniGle 2000; SWRC 2007) and Average Score per Taxon (ASPT) (Armitage *et al.* 1983; Friedrich *et al.* 1996).

The standardization of results is critical, and all assessments have been carried out based on the following standards: EN ISO 10870-2012; EN 27828:1994; EN 28265:1994; ISO 5667-3:1995 for aquatic benthic invertebrates.

Statistical analyses have been carried out to define possible similarities among monitoring stations or factors influencing the presence of different invertebrate taxa within a monitoring station.

This study provides an indicative assessment of water quality via biomonitoring and a comparison with the data from the national monitoring system. However, available monitoring data and assessment criteria do not yet allow for a comprehensive assessment of the environmental state of Drin water bodies in the Albania segment. Generally, most of the river is polluted largely due to the discharges of untreated wastewater. This implies that those river sections do not comply with the WFD criteria for 'good' status. The study shows the need to:

- Further increase the water monitoring activities and adequately allocate the resources to increase the analysing capacity at the national laboratory.
- Establish ecological monitoring as needed to comply with the WFD.
- Formally identify and characterize water bodies (including the determination of the ecological status of surface waters).
- Increase the sewerage collection and treatment service coverage, particularly in the more urbanized and densely populated areas where sewage in the natural environment presents the potential for public health problems.

MATERIALS AND METHODS

Site and sampling site description

The Drin River is formed by the confluence of two rivers: Black Drin and White Drin. The Black Drin drains an area of 9,209 km (including Prespa and Ohrid watersheds); 58% of this area extends in Albania (5,369 km^2) and 42% in North Macedonia (3,840 km^2) and flows to the north from North Macedonia to Albania (Kukës), where it merges with White Drin which springs at Zljeb Mountain in Kosovo, and drains an area of 4,964 km^2, 88% of which extends in Kosovo (4,360 km^2) and 12% in Albania (604 km^2).

It then flows west for about 335 km, of which 285 km flows within Albania and the remainder in Kosovo, North Macedonia and Montenegro. Its hydrologic network is dense, consisting of numerous rivers, streams, springs and natural lakes.

One of the Drin arms joins the Buna/Bojana River close to the Shkodra City and the other arm drains directly into the Adriatic Sea south of Shkodër close to Lezha City. The Shkodra Lake itself is fed by the Morača and Zeta rivers in central Montenegro with their tributaries and groundwater from the surrounding Karstic plateaus. The river basin is one of the most biodiverse hotspots in Europe.

The Drin Delta has been recognized as an important bird area of international importance by designation under the BirdLife International Convention.

Benthic macroinvertebrate sampling, as an integrated element of WFD monitoring requirements, has been carried out from July to October 2017. Invertebrate samples were collected according to a network of 11 stations along the Drin River Basin in Albania (Table 4). A more detailed description of each station is provided by the map of monitoring stations (Figure 1).

The exercise provided valuable clues for future water quality monitoring programmes (Table 4). The biological indices, calculated from the abundance data of the organisms, serve as a very good indicator of pollution and provide an indication for water quality assessment.

River basin pressures and current status

Assessment of waterbody status can be a reasonably simple exercise by comparison against standards based on a single analytical sample and assessment of pressures is more complex because (a) pressures are typically more diffusive and harder to measure and (b) different pressures combine in complex ways to influence a water body's status.

The best practice quantification of pressures can require significant data and analysis. Quantification of pressures, feasibly, requires significant amounts of good quality data, much of which are not collected in Albania at this time.

Urbanization, industrial development, agriculture and the presence of dumpsites are regarded as the main sources of pollution.

Urbanization

In the Drin River Basin, there are a total of 10 water companies responsible for water supply and water services, i.e., Shkodër, M. Madhe, V. Dejës, Pukë, Kukës, Has, Tropojë, Peshkopi, Bulqizë, and Pogradec (Table 1).

Groundwater is the main water source for drinking purposes.

The rate of population covered with supply services varies from 46% of Vau i Dejes to 96.7% for Pogradec Municipality.

Only 35.2% of the Municipalities of the Basin (Diber, Shkodër, Pukë, Kukës and Pogradec) have sewerage connections. However, the suburban areas of these municipalities are not yet covered by this service. The use of septic tanks is the most common solution.

In the cities of Has, Bulqize, Tropoje, Malesi e Madhe and Vau i Dejes, there is no wastewater network.

Two cities (Podradec and Shkoder) have a connection to a wastewater treatment plant (WWTP).

The pollution pressures from wastewater arise from inadequately treated effluent or discharges of untreated waters, as well as leaks, spills or overflows from collection systems, which also occur. The pollution load deriving from urban wastes can be determined using the following unit values for 1 population equivalent (PE)[1]:

- Biochemical Oxygen Demand (BOD_5) = 60 g/person/day.
- Total nitrogen (TN) = 11 g/person/day.
- Total phosphorus (TP) = 2.8 g/person/day.

[1]PE: Person Equivalent. Common applied values in EU countries.

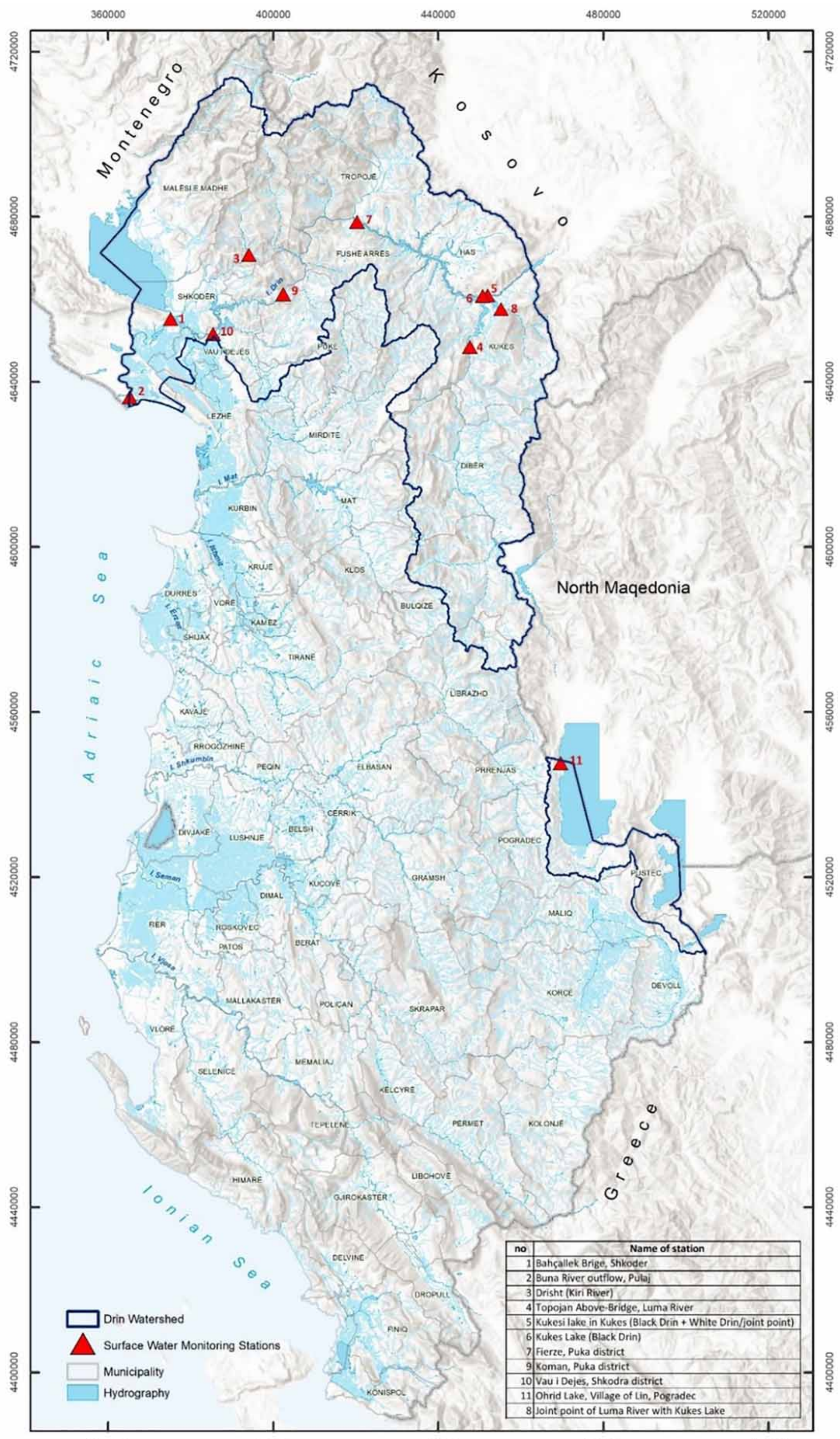


Figure 1 | A map of surface water monitoring stations within the Albanian Drin catchment area. Monitoring stations map prepared by Valbona Simixhiu.

