Assessment of Physico-Chemical Characteristics of Lana, Tirana and Ishmi Rivers Using IDW Interpolation

Enkelejda Kucaj, Marilda Osmani, Anira Gjoni, Azem Bardhi, Besim Kucaj, and Dolores Bujku

***Abstract*—Uncontrolled movement of the population in cities and an increased number of productive activities have significantly influenced the increase in polluting factors in the environment and the level of pollution in river waters. This study aims to evaluate the water quality in the Lana, Tirana, and Ishmi rivers using the physical and chemical parameters, to understand their temporal (seasonal) and spatial dynamics. The use of the Geographical Information System (GIS) based on the water quality information system and spatial analysis with Inverse Distance Weighted Interpolation (IDW) enabled the design of water quality indicators for the rivers study. Sampling was carried out in ten stations and water quality indicators were monitored from 2018 to 2020 and analyzed by the National Environment Agency laboratory. Spatial-time maps of physicso-chemical parameters were analyzed. Assessment of water quality was realized by IDW-s methods which serve as the monitoring of stations by examining the sources of water pollution in rivers bed. Water quality maps aim to identify the main areas requiring river pollution control. The dominant pollutant component of the water is TP, which determines at Ishmi river. The concentration of phosphates in water rivers was a great influence, with an average value for the year 2018 of 2.457 mg/L, and in 2020 reaches a value of 1.956 mg/L with an order TP> P_PO_4^{3-} > N-NO_2-> N-NO_3-. This strategy can be used as an effective tool to improve real-time monitoring of water river quality.**

***Index Terms*—Pollutant monitoring, water quality, maps, interpolation, sustainability, GIS.**

I. Introduction

Due to its morphological features, Albania is very rich in water systems. According to [1], Albania ranks among the first European countries in terms of the amount of water per capita of the population, which reaches over 13,000 m^3; about 44% of the amount of water originates within the country. Also, our country is considered an area with high biodiversity but also with serious concerns about human activity [2]. However, in recent years, river water pollution has attracted much attention worldwide and is being considered as one of the major problems in the 21st century [3]. In developing countries, water quality assessment did not develop as it happened with population growth and industrial evolution [4], but domestic, industrial, and agricultural discharges are directly discharged into the watershed without any treatment. Water pollution and its use has a direct impact on human health and has long-term consequences [5]. The rivers and the receiving waters are of serious concern to the rivers. Agriculture and industry consume large amounts of water that after processing they discharged into rivers. The environment with toxic substances: chemical compounds, organic matters, heavy metals, and pathogenic bacteria are prejudicial to the coastal environment [6]. Their discharges into rivers without any treatment, as well as urban discharges, affect the quality of surface waters, causing damage to the entire ecosystem near the area.

Sampling of physic-chemical parameters have a major role in understanding the evolution of water quality in function of time and space, protection and solving pollution problems along the flow of rivers.

The objective of this study is to identify the condition of the Lane, Tirana and Ishem rivers and propose alternatives for preserving the environment and increasing the well-being of the residents of the area. There are social, economic, and environmental dimensions to water pollution management issues that must be jointly addressed while seeking a sustainable solution [7]. Geographic Information Systems (GIS) are being recognized as a powerful tool in managing geographic information holistically without losing spatial-temporal variability, which is often critical in water quality assessment [8]. This technology integrates common database operations and statistical analysis with the unique benefits of visualization and geographic analysis provided by maps and spatial databases [9]. It enables us to look at cause-and-effect relationships with visual interpretation [10]. Furthermore, GIS techniques and the hydrogeological software package NETPATH, have been commonly used in hydrogeochemical modeling to base hydrogeological and hydrogeochemical information on surface and groundwater [11].

The spatial interpolation of its risks offers the possibility to target the priority zones for an intervention and the eligibility in its exploitation. Other authors have also used GIS and IDW interpolation techniques in the assessment of surface water quality [12]. According to [13], used the GIS platform in their study to identify natural and anthropogenic sources of metals in urban and rural soils. Also, [7] used GIS to monitor nutrient pollution loads and their spatial distribution in an agro-rural catchment in South Africa. Previous studies also offered different recommendations for water pollution control measures in rivers. Solid waste dumped throughout the territory along the riverbanks and the discharge of the sewage waters from towns and villages directly to the lake,

Manuscript received July 6, 2022; revised August 26, 2022.

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doi: 10.18178/ijesd.2022.13.6.1397

cause a rich level of nutrients and chemical detergents increasing the eutrophication of waters [14]. Many modern models are used to monitor the pollutants such as hydrology transport model [15].

