ASSESSMENT OF WATER QUALITY OF SITNICA RIVER BY USING WATER QUALITY INDEX (WQI)

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ABSTRACT

The main goal of this work is to show water quality and impacts on Sitnica River. Based on the previous studies, the main cause of the deterioration of Sitnica River water quality is anthropogenic activities, including wastewater, industrial, and agricultural discharge. This paper presents the assessment of the Sitnica River water quality by applying the Canadian Water Quality Index (WQI) in 16 monitored parameters, such as water temperature, turbidity, electrical conductivity, pH, dissolved oxygen and O₂ saturation, biochemical oxygen demand, chemical oxygen demand, etc. The parameters were measured in spring, summer, and fall, at 10 monitoring stations in the Sitnica River flow, from the spring to its confluence with the Ibër River. Based on the results obtained according to WQI, Sitnica's water quality varies from WQI-46 to WQI-95. The average WQI for the whole measurement period has resulted to be 63.5, meaning that the water of Sitnica River belongs to the marginal category. This indicates that the river has poor quality due to the effect of pollutants from various sources. This confirms the urgent need to undertake serious actions in monitoring the river and in managing it properly.

Keywords: Assessment, Water Quality Index, Physico-chemical parameters, Pollutant, Sitnica River.

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INTRODUCTION

Undoubtedly, water is one of the most important sources because without water there can be no life, and the whole process of life depends on it. Although a renewable source, water can be easily polluted in many forms, not only in the Republic of Kosovo, but around the globe too. The main sources of surface water pollution in our country are urban discharges containing organic substances, soluble phosphorus and nitrogen compounds, which favor the eutrophication process, pathogenic bacteria and viruses, heavy metals, as well as substances that affect the appearance of water, making it smell bad.^{1,22} The Kosovo Basin includes a well-developed hydrological network, with the Sitnica River as its main collector. This river crosses the basin from south to north and drains about 80% of the accumulating surface water in the northern direction.^{2,23} Sitnica River is endangered by a considerable number of agricultural areas, settlements with no adequate solution for the elimination or treatment of polluted waters, as well as by major industrial sites without an adequate solution.²⁴ The water quality of Sitnica River is affected by a large number of various pollutants; however, the environmental problems of this river are mainly the

result of the pollution from untreated industrial and wastewater discharges as well as from agricultural infiltrations throughout the flow.

One of the complicated issues in environmental management is communicating the condition of the environment to decision-makers and the public. This issue was partially solved by synthesizing and indexing several water quality parameters into a single number, a Water Quality Index (WQI).³ Water quality has direct relation with aquatic productivity.⁴ Maximum productivity depends on optimum level of physicochemical parameters.⁵ The first WQI was proposed by Horton in 1965. WQI involves integration of water quality variables in order to express the quality of water into information that is understandable and usable by the general public.⁶ Those indices methods are based on the comparison of the water quality parameters to regulatory standards and give a single value to the water quality of a source. The WQI has emerged as a central way to convey water quality information to policymakers and the general public and is regularly used for regulatory impact analysis. It is a compound indicator that aggregates information from several water quality parameters.^{7,25} The WQI has become one of the chief ways to communicate information about water quality and it represents a means of distilling information from multiple sources into one easily understood value.^{8,25}

The main purpose of this study is to assess the water quality of Sitnica River by applying the Water Quality Index (WQI) based on Physico-chemical parameters and to develop a database that will assist future management policies and water preservation of Sitnica River.²⁶

MATERIAL AND METHODS

Study Area

Sitnica River covers an area of 2,861 km² and flows in most of Kosovo Plain. It is the only major river that is completely (approximately 90 km in length) located within the territory of the Republic of Kosovo. It is known as a field river with frequent changes of bed and flood. Sitnica has no spring, but it is called with such a name from the location where the Shtime stream receives from the left side the Sazli stream near the village of Robovc, whereas its headwater is considered to be Topila, which originates from the northern end of the Derman peak (1364 m). From Topilla (1280 m) to Sitnica's confluence into Ibër the quota is 497.2 m, its absolute fall is 782.8 m, whereas its relative fall is 7.2%.²⁴ The average height of Sitnica River is 734 m and only 7.8% exceeds 1000 m. The Sitnica river network density calculated based on the Neumann formula is 824 m/km² on the right side, whereas on the left side is 512.8 m/km.^{2 9} The river is characterized by a quiet hydrological regime with an average flow rate of 12.9 m³/sec.^{10,24} Given this, the Sitnica River is one of the main rivers in Kosovo and the main branch of Ibër, who drains into the Black Sea.^{11,24}

Fig.-1: The Map of River Sitnica

EXPERIMENTAL

The methodology for the assessment and analysis of the water quality of Sitnica River by applying WQI is carried out by selecting the monitoring stations and taking water samples, conducting a laboratory analysis of samples, statistically processing the obtained results and calculating the WQI (Canadian Water Quality Index).