Table 1 | Water service provision in the Drin Basin, 2019

Municipality	Population 2019	WSS company	Water demand (m^3/year)	Water supply coverage (%)	Sewerage connection coverage (%)	Water treatment coverage (%)
Bulqizë	25.913	Bulqize UK Sh.A	1.134.989	76.0	0.0	0.0
Dibër	58.411	Peshkopi UK Sh.A	2.558.402	92.3	41.2	0.0
Malësi e Madhe	27.755	Malesi e Madhe U Sh.A	1.215.669	61.1	0.0	0.0
Shkodër	135.432	Shkodër UK Sh.A	5.931.922	52.1	41.0	12.1
Pukë	8.001	Bashkia Puke	350.444	47.8	43.7	0.0
Vau i Dejës	27.370	Vau Dejes UK Sh.A	1.198.806	46.0	0.0	0.0
Has	13.502	Has U Sh.A	591.388	65.9	0.0	0.0
Kukës	45.863	Kukes UK Sh.A	2.008.799	80.0	45.0	0.0
Pogradec	58.942	Pogradec UK Sh.A	2.581.660	96.7	74.0	80.5
Tropojë	17.229	Tropoje U Sh.A	754.630	83.9	0.0	0.0
Total	**418.418**		**18.326.708**	**70.4%**	**35.2%**	**15.3**

It is noted that the estimated organic load of 60 g/person/day corresponds to one PE, as defined in the Directive 91/271/EEC. The amount of Tot-P, Tot-N and BOD_5 within the basin can be estimated as follows:

Basin	PE	P load (ton/year)	N load (ton/year)	BOD_5 load (ton/year)
Drin	354.564	355	1.560	7.765

Industrial development

Industry places constant pressure on the water resources of the Drin–Buna River Basin. Six large industrial installations operating in the basin under Class A (industrial pollution prevention control (IPPC) compliant) permit requirements as shown in Table 2.

Mining is still the main economic sector in the Kukës and Dibër regions (Table 2), which is focused on anhydride (anhydrous calcium sulphate, $CaSO_4$) mining on the right side of Black Drin in the Dibër Region and on ferro-nickel, chromium and copper mining around Fierza Lake in the Kukës Region. By 2014, in the Kukës Region, there were approximately 80 small- and medium-sized operators that had obtained a mining permit (35 in Tropoje, 30 in Kukës and 15 in Hasii).

Due to the past mining activity, the Kukës region has inherited two former mining-related hotspots, i.e., the Hasi mine in Gjegjan and the copper-melting plant in Rexhepaj. The hotspots have dumpsites that still store large amounts of mining waste. The former copper mine in Gjegjan and the former copper-smelting plant in Rexhepaj still pose serious threats to the environment, although they are not active today. The copper-smelting plant in Rexhepaj is located only 300 m from the Luma River. Often, the waste ends up in the Luma River, which transports them directly to the Fierza Lake, only 1 km from the former plant.

Sediment (inert) exploitation of the Drin–Buna River Basin is also an activity that has seriously damaged the river tributaries over the last 25 years.

Table 2 | Large industrial installations in the Drin River Basin

Municipality	Product or processing	Activity by the EU Sector
Dibër	Construction and operation of the plant for chromium mineral enrichment	Metallurgy
Dibër	Construction and operation of chromium mineral processing	Metallurgy
Kukës	Construction and operation of chromium mineral processing factory	Metallurgy
Kukës	Plant for the chromium enrichment	Mineral
Shkodër	Plant for the processing of copper mineral	Metallurgy
Shkodër	Cement factory	Mineral

Agriculture

The major threats from agriculture and farming activities are associated with organic and inorganic pollution from mainly BOD, nitrogen and phosphorus which may cause deoxygenation and eutrophication of surface waters and contribute to declining fish stocks, a loss of biodiversity as well as pollution of groundwater resources and the prevention of water use for recreational purposes.

The effects of agriculture (and animal farming) on the status of surface water can be separated by point and diffuse sources. Regarding the point sources, there are discharges of wastewater from livestock farms in Shkodër municipality.

Agriculture run-off also remains a challenge for river pollution as it is a major contributor to the eutrophication of freshwater bodies.

Mineral fertilizers, such as nitrogen (N) and phosphorus (P), are widely used in agriculture to optimize production. They are important nutrients that are absorbed from the soil by plants for their growth. A surplus of nitrogen and phosphorus can, however, lead to environmental pollution like the eutrophication of surface water.

Mineral fertilizer consumption fluctuated substantially in recent years; it tended to increase through the 2002–2019 period, and was as follows in 2019:

Basin	Arable land with field crops (ha)	Total consumption (ton/ha)
Drin	72,968	9,204

Based on the information on the usage of fertilizers, it is possible to estimate the usage of different nitrogenous and phosphorus fertilizers in the river basin as shown in the below table.

Basin	Drin
Urea nitrogen (tonnes)	3.590
containing 46% N (tonnes)	1.651
Ammonium nitrate (tonnes)	3.314
containing 34.5% N (tonnes)	1.143
Tonnes of nitrogen applied	2.794
Super phosphate (tonnes)	2.301
containing 7.07% P (tonnes)	163
Total phosphorus applied	163

The main pollutants related to animal farming are BOD, nitrogen and phosphorus. Based on livestock structure data from InStat, the total load for N and P from animals can be estimated as follows:

	Drin	
Animal category	N load (ton/year)	P load (ton/year)
Cattle	6,040	671
Sheep	2,712	463
Pigs	1,307	381
Equidae	422	98
Poultry	102	68
Turkeys	3	1
Total	10,586	1,683

Solid waste disposal

Solid waste management in the basin is characterized by a lack of solid waste collection in rural areas, inadequate transport and a lack of suitable treatment and disposal facilities. The lack of adequate wastewater treatment and disposal areas (landfills) constitutes the main challenge and potential source of water pollution in the Shkodër and Kukës region. The three regions deposit their solid waste in improvised landfills (more precisely dumpsites) next to the riverbed, thus polluting the Drin–Buna River Basin and its tributary waters with their leachate. Shkodër is one of the few regions that have a sanitary landfill. However, the Shkodër Region also has four unsuitable solid waste disposal areas (dumpsites), while Kukës has 528 and Dibër has 429. The Velipoje dumpsite in Shkodër is located about 670 m from the Drin River, while Kukës has two dumpsites at a distance of about 500 m and 70 m from Black Drin and Fierza Lake, respectively. Peshkopi also has one dumpsite close to the river at a distance of not more than 220 m from Perroi i Llixhave, the Black Drin's tributary.

Water quality assessment

The National Environmental Agency (NEA) carries out surface water monitoring. Currently, due to resource and capacity limitations, BQEs are not routinely sampled or analysed in Albania. This limitation with respect to the compliant norms for full ecological status evaluation of waterbodies is recognized and is being addressed.

In 2019, the NEA identified five river water monitoring sites. Results of the monitoring are shown in the table subsequently (number 1 station being close to the source and number 5 being close to the mouth).

In relation to dissolved oxygen (DO), the waters of the Drin River Basin at the five stations are of good quality (Class II) (Table 3). There is sufficient DO to sustain aquatic life (above 5 mg/l) in the water of the Mati River Basin from Topojan to Drini i Zi, and in Buna, Drini-Lezhë and Drin in Shkodër. The highest concentration of DO is measured in Topojan with 9.6 mg/l. A gradual decrease in DO is noted from Topojan to Drini-Lezhë. The latter has the lowest concentration, although within the ecological quality standards (EQSs).

NH_4, NO_3, NO_2, and P-total measured in the river basin are within the EQSs, indicating that the water is of good quality. An exception is the level of NH_4, in Drini-Lezhë (Class IV) which indicates waters of poor quality.

The levels of BOD_5 concentrations in the Drin River increase gradually from Topojan (which indicates a good quality of water) to Bahçallëk, Muriqan and Shkodra Ura to a significant increase in the Drini-Lezhë which exceed the limit of good quality of 16%. The concentration of BOD_5 in Bahçallëk, Muriqan and Shkodra Ura clearly indicates a moderate chemical and biological quality of the river that could be attributed to discharges from wastewater, industrial effluents and agricultural run-off.

The concentration of NH_4 reaches the highest levels in Drin-Lezhë, where the results are for poor water quality limits. NH_4 concentrations are for water with high-quality status in Bahcallek, Muriqan and Topojan stations in Black Drin.