The city of Tirana is characterized by a Mediterranean climate, where summer is hot and dry and winter is mild and wet. In the Ishmit basin, the periods with the most precipitation are winter and autumn, during which 24% to 36% of the annual precipitation falls. The months with the most precipitation are November and December, when 9%-13% and 12-13% of the annual precipitation falls, respectively. The wet period of the year (October-May) includes 80%-82% of the annual rainfall, while in the dry period (June-September) falls only 18%–20% of the annual amount of rainfall [16]. However, due to the size and complexity of the hydrological, geological, and environmental characteristics of the watershed, there is always a challenge in integrating the data required to collect and manage a natural resource at such a spatial scale [7].

The annual average rainfall in the Albanian territory is 1,430 mm/year. As a result of irregular precipitation, rivers are rapid, erosive (in the eastern part of the country), and generally form wide and meandering beds in the western coastal lowlands [17]. Sustainable management approaches have been lacking in Albania as environmental protection activities come second as the priority has been given to problems such as economic growth, health care, educational needs, etc. Albania needs a river pollution control system, which should be effective not only in terms of environmental protection but also in terms of economic feasibility and social acceptability.

II. Materials and Methods

This study is focused on the determination of water quality and completion of a file with the data of the analyzed indicators.Based on this data, the water quality was categorized from the first class to the fifth class of Lana, Tirana, and Ishmi rivers. The river of Tirana originates in the village of Hurmz, being supplied with the water of the settlement and several streams that flow into its bed. It passes through the area of Shali e Zall Dajtit-Brar, Tufin e Ferraj, the village of Domje, and near Fush Preza it joins the river of Terkuza, forming the Ishmi River, which continues its way to flow into the Adriatic Sea in the Rodon Bay [15]. The segment of the Tirana River from the Brari bridge to the bottom of the Kamza bridge serves as a collector for the discharge of untreated industrial, agricultural, and urban water and various solid and liquid wastes. 1

The pollution of the Lana River continues from Lanabregasi to the bridge of the Technological, where untreated water from the residential area of the Kombinat neighborhood is discharged and continues with the same polluting parameters until Yrshek. In addition to the discharges of the industry, the sewage of Hastabake, the canal of Kongresi i Përmet street, Selita 1, 2 and 3, as well as several sewage canals, flow into the river of Lana. The Ishmi River flows through the plain to the east of the upper villages, eventually emptying into Ramshpati Bay. As a result of anthropogenic activity and the hilly relief, reservoirs have been built which discharge their previously untreated waters. Sampling was done in the period April-September, for a period of three years. The average values of data per station analyzed cover two meteorological seasons. The main parameters to be considered for surface water quality management, in general, include temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), chemical oxygen demand COD, biological oxygen demand (BOD_5), nitrite content $N\text{-}NO_2^-$, nitrate content $N\text{-}NO_3^-$, ammonia nitrogen content $N\text{-}NH_4^+$, phosphorus content TP, and reactive phosphorus content $P\text{-}PO_4^-$.

The sampling technique was used at each sampling site, using high density polyethylene (HDPE) plastic bottles below the water surface. The collected samples were placed in a thermostat and delivered the same day to the laboratory for analysis. The Tirana River is represented by these stations: T1, T2, T3 and T4. The Lana River is represented by stations L1, L2, L3, and L4. Ishmi River is represented by stations I1 and I2, as in the figure below. Analytical data processing for the period 2018–2020 was done with mathematical programs such as Excel, Graph, their distributions, dependence tables, etc.

TABLE I: Parameters and Standard Test Methods for Analyzing Water Quality of Samples

Param.		Method	Reference Standard
Temp	**^0C**	Portable mutiparameter	EN ISO 10523:2012
pH	**pH**	Potenciometre P. LMUP_SOP-pH	
DO	**mg/L**	Electrometric (DO meter)	
TDS	**mg/L**	Filtration, Gravimetry P. LMUP_SOP-(SS+TDS)	ALPHA:2017, 2540 Sec.C, B
COD	**mg/L**	Reflux distillation, followed by titrimetric	ISO 15705 : 2002
BOD_5	**mg/L**	Incubation technique with DO determination by DO meter	S SH ISO 5815 - 1 : 2003
$N\text{-}NO_2^-$	**mg/L**	Spektofotometri, P.LMUP_SOP-NO_{2-}	ALPHA:2017, SSH EN SSH ISO 11905: 1998
$N\text{-}NO_3^-$	**mg/L**	Spektofotometri, P.LMUP_SOP-NO_{3-}	
$N\text{-}NH_4^+$	**mg/L**	Spektofotometri, P.LMUP_SOP-NH4	
TP	**mg/L**	Digestion, followed by colorimetric	SSH ISO 715- 1 : 1998
$P\text{-}PO_4^-$	**mg/L**	Spektofotometri, P.LMUP_SOP-PO_{4-}	SSH ISO 6878 : 2004

Table I shows the parameters, methods and standards that were used during the analysis. The application of GIS and statistical methods were used to examine the impacts of inflow on river pollution. An advantage of GIS observations on measurements and water quality is that they provide spatial and temporal information of surface water characteristics [18].