Water sampling for analysis was carried out using instruments and containers based on ISO 5667-6 standard. The samples were not taken near the banks where the water flow velocity was lower. The samples were taken during three periods: spring, summer, and fall, at 10 monitoring stations along the Sitnica River flow, from its spring to its confluence into Ibër River.

During sample taking, standard tools were used; water samples were taken in glass bottles for the organic parameters and in polyethylene bottles for inorganic parameters. The sample bottles were labeled with the time, date and source of sampling; they were stored in the refrigerator at 4°C and transported according to the respective procedure. On the field, for conservation purposes, 0.5 mL of concentrated nitric acid (HNO₃) was added per 100 mL of sample.

Given that some of the water components in the taken samples may be volatile and easily decompose, some of the parameters were measured directly on-site, as is the case of water temperature (WT)²⁸, air temperature, electrical conductivity (EC), pH, dissolved oxygen (DO) and turbidity (TUR). The analysis of water samples taken in Sitnica River was conducted in the laboratory of the Hydrometeorological Institute of Kosovo.²⁶

Water quality parameters were determined using highly sophisticated measuring instruments. The methods used with these instruments were in line with standard methods of DIN, ISO, and EN²⁶: WT was measured using HI 98130 in accordance with DIN 38404-C4 standard; TUR was measured using AQUALITIC/PC COMPACT in accordance with ISO 7027; EC was measured using WTW 350i according to DIN EN 27888 (C8) (11/1993)²⁷; the pH value was measured using HI 98130 based on DIN 38404-C5, DO and O₂ saturation were measured using HI 9146 in accordance with ISO 5814: 2012, biochemical oxygen demand (BOD₅) was measured using Winkler in accordance with ISO 5815; Chemical Oxygen Demand (COD) was measured using chromate in accordance with ISO 15705; total organic carbon (TOC) was measured using UV-SECOMAN in accordance with DIN EN 1484 (H3); nitrates were measured using SECOMAN Prim Light in accordance with DIN 38405-D9; detergents (DET) were measured using SECOMAN UV in accordance with ISO 2870; phosphates were measured using SECOMAN Prim Light in accordance with ISO 6878; ammonium ion was measured using SECOMAN Prim Light in accordance with ISO 7150/1; nitrite was measured using SECOMAN Prim Light in accordance with DIN EN 26 777 D10, and sulfate was measured using SECOMAN Prim Light in accordance with ISO 8502-11: 2006 standard.²⁷

Canadian Water Quality Index

In order to assess the drinking water quality, we have widely used the Water Quality Index (WQI) developed by the Canadian Council of Ministers of the Environment.¹² WQI consists of three measures of variance from selected drinking water quality objectives.²² Those are: scope (F₁), frequency (F₂), and amplitude (F₃). The scope represents the water quality of the legal norm that does not meet objectives during the period of interest and is expressed by the equation²²:

$$F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}} \right)$$

Frequency represents the percentage of individual tests that do not meet objectives. It is expressed with the following equation²²:

$$F_2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) \cdot 100$$

Amplitude represents the amount by which failed tests do not meet objectives. It is expressed with the following equation²²:

$$F_3 = \left(\frac{nse}{0.01 \cdot nse + 0.01} \right)$$

Where, nse shows the normalized sum of excursions, that is, the summation by which individual tests do not meet objectives. WQI is then calculated according to the following equation²²:

$$WQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right)$$

The number 1.732 normalizes the resulting values to an extent between 0 and 100, where 0 represents the worst water quality and 100 represents the best water quality. Water quality is then ranked in one of the following six categories (Table-1).

RESULTS AND DISCUSSION

The findings of this research are outlined in Tables-1 to 4.