As for NO_3 and NO_2, the concentrations are for good quality status in all stations. To conclude, the measurements indicate a river with water quality that is generally of moderate quality, with the exception of the Drin-Lezhë station, which is of poor quality, and the Topojan station in Drini i Zi, which shows good quality status. The Drin-Lezhë station shows the highest concentration of all the parameters with the exception of NO_2. The highest values of nitrite were monitored in Ura Shkodër at 0.05 mg/l. The O_2 concentrations measured in the river show an aquatic environment that can sustain aquatic life. Based on the above results, the status of Drin river waters can be classified overall as 'moderate' quality (Class III) waters. The monitoring results indicate the presence of discharges of industrial and urban wastewater and possibly agricultural run-off (Table 4).

Biological analyses

Benthic invertebrate sampling

At each of the monitoring stations, three samples were taken randomly, i.e., unlike more complicated sampling methods, no other additional steps were taken before collecting the sample. Benthic invertebrates were taken from the river bottom (40–

Table 3 | Surface monitoring mean results for the Drin River Basin in 2019

		Parameter (mg/l)						
River Basin	**Monitoring station**	**DO**	**BOD_5**	**NH_4**	**NO_2**	**NO_3**	**P-Tot**	**EQS**
Drin	Shkodra Ura – 5	7.7	6	0.064	0.05	0.3	0.022	III
	Bahcallek – 4	8.5	6.8	0.03	0.02	0.5	0.03	III
	Muriqan – 3	7.6	6.3	0.04	0.03	0.2	0.3	III
	Drini-Lezhë –2	6.4	21.5	0.74	0.02	0.6	0.09	V
	Topojan. Black Drin – 1	9.6	2.1	0.01	0.01	0.3	0.04	II

Table 4 | Monitoring station characteristics within the Albanian Drin catchment area

No.	Monitoring station (country name of the station)	Coordinates *X*, *Y*	Substrate type[a] (sand, stone, etc.)	Water flow speed (medium, high and low)	Riparian vegetation (grass, bushes, etc.)	Socio-economic activity	Comments
1.	Albania, Bahçallëk Brige, Shkodër	375117.89 4655255.11	Mesolithal	Medium	Shrubs	Urban area	
2.	Albania, Buna River out flow, Pulaj	365213.170216 4636396.1188	Microlithal/ psammal	Low	Shrubs, grass	Residential and cultivated area (agriculture)	
3.	Albania, Drisht (Kiri River)	394119.02 4670812.06	Mesolithal	Low	Shrubs	Agriculture and farming	
4.	Albania, Topojan Above-Bridge, Luma River	447658.30275 4648499.84726	Mesolithal	Medium	Shrubs	Agricultural area	Inert point
5.	Albania, Kukës Lake (Black and White Drin joint point in Kukës)	451991.94 4660992.01	Microlithal	Medium	Shrubs	Urban area	
6.	Albania, Black Drin (Kukës Lake), Surroi	450751.570097 4660815.93992	Microlithal	Medium	Shrubs	Residential area	
7.	Albania, Fierzë, Puka district	420296.95 4678825.88	Microlithal	Medium	Shrubs	Agricultural area	hydro power plant (HPP) It is worth noting that the Drin River in many of its upper parts is subject to large floods due to the way the artificial Lake Fierza is managed. This makes the biomonitoring at these stations difficult.
8.	Albania, Joint point of Luma River with Kukës Lake	455227.3248 4657656.7375	Mesolithal	Medium	Shrubs	Agricultural area	
9.	Albania, Koman, Puka district	402431.1071 4661262.285	Mesolithal	Fast	Shrubs	Agricultural area	HPP
10.	Albania, Vau i Dejes, Shkodra district	385403.02 4651648.12	Mesolithal	Medium	Shrubs and grass	Agricultural area	HPP
11.	Albania, Ohrid Lake, Village of Lin, Pogradec	469661.04201 4547633.36847	Microlithal	Low	Shrubs	Residential area	

[a]*Note:* Psammal – sand; grain size 0.063–2 mm; microlithal – substrate of fine granules, 2–6 cm (small grains, sand); mesolithal – substrate of medium-sized granules, 6–20 cm.

60 cm) with a kick-net (mesh 500 μm) to gain sufficient samples from larger depths of water. The net is held upright on the stream bed by one individual, while the stream bottom upstream of the net is physically disrupted by a second individual. Kicking and turning over rocks and logs with the feet and hands dislodges organisms which are washed into the net by the current.

The samples were collected from areas of different current speed. All benthic macroinvertebrates were kept in 95% ethyl alcohol (ETOH). Before transferring to the laboratory, the jars were filled with alcohol to reduce the damage to the specimen and labelled. Each label contains the name of the station, number of the sample and date of sampling.

Benthic invertebrate sorting

Sorting consists of disaggregating the invertebrate taxa from the substrate and assessing the abundance of each group found in the respective sample. Sorting was carried out at the Tirana University, Faculty of Natural Sciences, Department of Biology, using the stereomicroscope (Zoom stereomicroscope, Zuzi, Z series). Each of the invertebrates present in the sample was counted and stored in 95% alcohol in separate plastic tubes, which were labelled with the data on the period, site or monitoring station. Each of the above phases was exercised for each replicate separately and for respective sampling sites and monitoring stations. The substrate disaggregation was realized carefully using the stereomicroscope. The invertebrate species found in the samples were conserved temporarily in Petri dishes in 95% alcohol and then counted and divided in the respective plastic tubes labelled, respectively, per each of the monitoring stations.

Taxa identification

Identification is carried out by using different identification keys such as Wallace & Wallace (2003), Edington & Hildrew (2005), Hickin (1968), Macan (1994), Hynes (1998), Tachet *et al.* (1980), Campaioli *et al.* (1994), Cao *et al.* (1998), and Parker & Salansky (1998). Identified family taxa were stored in small bottles with 95% alcohol for further identification at the species level.

Calculation of biotic indices

The biological assessment of water quality is carried out by calculating water quality indexes as follows:

EPT index (Plafkin *et al.* 1989). The EPT index displays the taxa richness within the insect groups which are sensitive to pollution and therefore should increase with increasing water quality. Initially developed for species-level identifications, this index is valid for use at the family level (Plafkin *et al.* 1989). The EPT index is calculated as the percentage of the individuals in the sample which belong to the aquatic insect orders Ephemeroptera, Plecoptera and Trichoptera. The EPT value classifies the water quality into quality classes as follows: (Table 5).

FBI – Family Biotic Index. This includes individuals from all the taxa identified in the sample (Bode *et al.* 1996); it considers the density of all taxa identified and the tolerance value per taxa. The FBI is used to assess the organic pollution of the aquatic ecosystems.

The formula applied for the calculation of FBI is:

$$\mathrm{FBI} = \frac{\sum x_i t_i}{n} \quad (1)$$

where

- x_i = number of individuals within a taxon,
- t_i = tolerance value of a taxon,
- n = total number of organisms in the sample.

Bio-classification of water quality based on the FBI is presented in Table 6:

Table 5 | Bio-classification of water based on the EPT–biotic index

EPT value	Class I (<2)	Class II (2–5)	Class III (6–10)	Class IV (>10)
Water quality	Polluted	Clean	Good	Very good

Table 6 | Bio-classification of water quality based on the FBI according to U.S. EPA Rapid Bioassessment Protocol II (Plafkin *et al.* 1989; Bode *et al.* 1996)

FBI	Water quality	Degree of organic pollution
0.00–3.75	Excellent	Organic pollution unlikely
3.76–4.25	Very good	Possible slight organic pollution
4.26–5.00	Good	Some organic pollution likely
5.01–5.75	Fair	Fairly substantial pollution likely
5.76–6.50	Fairly poor	Substantial pollution likely
6.51–7.25	Poor	Very substantial pollution likely
7.26–10.00	Very poor	Severe organic pollution likely

Biological Monitoring Working Party (BMWP) (Friedrich *et al.* 1996). This provides single values, at the family level, representative of the organisms' tolerance to pollution; the greater their tolerance towards pollution, the lower the BMWP scores. The BMWP index is calculated by the summation of the tolerant values of each taxon presented in the sample.

BMWP can be used to reflect the impact of organic pollution, such as results from sewage disposal or farm waste. Each group or family is allocated a score between 1 and 10 (the most sensitive organisms – score 10 and the least sensitive organisms – score 1), according to tolerance to environmental disturbance. The scores for each family represented in the sample are then summed to give the BMWP score. To reduce the effects of sample size, sampling effort and sampling efficiency on the results obtained by this method, the ASPT has been also taken into consideration and calculated. Based on the BMWP score, the water quality is classified into categories which indicate the pollution level in that monitoring station (Table 7).