The river pollution pathway was modelled using ArcView 10.4 [19], spatial analysis tools, and interpolating a point raster surface using an inverse distance weighted (IDW) technique. Previous studies have proven that (IDW) has irreplaceable advantages for data evaluation in rivers due to its high accuracy and is widely used by some authors in pollution modelling [20]. The resulting data was analyzed in Excel version 10.4 and ArcGIS [21]. The monitoring stations, distributed along the river (Fig. 1), were selected as pollution input data in the GIS model. The predicted asset values of each variable were grouped into pollution degree categories.

III. Results and Discussion

The results of the physic-chemical parameters that should be considered for the management of surface water quality, analyzed in all sampling locations along the flow of the Lana, Tirana and Ishmi rivers are presented respectively in Table II, for the period of 2018-2020. Spatial maps were made using GIS and IDW interpolation techniques (Fig. 2- Fig. 12), which clearly show the behavior of the physic-chemical pollutants identified and evaluated in the characterization analysis along the watershed. The colors used in the interpolation technique for the spatial distribution of different pollutants indicate hazardous and non-hazardous areas. The concentration and gradual change of each color varied according to the variation of the water quality of the rivers.

Fig. 1. Schematic presentation of sampling in the Lana, Tirana and Ishmi rivers.

TABLE II: Values of Physico-Chemical Analyses on Water Samples From Lana, Tirana and Ishmi Rivers for Period 2018-2022

Year	Param.	Unit meas	Monitoring stations T1	T2	T3	T4	L1	L2	L3	L4	I1	I2
Evaluation parameters for the year 2018	Temp.	^0C	13.0	13.4	15.4	15.8	12.3	13.5	16.5	17.4	15.9	16.5
	pH	pH	7.9	7.9	8.03	7.955	8.09	7.98	7.725	7.81	7.73	7.75
	DO	mg/L	11.50	10.89	10.03	5.40	11.25	7.36	5.30	4.15	4.50	5.75
	TDS	mg/L	62	78	120	60	169	135	119	103	99	164
	COD	mg/L	8	8	9	9	8	12	16	74	32	31
	BOD_5	mg/L	4	4.8	5.1	5	5	8	10	43	19	19
	$N\text{-}NO_2$-	mg/L	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	$N\text{-}NO_3$-	mg/L	0.20	0.38	0.48	0.56	0.47	0.42	0.357	0.197	0.335	0.313
	$N\text{-}NH_4$+	mg/L	0.02	0.21	0.28	0.33	0.07	3.25	4.34	10.13	7.20	7.06
	TP	mg/L	0.111	0.121	0.156	0.171	0.147	0.320	0.524	1.642	0.755	0.511
	$P\text{-}PO_4$-	mg/L	0.089	0.096	0.122	0.141	0.117	0.211	0.381	1.414	0.624	0.430
Evaluation parameters for the year 2019	Temp.	^0C	15.4	15.8	16.2	16.9	14.6	15.4	16.5	18.1	17.3	18.2
	pH	pH	7.9	7.8	8.02	7.9	8.04	7.9	7.81	7.71	7.66	7.64
	DO	mg/L	10.17	9.01	7.56	6.44	9.76	8.74	5.62	3.6	4.75	5.19
	TDS	mg/L	68	74	88	98	77	86	91	96	96	105
	COD	mg/L	10	12	18	26	13	54	108	139	59	41
	BOD_5	mg/L	5	10	14	17	7	24	56	92	35	24
	$N\text{-}NO_2$-	mg/L	0.007	0.09	0.018	0.022	0.01	0.015	0.014	0.02	0.02	0.01
	$N\text{-}NO_3$-	mg/L	0.29	0.35	0.48	0.56	0.51	0.48	0.35	0.197	0.38	0.35
	$N\text{-}NH_4$+	mg/L	0.057	1.251	3.18	3.188	0.679	2.349	7.89	16.154	8.565	7.065
	TP	mg/L	0.067	0.154	0.289	0.351	0.207	1.247	2.023	2.293	1.22	0.75
	$P\text{-}PO_4$-	mg/L	0.051	0.087	0.201	0.263	0.168	0.874	1.561	1.847	0.973	0.618
Evaluation parameters for the year 2020	Temp.	^0C	18.86	18.25	19.02	19	18.6	18.65	19.02	18.7	18.5	19
	pH	pH	7.85	7.89	7.68	7.86	7.89	7.56	7.49	7.73	7.65	7.55
	DO	mg/L	10.7	9.1	8.7	7.0	9.9	8.5	6.2	4.5	4.5	4.8
	TDS	mg/L	257	195	123	36	20	35.7	38.6	56.1	40	33
	COD	mg/L	4	5.2	16.3	18	14	24	30.2	39	26.6	25
	BOD_5	mg/L	2	11	14	12	8	24	38	85	25	19
	$N\text{-}NO_2$-	mg/L	0.003	0.034	0.0075	0.0083	0.0080	0.007	0.006	0.007	0.016	0.003
	$N\text{-}NO_3$-	mg/L	0.250	0.341	0.562	0.730	0.610	0.681	0.741	0.800	0.690	0.613
	$N\text{-}NH_4$+	mg/L	0.588	0.941	2.891	3.98	0.660	0.987	5.621	21.400	9.92	6.66
	TP	mg/L	0.040	0.098	0.235	0.510	0.250	0.781	1.956	3.47	1.039	0.946
	$P\text{-}PO_4$-	mg/L	0.026	0.175	0.214	0.419	0.210	0.914	1.542	2.750	0.860	0.790