Water Temperature (WT)

Water temperature is a very important parameter that governs most of the physical, chemical and biological properties of aquatic habitats. Water temperature influences growth, liability, abundance and distribution of fishes. Freshwater fishes have optimum growing temperatures ranged from 25-30 °C to which they grow quickly. About 35°C is commonly considered as the maximum tolerance for most survival of aquatic life.^{13,30} The analyzed water samples of the Sitnica River had different temperatures during the three monitoring periods. In spring WT varied from (S1) 6.4 to 14°C (S6), in summer it varied from (S1) 14.9 to 23.5°C (S5), and in fall from (S1) 10.2 to 16.5°C (S6). The biggest variation was observed between spring and summer, with a range of around 8.5-9.5°C, whereas between fall and summer the variations were smaller and the values fluctuated around 4.7-7°C. The temperature rise had such a trend that besides being impacted by the seasons and the air temperatures, which rise during the day (midday) in the river water, was also impacted by the urban discharges, especially S6 station due to its contact with Prishtina River, known as the river with the highest temperature in our country (IHMK). According to the Romanian standard for the assessment of the ecological status of surface waters (GD161)²², the recommended value for WT is <30°C, therefore the WT values found in the water of Sitnica River resulted to be within the recommended values of the GD161 regulation, ranking the water of this river in the first class. The average annual value with the standard deviation for WT was 15.84 ± 4.38°C.

Fig.-2: Variation of Values of WT and TUR

Turbidity (TUR)

Another indicator that has been analyzed was turbidity. Turbidity is the cloudiness of a water body caused by suspended solids that are generally invisible to the naked eye.¹⁴ This parameter was present throughout the course of the three monitoring periods; the highest values were obtained a few moments after

precipitations, as happened in the summer season at S1 station (61 NTU) and at S10 station (85 NTU), whereas at other stations TUR was proportional to the polluting pressure, as is the case of S6 where the increase in value was caused by the Prishtina River, known as a collector of the entire Prishtina city, which always has high turbidity. The presence of turbidity in the Sitnica River shows that precipitation affects directly and rapidly the increase of turbidity, and at the same time affects the increase of erosion as well as the surface of soil and river bed. The recommended value for TUR according to the GD161 standard is <20 NTU units. In Sitnica River water TUR values resulted to be within the recommended values of the GD161 regulation and the water of this river is ranked in the first class. The average annual value with the standard deviation for TUR was 1682 ± 19.68 NTU.

Electrical Conductivity (EC)

Conductivity is the measure of the capacity of a substance or solution to conduct electric current and is used to determine the total dissolved solids in water.¹⁵ EC is a useful indicator of the mineralization in a water sample.¹⁶ High EC in natural water is an indicator that that water may be polluted. During our research EC in the three seasons was the lowest (below 300 $\mu\text{S}/\text{cm}$) at S1 station, which suggests that the water had a high purity without polluting pressure. We also noted that there is an increase of EC throughout the river flow from the monitoring station S2 to S6, where it reached the maximum values in the three monitoring periods (884 $\mu\text{S}/\text{cm}$), then there is a decrease of EC value to 618 $\mu\text{S}/\text{cm}$, which varies from the S1 with more than 300 $\mu\text{S}/\text{cm}$. According to the GD161 standard, the recommended value for EC is <2000 $\mu\text{S}/\text{cm}$. In the Sitnica River water the EC values resulted within the recommended values of the GD161 regulation and the water of this river is ranked in the first class. The average annual value with standard deviation for EC was $617.70 \pm 145.99 \mu\text{S}/\text{cm}$.

Fig.-3: Variation of Values of EC, TDS and pH.

Total Dissolved Solids (TDS)

Total dissolved solids are a parameter, which is directly proportional to the previous parameter, if EC increases, TDS will also increase. TDS is mainly composed of Ca^{2+} , Mg^{2+} , bicarbonates, carbonates, sulfates, chlorides, nitrates and other substances. Higher values of total solids are mainly due to the presence of silt and clay particles in the river water¹⁷. The lowest values of this parameter during the three periods were obtained at S1 station (131 mg/L in spring, 140 mg/L in summer and 135 mg/L in fall), whereas the highest values were obtained at S6 (446 mg/L in spring, 345 mg/L in summer, and 390 mg/L in fall). The recommended value for TDS according to the GD161 standard is <1000 mg/L. In Sitnica River water, the TDS values resulted to be within the allowed limits and the river water is ranked in the first class. The average annual value with a standard deviation for TDS was 309.37 ± 73.28 mg/L.