SWRC – Biotic Index (Schmiedt *et al.* 1998; MC GoniGle 2000; SWRC 2007). This index is used for the water quality assessment in aquatic ecosystems. It expresses the relation between water quality and the number of the SWRC – Biotic Index (Stroud Water Research Centre – Biotic Index 2007).

The formula applied for the calculation of the SWRC index is:

$$[\text{SWRC} - \text{Biotic Index}\ ] = \frac{\sum(\text{TV}) * d}{D}$$

where

- TV is given tolerance values for all the families found in the study,
- d is the density of each family,
- D is the total amount of densities.

The SWRC value is used to define the biological water quality status in our monitoring stations (Table 8).

Average Score per Taxon (ASPT) (Armitage *et al.* 1983; Friedrich *et al.* 1996). It represents the average tolerance score of all taxa within the community and was calculated by dividing the BMWP by the number of families represented in the sample. Water quality status has been defined, taking into consideration the values of ASPT per each monitoring station (Table 9).

Table 7 | Water quality assessment based on the BMWP score

BMWP score	Category	Interpretation
0–10	Very poor	Heavily polluted
11–40	Poor	Polluted or impacted
41–70	Moderate	Moderately impacted
71–100	Good	Clean but slightly impacted
>100	Very good	Unpolluted, unimpacted

Table 8 | Water bio-classification by SWRC (2007)

SWRC – Biotic Index	0–3.75	3.76–5.0	5.10–6.50	6.60–10.00
Water quality	Excellent	Good	Fair	Poor

Table 9 | Water bio-classification by Friedrich *et al.* (1996)

ASTP value	Water quality assessment
>6	Clean water
5–6	Doubtful quality
4–5	Probable moderate pollution
<4	Probable severe pollution

Statistical analyses

The data are statistically analysed by descriptive statistics to investigate the level and the variation of the data. Probability distribution was tested by Kolmogorov–Smirnov test, $p > 0.05$. The correlation between variables as the first step of multivariate analysis such as factor analysis (FA) and cluster analysis (CA) is conducted to investigate the association of variables that may indicate behaviours of the variables which do indeed affect each other or are affected by similar factors. Clustering environmental variables is an important method for characterizing environmental variables based on their correlation matrix. FA and CA are usually used in environmental studies by different authors (Vaughan & Ormerod 2005; Qarri *et al.* 2014; Lechner *et al.* 2016; Duka *et al.* 2017; Keci *et al.* 2020) for analysing spatial and temporal variations of environmental parameters caused by natural and anthropogenic sources and evaluating water quality for drawing out meaningful conclusions. CA is used in this study. MINTAB 19 software package was used for statistical data analysis.

RESULTS AND DISCUSSION

Biological water quality assessment

A total of 41 taxa of benthic invertebrates have been identified in the 11 monitoring stations along the Drin River in Albania during the monitoring period July–October 2017. It is important to underline that the results of this monitoring campaign provide preliminary/indicative information on the biological water quality status of the water in the Drin River in Albania. This monitoring exercise should be followed by a continuous monitoring programme as required by the WFD. Only long-term monitoring of water quality may allow the proper definition of the ecological status of water bodies in the Drin River. However, our study gives a good insight into the future action that should be taken to achieve the water quality standards as required by the WFD.

Biotic indices are calculated per each monitoring station separately, and water quality status has been defined based on each biological index value per each monitoring station. It is worth emphasizing that changes in the water quality description by bio-classification categories at the same station are observed because the biotic indexes used in this study have different numbers of grading scales.

The overall status has been defined based on the biotic indices' values obtained during this monitoring campaign by using the status classification terminology in the context that Annex V of the WFD provides:

- High ecological status
- Good ecological status
- Moderate ecological status
- Poor status
- Bad status

The ecological status presented in Table 10 should be considered 'indicative' due to the limited monitoring data of the Drin River. However, the real pollution rate and the overall classification tendency of a station are according to its quality.

Table 10 | Biotic indices' values, respective water quality classification and overall quality status assessment in each monitoring station of the Drin River Basin, Albania

No.	Monitoring station	EPT index	FBI index	BMWP index	SWRC index	ASPT index	Overall status
1.	Albania, Bahçallëk Brige, Shkodër	3 Clean	5.90 Fairly poor	44 Moderate	5.92 Fair	5.50 Doubtful	Moderate
2.	Albania, Buna River out flow, Pulaj	1 Polluted	5.90 Fairly poor	20 Poor	5.98 Fair	4 Probable moderate pollution	Poor
3.	Albania, Drisht (Kiri River)	6 Good	4.65 Good	64 Moderate	4.68 Good	5.81 Doubtful	Good
4.	Albania, Topojan Above-Bridge, Luma River	6 Good	3.69 Excellent	81 Good	3.51 Excellent	5.47 Doubtful	Good
5.	Albania, Kukës Lake (Black and White Drin joint point in Kukës)	1 Polluted	5.94 Fairly poor	48 Moderate	6.63 Poor	4.36 Probable moderate pollution	Poor
6.	Albania, Black Drin (Kukës Lake), Surroi	4 Clean	6.27 Fairly poor	72 Good	5.86 Fair	5.14 Doubtful	Moderate
7.	Albania, Fierzë, Puka district	1 Polluted	6.03 Fairly poor	41 Moderate	6.15 Fair	4.1 Probable moderate pollution	Moderate
8.	Albania, Joint point of Luma River with Kukes Lake	6 Good	3.93 Very good	85 Good	3.82 Good	5.67 Doubtful	Good
9.	Albania, Koman, Puka district	2 Clean	4.10 Good	48 Moderate	5.23 Fair	6 Doubtful	Moderate
10.	Albania, Vau i Dejes, Shkodra district	0 Polluted	5.96 Fairly poor	35 Poor	6.14 Fair	5.83 Doubtful	Poor
11.	Albania, Ohrid Lake, Village of Lin, Pogradec	2 Clean	6.28 Fairly poor	41 Moderate	6.24 Fair	4.55 Doubtful	Moderate

The first two stations belong to the same sub-basin and are close to the river Delta; the low water quality is expected due to an increase of the organic load from the urban and rural areas as well as from the process of intensification of agricultural activities in the Shkodra area. However, further monitoring at different depths is needed for a better status definition.

The 3rd station is located at the upper part of the Kiri River (the Drin River tributary). A very small number of individuals (48) were collected at this station, but invertebrate taxa were well presented here; 6 orders and 12 classes have been identified. The low number of individuals reflects the features of the benthic Mesolithic substrate type in this monitoring station. The water quality in this station is classified as good based on the indices' calculation; this result is connected to the location of the station in the upper part of the Kiri River; however, there is a slight impact due to agricultural and farming activities within the basin area close to the monitoring station.

The 4th monitoring station is located in the Luma River, one of the tributaries of the Drin River, which flows into the Lake of Kukës. This monitoring station presented a considerable number of benthic invertebrate individuals (597) belonging to 7 orders and 16 families.

The Luma River appeared to have the highest level of biodiversity compared to the rest of the monitoring stations. This sampling point has served as a reference monitoring station for the Albanian segment of Drin River; based on all the biological indices calculated, the water of the monitoring station is classified at the highest water quality classes. The good water quality in the monitoring station is due to undisturbed river benthos and a lack of intensive agriculture activities at the upper part of the tributary.

The 5th monitoring station – Kukës Lake (Black and White Drin joint point in Kukës) presents a dominance of pollution-tolerant benthic invertebrates (Chironomidae family, order Diptera – 49% and the Haplotaxidae family, class Oligochaetes – 29%). A total of 162 individuals were identified, belonging to 9 orders and 12 families. The presence of pollution-tolerant taxa indicates poor water quality in this monitoring station. Poor water quality has been indicated from the biotic indices' calculation as well (Table 10). The results indicate a considerable pollution load coming from White and Black Drin, as well as urban waste.

At the 6th monitoring station – Black Drin (Kukës Lake), Surroi, 82 individuals belonging to 10 orders and 14 families of benthic macroinvertebrates are identified. The samples were taken to the inner part of the Kukës Lake basin. The most frequent taxon in the monitoring station is the Gammarridae family (21%) with a relatively high tolerance to pollution. Based on the values of biotic indices, the quality of the water at Kukës Lake is classified as moderated, presenting an average water quality with slight water contamination, due to the increase of the organic load concentration and the reduction of water flow during summer.