A. Water Temperature

The fluctuation of river water temperature usually depends on the season, geographical position, or the temperature of the discharge waters in the river. Fig. 2 shows the trend of temperature values for the period 2018–2020 for the rivers Tirana, Lana, and Ishmi.

The temperature values presented in the following maps demonstrate variability for the three years of study. The comparison of the progress of water temperatures in the three rivers leads to the conclusion that these temperatures fluctuate significantly below 5-7 ℃. Based on the average temperature values, they reach their peak in the rivers of Tirana and Ishmi, respectively, the first stations and the last two stations. This is explained by the numerous discharges into the Tirana River, and in the case of the Ishmi River, the values range from 16-20 ℃ throughout the year. Since Ishmi is mainly fed by surface waters with relatively high mineralization, the average temperatures are mostly high. This river brings with its hundreds of tons of urban waste, especially plastic, from the three cities: Tirana, Krujë and Fush Kruje. Climatic conditions have an important role in increasing the average temperatures of these three rivers, since the last five years have brought a disturbance and displacement of the seasons.

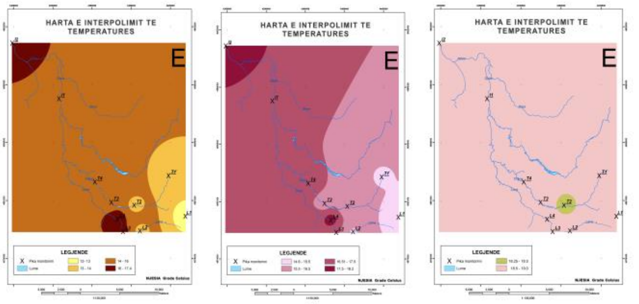

Fig. 2. Interpolation maps of average temperature values for the year 2018-2020.

B. pH Values

In general, the optimum pH value for sustainable aquatic life was pH 6.5–8.2. Its values in the river stations of Tirana and Lana fluctuate from 7.5 to a maximum value of 8.04. The average values for each station throughout the years have varied within the limits of 7.9. The average pH values for rivers resulted within the limits recommended by the EU Directive 76/160/EEC < 8.5, ranking them in good condition. According to NIVA, they belong to the first class of environmental quality, the state of well (pH > 6.5). These values undergo a big change only in the stations of the Ishmi river, respectively in St. L1. The waters in this area are affected by the drainage systems of agricultural lands. Therefore, the water of these rivers should be used in the most sustainable manner. Also, it is necessary for all farmers to calculate the amount of chemical/organic fertilizer they use for agricultural lands. The pH value represents the activity of hydrogen ions, which affect chemical and biological reactions in the body of water [22].

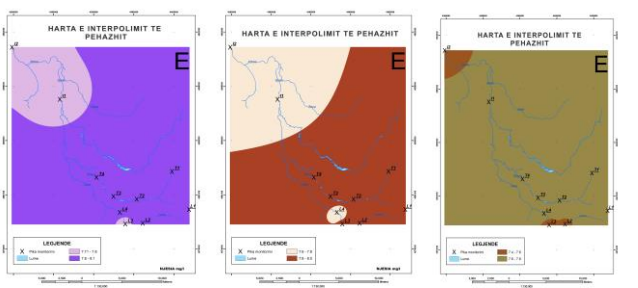

Fig. 3. Interpolation maps of average pH values, for the year 2018-2020.

The most critical parameters that worsen the quality of these waters are the content pH and temperature values. These values fluctuate within the limits of the standard values for each monitoring station.