Concentration of Hydrogen Ion (pH)

Due to the climate change and the effect of carbon, sulphur and nitrogen oxides emissions from the atmosphere, the determination of pH values is of particular interest with regard to the phenomenon of acidification of surface water. The pH has a relationship with the solubility and accumulation of heavy metal in river water as well as sediments according to Singh *et al.*¹⁸ The seasonal change of temperature plays also an important role as it affects the development of water exchange reactions. In the analyzed water samples, the obtained values for the pH do not show high variation, namely not higher than 1 unit

of measurement. We also notice that all values are higher than $\text{pH} = 7$, ranging from 7.69-7.99 during the spring, 7.25-8.27 during the summer, and 7.54-8.2 during the fall; therefore, they are quite basic and lie generally within the range of stable values for all seasons. The recommended pH value according to the GD161 standard is 6.5-8.5. In Sitnica River water the pH values resulted to be within the recommended values of the regulation and the water of this river is ranked in the first class. The average annual value for pH with a standard deviation was 7.67 ± 0.23 .

Dissolved Oxygen (DO)

The amount of DO in surface water is impacted by the water temperature values and the level of pollutants found therein, and consequently our measurements have shown that the DO values at the monitored stations differ. The highest values during the three periods were obtained at S1 station (reference station) at 10.51 mg/L in spring, 7.4 mg/L in summer, and 9.37 in fall, whereas the lowest value based on the measurements made was 0.53 mg/L at S7 in spring, 1.6 mg/L at S3 in summer, and 2.49 mg/L at S4 in fall. Based on the results presented in Tables-1 to 3 it is evident that the DO amount at all stations during the summer season was significantly lower, confirming the impact that temperature has on this parameter. The recommended DO value according to the GD161 standard is $> 4 \text{ mg/L}$. During the spring season, two DO values were below the recommended value of the regulation: 2.81 mg/L (at S6) and 0.53 mg/L (at S7). Other values during this season resulted within the recommended values. During the summer season, the DO was within the recommended values only at S1; at all other stations, the DO values were below the recommended values of the regulation (S2-1.9; S3-1.6; S4-1.7; S5-2.8; S6-1.9; S7-2.4; S8-1.7; S9-3.5 and S10-3.8 mg/l). During the fall season, the DO was within the recommended values at S1, S2, S9 and S10; at other stations the DO values were below the recommended values of the regulation (S3-3.03; S4-2.49; S5-3.15; S6-3.31; S7-2.84; and S8-3.21 mg/L). The average annual value with standard deviation for DO was $4.07 \pm 2.33 \text{ mg/L}$.

Fig.-4: Variation of Values of O_2 , and TOC.

Oxygen Saturation (OS)

As for the oxygen saturation during the three monitoring periods, the highest values (over 90%) were obtained at S1 station, which results in its natural condition without anthropogenic polluting pressure, whereas the lowest values for most stations with regard to oxygen saturation were recorded during the summer from 22% to 53%. Based on these values we can conclude that there was no eutrophication process in this river water. The recommended OS value according to GD161 standard is $> 30\%$. During the spring and fall, the OS values were below the recommended value of the regulation only at S7, namely 5.5% (spring) and 29.6% (fall); other values during these seasons resulted to be within the recommended values. During the summer season, the OS values were below the recommended values at (S2-26; S3-22; S4-23; S6-27 and S8-24%) stations. The average annual value with standard deviation for OS was $44.79 \pm 22.05\%$.

Chemical Oxygen Demand (COD)

COD indicates the presence of organic substances in water. The chemical oxygen demand values during the spring varied from 3.8 to 60.5 mg/L, in summer they varied from 4.2 to 134 mg/L, whereas in fall they varied from 0.1 to 106 mg/L. This suggests that COD in the first stage had an increase in organic

pollution but in fact, it was lower than in the second stage, namely in the summer season when there is less water. Based on the monitored values we noticed that Sitnica River was subjected to pollution by organic substances during all seasons. The recommended COD value according to the GD161 standard is <50 mg/L. During the spring only one value was above the recommended value of the regulation: 60.5 mg/L (S6); in summer there were 6 values above the recommended value: S3-57; S6-83; S7-56; S8-72.5; S9-93 and S10-134 mg/L, and in fall there were 7 values above the recommended value of the regulation: S3-65.5; S4-57.5; S6-106; S7-58.2; S8-76.9; S9-105.4 and S10-95.8 mg/L. Most of COD values in Sitnica River during the summer and fall resulted to be above the recommended value of the regulation, indicating that based on this parameter the water is highly polluted and is ranked in the fifth class. The standard annual value for COD with standard deviation was 49.70 ± 34.57 mg/L.