The 7th monitoring station, Fierzë, Puka district, is located over the Koman Lake area where the Drin River meets the Valbona River. The source of pollution at this sampling point is Fierza town and its surroundings. The station is characterized by numerous alluvial deposits. In total, 252 benthic macroinvertebrate individuals were sampled at this station, belonging to 8 orders and 12 families. The dominant family in this station is the Gammaridae family (76%). The presence of the Hydropsychidae family is an indication of the presence of organic pollution at this station. Indices' values classify the water of this monitoring station as moderate.

The 8th monitoring station, a joint point of the Luma River with the Kukës Lake, presents good water quality; this is dedicated to the Luma River, which has good quality and high biodiversity and influences the decrease of the nutrient loads' concentration in the Kukës Lake. A total of 516 macroinvertebrate organisms were identified, belonging to 8 orders and 16 families. Biotic indices' values classify the water of this monitoring station as good (Table 10).

The 9th monitoring station in Koman, Puka district, presents a stressed area due to a hydropower plant downstream of Koman Bridge. During sampling, the quantity of water was considerably high due to the HPP operation; these continuous periodical changes in the river flow have an impact on the stable benthic invertebrate community. Consequently, only 58 individuals, belonging to 8 orders and 9 families, were identified in the samples taken at this station. Pollution-tolerant taxon (Gammaridae) was the most dominant in the benthic invertebrate samples. Biotic indices' values calculated indicate moderate pollution in this monitoring site (Table 10).

The 10th monitoring station, Vau i Dejës (Shkodra district), is located at the lower part of the Drin River in an area impacted by the urban discharges from Vau i Dejës and continuous river flow changes due to HPP of Ashta and Vau i Dejës. These activities influence the presence of sensitive taxa and stable invertebrate communities in the water; therefore, no sensitive taxa were present in the benthic invertebrate samples, indicating bad water quality for this monitoring station. The invertebrates present at this monitoring station have a high tolerance value to pollution. Indices' values indicate poor water quality as well (Table 10).

The 11th monitoring station is located at Lake Ohrid, Lin, Pogradec; a total of 129 benthic organisms were identified, belonging to 7 orders and 9 families. The taxon with the highest dominance is Gammarridae (71%), which is a tolerant taxon. This is an indication of the presence of a slight pollution. Biotic indices' values show moderate water quality of this monitoring station due to agricultural, rural and recreative activities around the area.

The stations with the best water quality and with minimal pollution are, respectively: the 3rd monitoring station – Drisht (Kiri River), the 4th station – Albania, Topojan Above-Bridge, Luma River and the 8th station the joint point of the Luma River with the Kukës Lake (Table 10).

In general, they are classified as good water quality – only 3 monitoring stations out of 11 monitoring stations: 3rd monitoring station (Drisht, Kiri River), 4th monitoring station (Topojan Above-bridge, Luma River) and 8th monitoring station (joint point of the Luma River with the Kukës Lake). The best water quality, according to the monitoring results, is in the Luma River. However, the three good status monitoring stations show a slight level of pollution that may be due to anthropogenic activities around the stations.

The 1st monitoring station (Bahçallëk Brige, Shkodër), 6th monitoring station (Black Drin, Kukës Lake, Surroi), 7th monitoring station (Fierzë, Puka district), 9th monitoring station (Koman, Puka district) and 11th monitoring station (Ohrid Lake, Village of Lin, Pogradec) are classified as moderate.

Meanwhile, the 2nd monitoring station (Buna River outflow, Pulaj), 5th monitoring station (Kukës Lake, Black and White Drin joint point in Kukës) and 10th monitoring station (Vau i Dejës, Shkodra district) appear to have poor water quality.

This categorization reflects considerable pollution in these sampling points of the river.

Beside the impact of urban wastewater discharges, agricultural and farming activities, HPPs, mining and solid waste, it is important to consider the transboundary character of the Drin River; there may be cases where the pollution load is increased due to tributaries flowing into the Albanian part of the Drin River from Drin riparian countries. This may be one of the reasons that the water quality in the 5th monitoring station (Kukës Lake, Black and White Drin joint point in Kukës) is poor because of pollution load coming from White Drin in Kosovo, or the moderate water quality in the 11th monitoring station (Ohrid Lake, Village of Lin, Pogradec), due to additional impact of intensive agriculture areas in North Macedonia.

Statistical analyses

According to the amplitudes of benthic invertebrate families per each monitoring station in the Drin River, Albania, a very high fluctuation of values is observed, which shows a high variation that may come due to the influence of different factors (Figure 2). The Kolmogorov–Smirnov test results show that data do not follow normal distribution, $p < 0.05$.

The highest number of benthic invertebrates is present at the 1st, 4th and 10th monitoring stations; the dominating invertebrate family at station 4 is Baetidae, Ephemerillidae which are pollution-sensitive taxa, indicating good water quality at this station; the presence of families with medium tolerance towards pollution (Hydropsichidae) shows slight pollution of water, whereas the dominating invertebrate families at monitoring stations 1 and 10 are, respectively, Chironomidae and Haplotaxidae which have a high tolerance value towards water pollution, indicating moderate and poor water quality, respectively. This classification of water quality is the same as the one carried out based on the biotic indices' values (Table 10).

Monitoring stations with the medium presence of invertebrate families are stations 5, 6, 7 and 8. Monitoring station 8 (joint point of the Luma River with the Kukes Lake) is dominated by sensitive taxa Baetidae and less by tolerant taxa of Simulidae; this shows a good quality of water in the monitoring station with slight pollution. Monitoring station 5 (Kukes Lake – joint point of White Drin and Black Drin) is dominated by pollution-tolerant invertebrates Chironomidae, Haplotaxidae and Unionidae showing poor quality of water (Figures 2 and 3).

Monitoring stations 6 (Black Drin, Surroi) and 7 (Fierza, Puka District) are dominated by families with high tolerance towards pollution Gammarridae, Haplotaxidae indicating pollution of water at these stations. It is noticed that the presence of sensitive families is also observed in very low numbers as Caenidae, Baetidae, Hydropsychidae (6th monitoring station) and Hydropsychidae with medium tolerance at the 7th monitoring station. The presence of sensitive- or medium-tolerant families indicates a moderate pollution level in these monitoring stations (Figures 2 and 3).

The 2nd, 3rd, 9th and 11th monitoring stations have generally a low number of invertebrate individuals (Figures 2 and 3).

Monitoring station 2 (Buna River outflow, Pulaj) is dominated by tolerant invertebrate families Gammarridae and Chironomidae, and there are no presence of sensitive taxa. This indicates a high level of pollution and poor water quality.

Monitoring station 3 (Drisht, Kiri River) has a low number of invertebrate individuals generally, but this number is dominated by sensitive- and medium-tolerant families such as Ephemerellidae, Baetidae, Chloroperlidae and Hydropsychidae showing good water quality; there are tolerant families present in this monitoring station as well, indicating a slight level of pollution (Figures 2 and 3).

The monitoring stations 9 and 11, even though with a generally low number of benthic invertebrates, are dominated by tolerant taxa such as Culicidae and Gammaridae (9th monitoring station, Koman, Puka district) and Gammaridae,

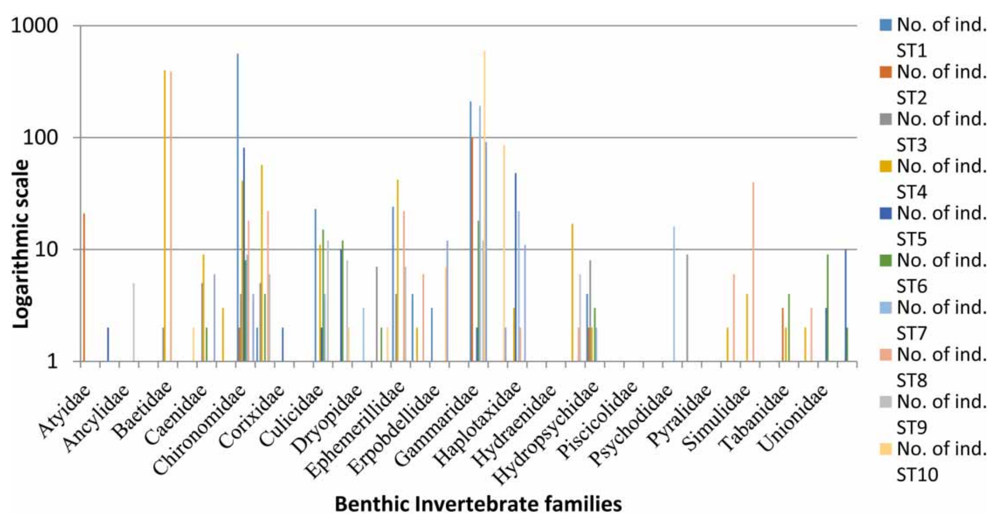


Figure 2 | Amplitudes of benthic invertebrate families per each monitoring station in the Drin River, Albania.