C. Dissolved Oxygen (DO)

The content of dissolved oxygen in waters determines their "health state" and the number of living things in an aquatic environment. The lowest average DO value in the Tirana River was 3.6 mg/L at the L4 station for 2019, and the highest average value recorded at the L2 station in the Ishmi River for 2018 was 11.50 mg/L. The annual mean values of dissolved oxygen for the three rivers range from 0.88–1.375 mg/L. This is due to the increase in polluting parameters in the river. When the water is polluted with a large amount of organic matter, a part of the dissolved oxygen will be rapidly consumed during the biological processes, which will affect the quality of the water. The reduction of oxygen in the water will affect the aquatic life [23]. According to NIVA and the EU Directive, the quality of these waters belongs to classes III-IV.

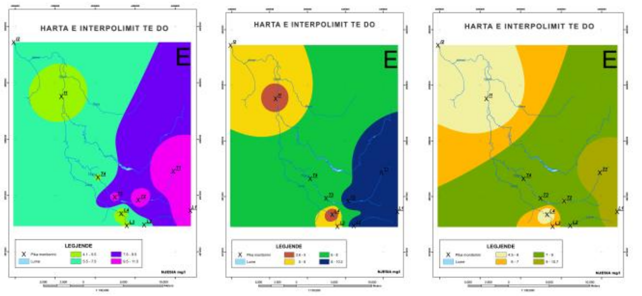

Fig. 4. Interpolation maps of DO average values, for the year 2018-2020.

D. Total Dissolved Solids (TDS)

The concentration of the amount of total dissolved substances in natural waters are determined based on the number of solids in the water: mineral substances (soil particles) or organic substances (algae, plants). Also, TDS depends on drainage geology, precipitation, and water balance (evapotranspiration and precipitation) [24]. The results show that the minimum average value was 20 mg/L, recorded at the L1 station in 2020, and the maximum was 257 mg/L at the T1 station. From Table II, the most significant low results are for the river of Lana compared to the river of Tirana. The average values were outside the allowed rates according to the NIVA classification, where the limit for class V quality was 10 mg/L. The TDS results obtained in river waters are many times higher compared to the rates of urban liquid discharges based on VKM no. 177 in our country, 35 mg/L.

The high TDS values during monitoring, especially in 2018, may be related to the increase in the load of soluble salts, increase in the number of fertilizers, discharge of sewage, and mainly erosion of the banks of the river. To reduce the level of TDS, it is necessary to avoid the high use of chemical fertilizers by farmers around the area where the riverbed passes, to avoid erosion, etc. The high content of TDS in river waters causes the inhibition of photosynthesis, the decrease of oxygen content in the waters, and therefore the abnormal development of aquatic flora and fauna, directly or indirectly affecting human health.

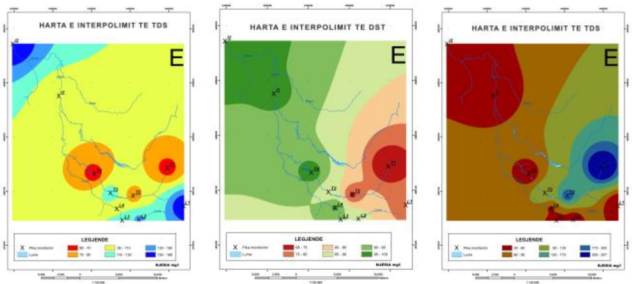

Fig. 5. Interpolation maps of average TDS values, for the year 2018-2020.

E. Chemical Oxygen Demand (COD)

The lowest average value of the chemical oxygen demand was found in the Tirana River at station T1 in 2020 at a value of 4 mg/L. The highest average value of chemical oxygen demand was recorded in 2019 in the Lana River at station L4 with a value of 139 mg/L. COD values were higher in the Lana and Ishmi rivers than in Tirana. The values move significantly from year to year due to weather conditions. During the rainy season, the values tend to increase. It is necessary to treat the water before it is discharged into the river. In Lana and Ishmi, two rivers in which liquid urban discharges were poured more than in the river of Tirana, which has a greater geographical extent.

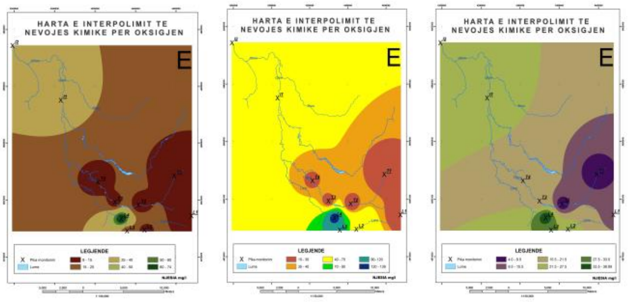

Fig. 6. Interpolation maps of average values of COD, for the year 2018-2020.