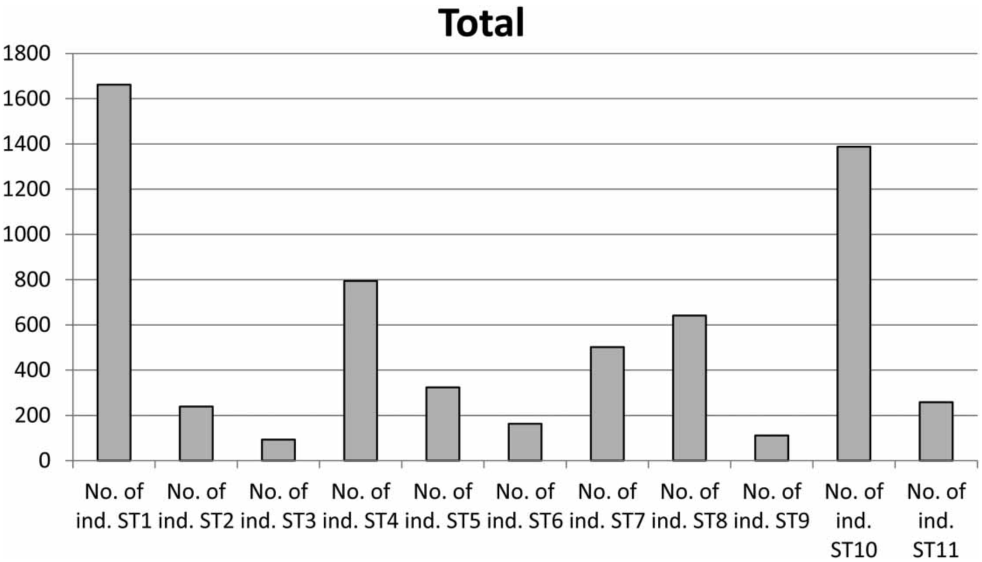


Figure 3 | The trend of the number of invertebrates in the monitoring stations along the Drin River Basin, Albania.

Erpobdellidae, Haplotaxidae (11th monitoring station, Ohrid Lake, Lin, Pogradec) indicate the presence of pollution in both monitoring stations. Both sampling points are located at the lake shore, and it may be that the sampling equipment has influenced the low number of invertebrate individuals (Figures 2 and 3).

Figure 3 shows the trend of the number of invertebrate individuals at the monitoring stations along the Drin River in Albania. The total individuals' trend goes from the highest total number to the lowest total number of invertebrates as follows: 1st > 10th > 4th > 8th > 7th > 5th > 2nd > 11th > 6th > 3rd–9th. The differences in the total number of individuals at each station are the result of station geomorphology, climate factors and water quality. The 1st, 10th, 4th and 8th monitoring stations have mesolithal substrate type and medium flow, and there is the presence of anthropogenic activities such as urban waste discharge and agriculture. The 1st and 10th monitoring stations have moderate quality status, while the 4th and 8th have good water quality status. The total number of individuals decreased at the 4¯8th monitoring stations but was dominated by sensitive invertebrates, indicating better water quality in these stations. The 7th, 5th, 2nd, 11th and 6th monitoring stations are characterized by a substrate of fine granules (microlithal) with low–medium water flow and moderate-to-poor water quality.

The 3rd and 9th monitoring stations have the lowest total number of invertebrate individuals; they have a mesolithal-type substrate. Furthermore, the presence of agricultural activities in the surroundings of both sampling points indicates a possible load of nutrients in the water. Based on the biotic indices' calculation, the water at the 3rd monitoring station is classified as good, while the water at the 9th is classified as moderate (Table 10). The good water quality at the 3rd station is due to the Luma River flowing to the Kukës Lake, increasing the quality of water.

A box-plot diagram of individual standard deviations is used to calculate the intervals of numbers of individuals per monitoring station. The box-plot diagram shown in Figure 4 groups monitoring stations 3, 6 and 9 together, monitoring stations 1, 2, 5 and 10 together and monitoring stations 4, 7, 8 and 11 together.

Monitoring stations 3, 6 and 9 are characterized by a minimum trend of invertebrate individuals' presence in these monitoring stations (Figure 3). Based on the indices' values, these monitoring stations appear to have good (st. 3) to moderate (st. 6 and 9) water quality (Table 10); furthermore, stations 6 and 9 are located in lakes (Figure 1).

Water quality in the monitoring stations 1, 2, 5 and 10 is classified from moderate (st. 1) to poor (st. 2, 5, 10) (Table 10). Monitoring stations 1, 2 and 10 are located at the river delta area, which influences the water quality of these stations, while monitoring station 5 is located in the joint point with White Drin, which flows from Kosovo to Albania influencing the water quality of this station (Figure 1). Monitoring stations 1 and 10 are characterized by a high presence of tolerant invertebrates, whereas monitoring stations 2 and 5 are characterized by the medium presence of invertebrates (Figure 3).

Monitoring stations 4, 7, 8 and 11 are characterized by a medium trend of invertebrate individuals' presence (Figure 3), and the water quality of these stations is classified from good (st. 4, 8) to moderate (st. 7, 11) according to biotic indices' values (Table 10).

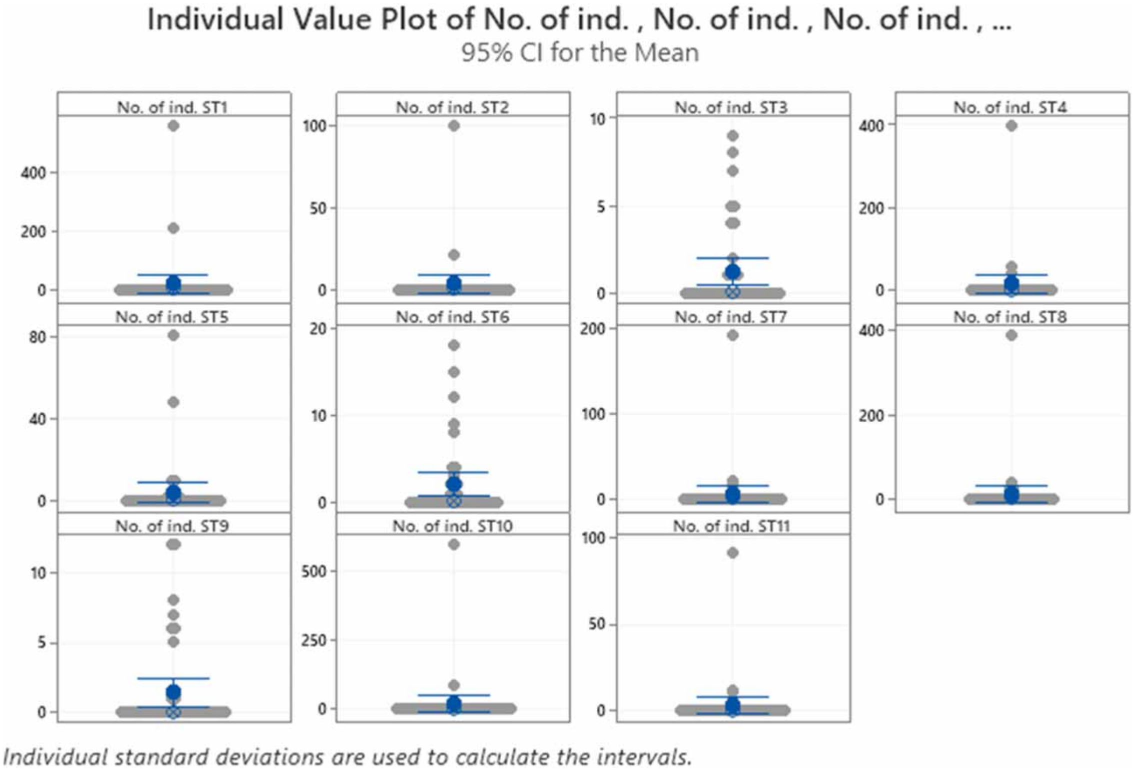


Figure 4 | A box-plot diagram of the number of individuals per monitoring station in the Drin River Basin, Albania.

Cluster analyses have been carried out to define the similarities between monitoring stations and between benthic invertebrate families present in our samples (Figure 5). Figure 5 shows two clusters of monitoring stations; the first one with higher similarity includes monitoring stations 1, 3, 4, 5 and 8, while the second cluster with lower similarity includes monitoring stations 2, 6, 7, 9, 10 and 11.

Monitoring stations 1 (Bahcallek Bridge, Shkodër) and 5 (Kukës Lake – Black and White Drin Joint point) are both lake sample points with medium flow speed and both located in urban areas; biotic indices' values (Table 10) show the presence of pollution at both locations and classify the water as moderate and poor, respectively.

The 4th monitoring station (Topojan, Luma River) and the 8th (joint of the Luma River with the Kukës Lake) show similarity. The water quality at both sampling points is classified as 'good' based on biotic indices' values. Both monitoring stations have mesolithal substrate types with the medium-speed flow and are surrounded by agricultural areas.

The 3rd monitoring station (Drisht, Kiri River) has higher similarity with stations 4 and 8 than with the 1st and the 5th station; this derives from the fact that the water quality based on biotic indices' values is classified as 'good' with the dominance of sensitive and medium-tolerant invertebrate taxa identified at the three stations; the presence of slight pollution at the three sampling points is the consequence of agricultural and farming activities within the areas around the three monitoring stations.

The second cluster groups' monitoring stations 2, 6, 7, 9, 10 and 11 with lower similarity compared to the first cluster.

The 2nd monitoring station (Bura River outflow, Pulaj) and the 11th monitoring station (Ohrid Lake, Lin, Pogradec) have the same physical parameters such as microlithal substrate type and low water speed flow. Both are in residential areas, meaning that there are continuous anthropogenic activities which pose an impact on the water quality at both stations.

The 11th monitoring station (Ohrid Lake, Lin, Pogradec) appears to have similarity with the 7th station – (Fierze, Puka District) as well; both of them are located at lakes shores and have microlithal substrate type and similar invertebrates' taxa presence classifying the water at both these sampling points as moderate.

The 6th monitoring station (Black Drin, Kukes Lake) and the 9th monitoring station (Koman, Puka District) are both located at lakes' shores with moderate water quality according to biotic indices' values calculated based on benthic invertebrate communities present in our samples.

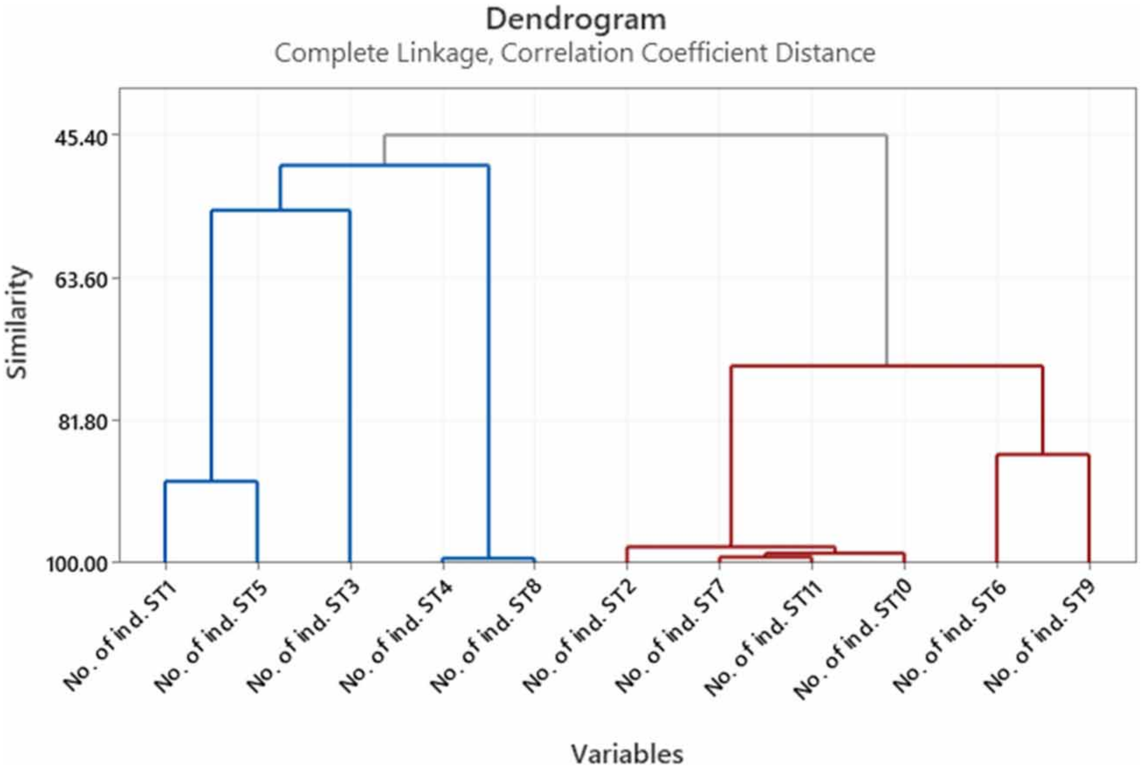


Figure 5 | Similarity between monitoring stations in the Drin River Basin, Albania.

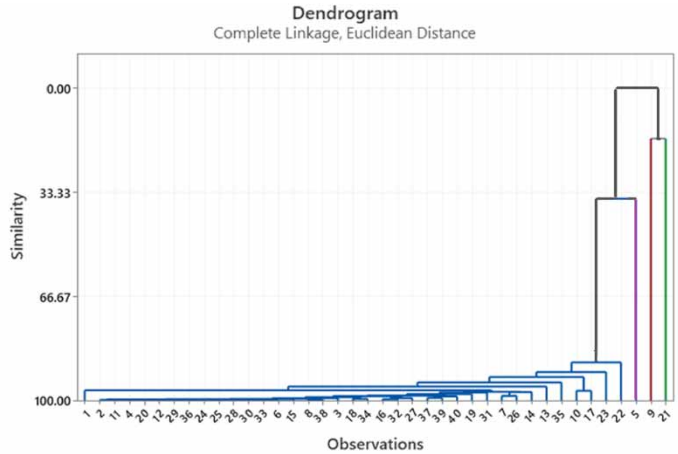
The cluster of monitoring stations 2 and 11 shows similarity with the cluster of monitoring stations 6 and 9 (Figure 5); the 6th monitoring station (Black Drin, Kukes Lake), the 9th monitoring station (Koman, Puka District) and the 11th monitoring station (Ohrid Lake, Lin, Pogradec) are located at lake shores with moderate water quality according to biotic indices' values. The 2nd monitoring station (Bura River outflow, Pulaj) has the same physical parameters like microlithal substrate type and low water speed flow as the 11th monitoring station (Ohrid Lake, Lin, Pogradec) and the 6th monitoring station (Black Drin, Kukës Lake). The water quality in this station is worse compared to the other sampling points within the cluster, not just due to socio-economic activities in the surroundings; this monitoring station is located in the last part of the Drin River before it joins the Adriatic Sea; therefore, the water has a higher concentration of pollution load.

Similarities between benthic invertebrate families present in our samples are assessed through cluster analyses and presented in Figure 6. Three family clusters are identified, showing that there are three invertebrate families differing significantly from each other.

Invertebrate family no. 5, which corresponds to the Baetidae family, Ephemeroptera order, differs from invertebrate families 9 and 21, respectively, Chironomidae family, Diptera order and Gammarridae family, Amphipoda order.

Ephemeroptera and Plecoptera are classified as sensitive benthic invertebrates, while Insecta/Trichoptera is classified as taxon with medium tolerance towards water pollution (EPA, USA). However, Ephemeroptera together with orders of Plecoptera and Trichoptera are the main quality indicator taxa, where their number of families is used as the basis for the calculation of the EPT index, which together with other biotic indices helps to assess the water quality for the specific sampling point. Tolerant invertebrate taxa are Insecta/Diptera/Chironomidae, Annelidae/Olighocheta, Hirudinea, and Molusca/Gastropoda (EPA, USA).

Based on cluster analyses, Baetidae family, Ephemeroptera, differs from the other two families Chironomidae family, Diptera order and Gammarridae family, Amphipoda order. The factor influencing this clustering is the sensitivity of these taxa towards water pollution. The Baetidae family has a low tolerance value (4), and it is considered a sensitive taxon towards water pollution, while Chironomidae family, Diptera order and Gammarridae family, Amphipoda order both have a high tolerance value (6) and both are considered as tolerant taxa towards pollution.