F. Biological Oxygen Demand (BOD)

The data shows that the highest average value recorded for NBO_5 was 92 mg/L for the Lana River at station L_4 in 2019. The lowest average value was 2 mg/L, recorded in 2020 for the Tirana River at station T_1. The average values presented in Table II show a high content of BOD_5 in the rivers of Lana and Ishmi. Compared to the EU standards, $BOD_5 > 18$ (very bad condition), the waters of the Ishmi and Lana rivers were outside the permitted standards for fish survival. The high BOD_5 value during wet and dry times is related to the level of organic matter load from sewage, industrial or urban discharges [25]. High levels of BOD refer to the advance of the organic matters that leads to the depletion of oxygen [26]. Therefore, it is necessary to reduce the level of organic matter to increase the concentration of oxygen. Based on the quote from [27] the BOD values are higher than the BOD_5 values and from maps no. 6 and 7, there is a similar trend between them.

Typically, both BOD and COD are the main parameters analyzed to indicate the degree of pollution in the river [28]. The established empirical relationship between BOD and COD determines of rivers water quality [27]-[29].

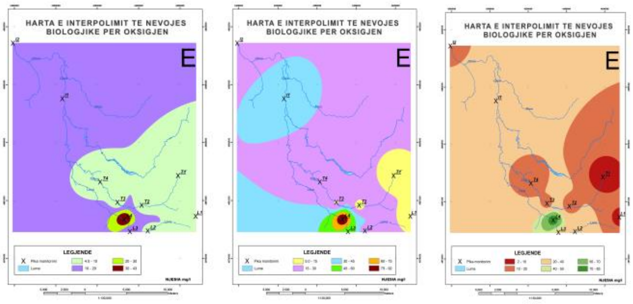

Fig. 7. Maps of interpolation of average values of BOD_5, for the year 2018-2020.

The ratio of BOD: COD mean value for the year 2018 was respectively 0.56 for Tirana River, 0.51 for Lana River, and 0.60 for Ishmi River. The ratio of BOD: COD mean value for the year 2019 was respectively 0.69 for Tirana River, 0.57 for Lana River, and 0.59 for Ishmi River.

The ratio of BOD: COD mean value for the year 2019 was respectively 0.89 for Tirana River, 0.82 for Lana River, and 0.85 for Ishmi River. The COD/BOD ratio is useful for assessing the amount of sewage available for biological treatment. It is also noted that a BOD: COD ratio of less than 1 was observed most of the time, for all the three rivers in the study, wastewater not biodegradable. In conclusion, the BOD: COD ratio is found to be an indicator of organic matter content in the rivers.

The ratio of COD/BOD_5 showed that after the effluent discharged into the rivers, it was not able to self-purify the organic pollutant.

Regarding the measured values of salinity, suspended matter, NKO, and NBO_5 were noticed that are significantly above the standard values. This shows that anthropogenic activity has greatly influenced these parameters. Suspended solids have a very high content because of rapid erosion in these watersheds. The increase in salinity values at the stations where the flow passes into the urban area is a result of the discharge of liquid urban waste. Low values of dissolved oxygen are observed in the lower part of the river flow due to urban waste discharges. The maps also show the high values of BOD in all monitoring stations, but especially in the Lana and Ishmi rivers. The high values of BOD_5 prevail in all stations throughout the period studied, except for stations T_1, T_2, which belong to upper flow, where the river has not yet entered the urban area.

G. Content of Nitrites $N\text{-}NO_{2\text{-}}$

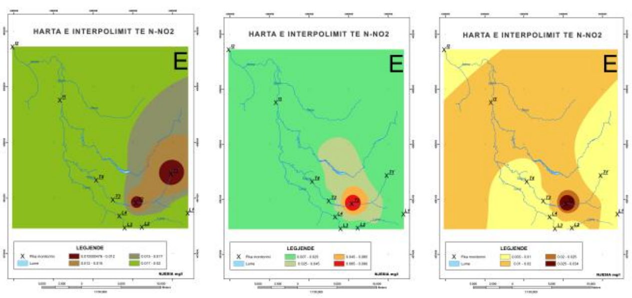

Fig. 8. Interpolation maps of average $N\text{-}NO_2$- values, for the year 2018-2020.

Table II is clearly observed that the nitrite values are higher for the Lana River. The recommended level for water, according to the EU Water Framework Directive, indicates a poor state. Nitrite content is an indicator of pollution from wastewater discharges [30], [31]. The graph shows that the average values of $N\text{-}NO_{2-}$ result in a higher presence in the river of Lana than in the river of Tirana. This may come because of greater pollution in the Lane River than the Tirana River. However, levels above 0.1 mg/L can cause damage to fish, depending on the duration of exposure [5].