Observations	Family Name
1	*Atyidae*
2	*Agriotypidae*
3	*Ancylidae*
4	*Anthomyidae*
5	*Baetidae*
6	*Bithyniidae*
7	*Caenidae*
8	*Ceratopogonidae*
9	*Chironomidae*
10	*Chloroperlidae*
11	*Corixidae*
12	*Chrysomelidae*
13	*Culicidae*
14	*Dreissenidae*
15	*Dryopidae*
16	*Elmidae*
17	*Ephemerillidae*
18	*Empididae*
19	*Erpobdellidae*
20	*Gaeridae*
21	*Gammaridae*
22	*Neritidae*
23	*Haplotaxidae*
24	*Hydraacarina*
25	*Hydraenidae*
26	*Hydrophilidae*
27	*Hydropsychidae*
28	*Planorbidae*
29	*Piscicolidae*
30	*Philopotamidae*
31	*Psychodidae*
32	*Physidae*
33	*Pyralidae*
34	*Rhyacophilidae*
35	*Simulidae*
36	*Sphaeriidae*
37	*Tabanidae*
38	*Tipulidae*
38	*Unionidae*
40	*Valvatidae*

Figure 6 | Similarity between invertebrate families present in the monitoring stations, Drin River Basin, Albania.

CONCLUSIONS AND RECOMMENDATIONS

1. *Only three monitoring stations*: the 3rd monitoring station (Drisht, Kiri River), the 4th monitoring station (Topojan Above-Bridge, Luma River) and the 8th monitoring station (joint point of the Luma River with Kukës Lake) are classified as good water quality out of 11 monitoring stations. The best water quality, according to the monitoring results, is identified in the Luma River. However, the water of three monitoring stations classified as 'good' quality shows a slight level of pollution that may come due to anthropogenic activities around those monitoring stations.
2. The 1st monitoring station (Bahçallëk Brige, Shkodër), the 6th monitoring station (Black Drin, Kukës Lake, Surroi), the 7th monitoring station (Fierzë, Puka district), the 9th monitoring station (Koman, Puka district) and the 11th monitoring station (Ohrid Lake, Village of Lin, Pogradec) are classified as moderate.
3. Meanwhile, the 2nd monitoring station (Buna River outflow, Pulaj), the 5th monitoring station (Kukës Lake, Black and White Drin joint point in Kukës) and the 10th monitoring station (Vau i Dejes, Shkodra district) appear to have poor water quality based on biotic indices' values.
4. The correlation analysis of the biomonitoring results with those obtained by the chemical monitoring network at NEA is hard as the sampling points are not the same, and the sampling periods are different. However, there is a substantial complementarity between chemicals and biodata as both show a tendency of water quality towards 'moderate' status.
5. In general, the Albanian part of the Drin River appears to have considerable pollution at the monitoring stations selected for this preliminary study.
6. Beside the impact from urban wastewater discharges, agricultural and farming activities, HPPs, mining and solid waste, it is important to consider the transboundary character of the Drin River and its basin; there may be cases where the pollution load is increased due to tributaries flowing into the Albanian part of the Drin River from the Drin riparian countries.
7. Factors influencing similarity between monitoring stations are the nature of the sampling point (lake, river, delta/outflow), substrate type, speed flow, and water quality of the monitoring stations; considering these factors, there have been identified two clusters of monitoring stations; the first one with higher similarity includes monitoring stations 1, 3, 4, 5 and 8, while the second cluster with lower similarity includes monitoring stations 2, 6, 7, 9, 10 and 11.

8. Based on cluster analyses, Baetidae family, Ephemeroptera differs from the other two families, Chironomidae family, Diptera order and Gammarridae family, Amphipoda order; the factor influencing this clustering is the sensitivity/tolerance value of these taxa towards pollution in the water.

Recommendations

1. There is a need for a long-term monitoring programme for the Drin River and its Basin in Albania.
2. The monitoring programme should be discussed and harmonized with Drin River monitoring programmes of Drin Riparian Countries.
3. All BQEs as required by the WFD should be monitored in Drin river, Albania.
4. Reference conditions should be defined as per the requirements of WFD.
5. There is the need for water body delineation for the Drin River, taking into consideration all required parameters including pressures within the area.
6. Each water body should have a minimum of one water quality monitoring station.

ACKNOWLEDGEMENTS

The study presented in this article benefited from the support of the GEF/UNDP Drin Project 'Enabling Transboundary Cooperation and Integrated Water Resources Management in the Extended Drin River Basin'.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

Armitage, P. D., Moss, D., Wright, J. F. & Furse, M. T. 1983 The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites. *Water Research* **17** (3), 333–347. https://doi.org/10.1016/0043-1354(83)90188-4.

Bode, R. W., Novak, M. A. & Abele, L. E. 1996 *Quality Assurance Work Plan for Biological Stream Monitoring in New York State*. NYS Department of Environmental Conservation, Albany, NY, p. 89.

Campaioli, S., Gheti, P. F., Minelli, A. & Ruffo, S. 1994 Manuale per riconoscimento dei Macro-invertebrati delle acque dolci italiane. *Provincia Autonoma di Trento* **1**, 9–14. 27–190.

Cao, Y., Dudley Williams, D. & Williams, N. E. 1998 *How Important are Rare Species in Aquatic Community Ecology and Bioassessment?* Division of Life Science, University of Toronto, Limnology and Oceanography, Volume 43 Number 7.

Duka, S., Pepa, B., Keci, E., Paparisto, A. & Lazo, P. 2017 Biomonitoring of water quality of the Osumi, Devolli, and Shkumbini rivers through benthic macroinvertebrates and chemical parameters. *Journal of Environmental Science and Health, Part A* **52** (5), 471–478. http://dx.doi.org/10.1080/10934529.2016.1274167.

Edington, J. M. & Hildrew, A. G. 2005 *A Revised Key to the Caseless Caddis Larvae of the British Isles, with Notes on Their Ecology*. Freshwater Biological Association, Scientific Publication, Ambleside.

Friedrich, G., Chapman, D. & Beim, A., 1996 The Use of Biological Material in Water Quality Assessments. In: *A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring*, 2nd edn (Chapman, D., ed.). E & FN Spon, New York, p. 146.

Hickin, N. E. 1968 Caddis Larvae of the British Trichoptera. Associated University Presses, Inc., Cranbury, NJ.

Hynes, K. E. 1998 Benthic macroinvertebrate diversity and biotic indices for monitoring of 5 urban and urbanizing lakes within the Halifax regional municipality (HRM), Nova Scotia, Canada. *Soil & Water Conservation Society of Metro Halifax* **xiv**, 114.

Keci, E., Nuro, A. & Lazo, P. 2020 *Assessment of Surface Water Quality of Shkumbini River, Albania; Monography*. Lambert Academic Publishing, Saarbrücken, Germany. ISBN: 978-620-0-53208-4.

Lechner, A. M., McCaffrey, N., Mc Kenna, P., Venables, W. N. & Hunter, J. T. 2016 Eco-regionalization classification of wetlands based on a cluster analysis of environmental data. *Applied Vegetation Science*. doi:10.1111/avsc.12248.

Macan, T. T. 1994 *A Key to the British Fresh- and Brackish-Water Gastropods*, Vol. 11. Freshwater Biological Association. The Ferry House, Scientific Publication, p. 46.

MC GoniGle, J. 2000 *Education: Leaf Packs and Beyond*. Stround Water Research Center, USA.

Parker, R. C. & Salansky, K. G. 1998 *Benthic Macroinvertebrate Protocol Manual*, p. 16.

Plafkin, J. L., Barbour, M. T., Porter, K. D., Gross, S. K. & Hughs, R. M. 1989 *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish*. Assessment and Water Protection Division, U.S. Environmental Protection Agency, Washington, D.C, p. 134. Report EPA/440/4-89-001.

Qarri, F., Lazo, P., Bekteshi, L., Stafilov, T. & Frontasyeva, M. 2014 The effect of sampling scheme in the survey of atmospheric deposition of heavy metals in Albania by using moss biomonitoring. *Environmental Science and Pollution Research*. doi:10.1007/s11356-014-3417-3.

Schmiedt, K., Jones, R. L., Brill, I. & Pikal, W. 1998 *EPT (Epheromeraptera, Plecoptera and Trichoptera) Family Richness Modified Biotic Index*.

SWRC – Stroud Water Research Centre 2007 Leaf Pack Network: Watersheds. Available from: www.stroudcenter.org/lpn/more/data.

Tachet, H., Bournaud, M. & Richoux, P. 1980 *Introduction á l'étude des macro invertebres des eauxdouces. C. R.D.P. Lion*. UNECE – The United Nations Economic Commission for Europe, pp. 130–150.

Vaughan, P. & Ormerod, S. J. 2005 The continuing challenges of testing species distribution models. *Journal of Applied Ecology* **42**, 720–730.

Wallace, I. D. & Wallace, B. 2003 *Keys to the Case Bearing Larvae of Britain and Ireland*, Vol. 61. Freshwater Biological Association. The Ferry House, Scientific Publication, p. 249.

First received 2 June 2022; accepted in revised form 19 August 2022. Available online 3 September 2022