H. Content of Nitrates $N\text{-}NO_{3-}$

Nitrate is the most oxidized form of nitrogen compounds and is mainly present in natural waters. The content of nitrates in the water of the rivers of Tirana, Lana, and Ishmi ranged from the range of 0.20 mg/L in 2018, which was recorded at the T_1 station of the Tirana River, to 0.8 mg/L in 2020 at the L_4 station of the Lana River. As can be seen from the maps presented in Fig. 9, the progress of the average values of nitrites from 2018-2020 shows that the average values have been maintained. In the rivers Ishmi and Lana, the highest average values were found, values which coincide with industrial spills and discharges, sewage sludge, and urban discharges. When the concentration of nitrates in the waters was higher than 0.2 mg/L, a tendency for the waters to become eutrophic was shown [32]. Eutrophication in European lakes has been a major concern for decades [33]. According to the classification of the Water Framework Directive, these waters were classified in good condition (<0.8) of environmental quality class I and II. Based on the average values found and comparing these values with the water quality classification according to UNECE, they are classified in class I, (< 5).

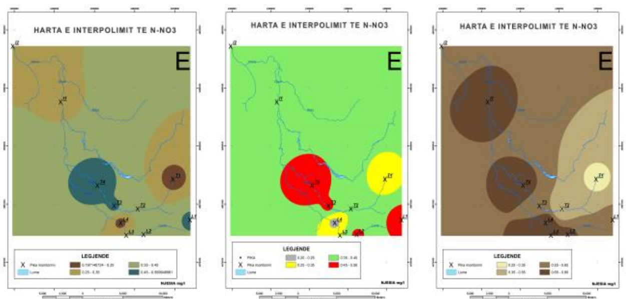

Fig. 9. Interpolation maps of average N-NO3- values, for the year 2018-2020.

I. Ammonia Nitrogen Content $N\text{-}NH_{4+}$

The ammonia nitrogen concentration in the Tirana River for 2018 varied from 0.02 mg/L at station T_1 to 10.13 mg/L at station T_4. The Lana and Ishmi rivers record the highest average values, which ranged up to 21.4 mg\l. The graph shows that the Lana River results in higher concentrations of NH_{4+} due to the wastewater discharges of the city of Tirana. From the progress of the average values (Table I), all the stations have exceeded the limit of > 1.5 mg/L according to the EU Water Framework Directive, being classified in class V, poor environmental quality water condition. Also, according to UNECE, the waters of the river of Tirana were classified in class IV, while the waters of the river of Lana were classified in class V. Such waters have been the waters of these rivers, according to [1].

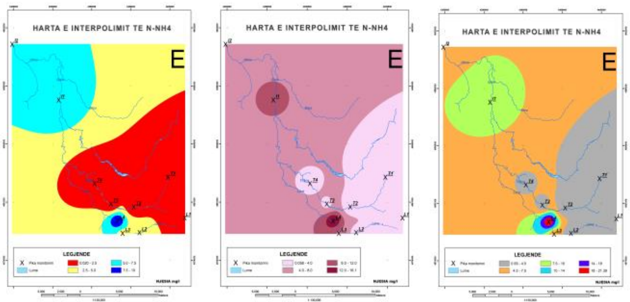

Fig. 10. Interpolation maps of average N-NH4+ values, for the year 2018-2020.

The main cause was the large discharges of urban waste, which caused deoxygenation of the water, thus increasing the biological need for oxygen. The content of nitrites in these rivers was indicative of pollution from sewage discharges. Also, high values of nitrates are observed in the stations crossing the city: st-L_3, st-L_4 and st-I_1, st-I_2. From the maps, was seen that over the years, these values have decreased. The low values of nitrates in the stations of Ishmi are a consequence of the self-cleaning ability of the waters. The waters of the Ishim basin had nitrate content that far exceeds the recommended levels.

J. Total Phosphorus Content

Total phosphorus content is considered a key parameter in many monitoring programs for assessing the nutrient status of rivers and lakes. In Table II, the progress of the average values of TP was shown, in which the stations L_2, L_3, L_4 and I_1, I_2 were clearly distinguished in relation to the much higher concentrations of phosphates. The average values ranged from 0.11 mg/L as the minimum average value at the T_1 station, to 1.64 mg/L at the L_4 station of the Ishmi River, as the average maximum value for the period of 2018. For the period of 2020, the content of TP reached the highest values and concentrations of 3.47 mg/L at station L_4. The main sources of phosphates in the waters of the Lana and Ishmi rivers are untreated urban liquid discharges containing solutions of detergents containing phosphorus. Phosphorus is a limiting element for photosynthesis, so to prevent the eutrophication of the waters of these rivers, a reduction of phosphate discharges is required.

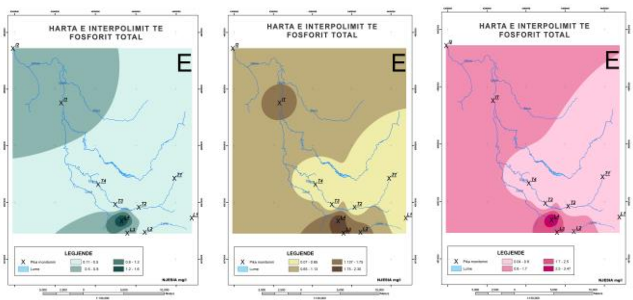

Fig. 11. Interpolation maps of average values of TP, for the year 2018-2020.

K. Content of Reactive Phosphorus PO_{4-}

The concentration of phosphorus in the rivers of Tirana, Lana, and Ishmi ranged in different values for the period of 2018-2020. The lowest average value was recorded at station T1, with 0.026 mg/L in 2020 increasing to 2.75 mg/L in 2020.

For station T_1, the lowest average value was 0.059 mg/L for 2019, increasing from a value of 1.847 mg/L in 2019. As can be seen in Table II, these stations throughout the 2018-2020 period result in high concentrations of reactive phosphorus. According to these values, compared to the Water Framework Directive (>0.5 mg/L), the waters of the rivers of Tirana are respectively classified in class IV and Lana in class V (bad and very bad condition). The increase in the level of PO_4- in these rivers may be due to the high concentration of detergents in sewage and their discharge into these rivers without treatment.

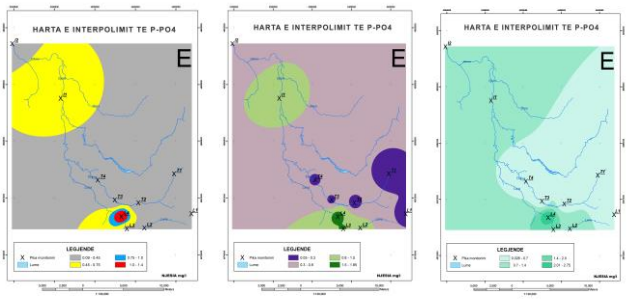

Fig. 12. Interpolation maps of average values of P-PO_4-, for the year 2018-2020.

Increasing the concentration of phosphates above the necessary values for biomass production poses a risk, encouraging the bloom of planktonic algae and the passage of water into a eutrophic or even dystrophic state. The main sources of phosphates in natural waters are detergents and phosphate fertilizers. Pond water of very poor quality is characterized by high values of TP.

Physio-chemical pollutant maps created using IDW interpolation showed that visually contaminated was mainly by discharges that flow into these waters. Therefore, due to the high Physic-chemical load, water rivers should not be used directly. It is to protect the environment and human health.

IV. Conclusions

Pollution from urban discharges: In the study area, there was still no processing/cleaning plant for liquid urban discharges. Sewage was discharged directly into the water system and goes to the sea. The Lana River and Tirana have become the main collectors of liquid urban discharges. Consequently, a large amount of pollution is observed in the lower parts of the flow.

Pollution from solid and liquid industrial discharges. The characteristics of waters where industrial discharges occur are closely related to the type of industry. The higher the temperature, the more dangerous the content of toxic substances. They can destroy any kind of organism, down to microscopic ones. Industrial discharges and discharges of urban solid waste represent the biggest source of water pollution, because their quantities are large.

Damage to the vegetation cover and erosion: The over-extension of agriculture, deforestation, and terracing for agricultural land up to the most fragile hill slopes were the first steps in the damage to the natural vegetation cover. As a result of the damage to the plant cover, the water-holding capacity of the soil and groundwater is greatly reduced. On the other hand, surface waters experience great fluctuations, which are often accompanied by overflows and floods. Due to erosion, the chemical composition of the waters also changes, the mineral content increases, etc., which promotes the eutrophication of river and sea waters.

Based on the above conclusions, the following measures are recommended: Farming on riverbanks should be banned as fertilizers used by farmers to improve soil nutrients are easily washed into the river and increase phosphorus and COD concentrations. Also, the disposal of urban waste, which clogs the riverbed, should be prohibited. Prior water treatment should be taken into consideration to improve its quality in accordance with the Albanian and European standards, to protect the environment and the human health. The relevant environmental law enforcement agencies should identify the sources of pollution in the places indicated by the maps and then impose disciplinary measures against the polluters.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

Author Contributions

All authors had contributed to this research and approved the final version of the manuscript.

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