Biochemical Oxygen Demand (BOD₅)

Biochemical oxygen demand is an indicator that confirms the pollution from urban discharges, which was also proved by the values obtained during our laboratory analysis and also by comparing the values of stations that are always under constant pressure with the reference station S1. In the analyzed water samples, the values during spring varied from 2.0 (S2) to 29.2 (S6) mg/L, in summer from 1.9 (S1) to 59.8 (S10) mg/L, and in fall from 0.1 (S1) to 42.3 (S9) mg/L. Therefore, it is noticed that the amounts were significantly higher during the summer and fall seasons as there was less water in the river flow, whereas the impact of the water discharge was higher. The recommended value for BOD₅ according to the GD161 standard is <20 mg/L. Out of thirty measured values, sixteen BOD₅ values were above the recommended value of the regulation, which indicates that Sitnica River water, based on this parameter, is highly polluted and is ranked in the fifth class. The average annual value with the standard deviation for BOD₅ was 21.29 ± 14.20 mg/L.

Fig.-5: Variation of Values of BOD, COD, and NO₃⁻.

Total Organic Carbon (TOC)

TOC is the measurement of the concentration of all organic carbon atoms covalently bonded in organic molecules of a given water sample. The TOC values in spring range from 1.6 (at S2) to 19.8 (at S6) mg/L, in summer they range from 1.3 (at S1) to 41.4 (at S10) mg/L, and in fall the values range from 0.1 (at S1) to 30.4 (at S9) mg/L. It is noted that in the last monitoring stations we have an increase of TOC values, especially during the summer and fall seasons. The recommended value for TOC according to the GD161 standard is <30 mg/L. Only one TOC value was above the recommended value of the regulation: 30.4 mg/L (at S9, in fall); other values resulted within the recommended values. The average annual value with the standard deviation for TOC was 15.32 ± 10.52 mg/L.

Nitrate (NO₃⁻)

Based on the analysis presented in tables (1-3), the highest nitrate values during the three monitoring periods were recorded in the last stations, namely in spring 6.7 mg/L at S9 and in summer 10.0 mg/L at S10, whereas the highest values during the fall season were recorded at S10 with 11.5 mg/L. On the other hand, the lowest nitrate values <0.01 were recorded at S1 station during the three periods. The content of nitrate in river water is thought to be mainly of urban and agricultural origin, which ends up in water from soil washing and erosion. Since there were no high amounts of nitrite in the water, no eutrophication was expected, which would then be associated with dissolved oxygen consumption and difficulties in further

normal biotic development. The recommended value for NO_3^- according to the GD161 standard is <11.20 mg/L. One NO_3^- value was above the recommended value: 11.5 mg/L (at S10, in fall); other values of NO_3^- in Sitnica River water resulted within the recommended values of the regulation. The average annual value with standard deviation for NO_3^- was 3.76 ± 3.96 mg/L.

Detergents (DET)

As for detergents in the three monitoring periods the highest values were recorded in the middle flow of the river, namely at S6 station during spring with 2 mg/L, in summer with 2.4 mg/L, as well as at S7 during fall with 1.3 mg/L due to the impact of the Prishtina and Fushë Kosova collector, whereas the lowest values during the monitoring period were again registered at S1 station. The recommended DET value according to the GD161 standard is <0.50 mg/L. Nine DET values were above the recommended value: 1.1; 2; 1.4 mg/L (S2, S6 and S7 in spring), 0.7; 2.4 and 1.6 mg/L (S2, S6 and S7 in summer), 0.6; 0.7; and 1.3 mg/L (S3, S6 and S7 in fall). The average annual value with the standard deviation for DET was 0.52 ± 0.64 mg/L.

Fig.-6: Variation of Values of DET, PO_4^{3-} , and NH_4^+ .

Phosphate (PO_4^{3-})

The measurements of phosphate amount during the three monitoring periods indicated that the highest values of this parameter almost throughout the entire course were obtained in the summer period. The lowest values of phosphate during the three periods were measured in the waters of S1 station, whereas the highest values were measured at S6 station in spring with 1.564 mg/L, in summer with 2.750 mg/L, and at S9 station in fall with 1.436 mg/L. The recommended value for PO_4^{3-} according to the GD161 standard is <0.190 mg/L. Twenty-seven PO_4^{3-} values were above the recommended value of the GD161 Regulation, which shows that the river water is polluted with this pollutant and that the water of this river is ranked below the fifth class. The standard annual value for PO_4^{3-} with standard deviation was 1.08 ± 0.60 mg/L.

Ammonium Ion (NH_4^+)

The highest values of NH_4^+ were measured in summer at S6 station and had a value of 21.5 mg/L as opposed to values measured in spring, which were significantly lower. This is related to the increase in precipitation, which consequently leads to the reduction of NH_4^+ concentration. The lowest value during spring was obtained at S1 and had a value of 0.568 mg/L, whereas during summer and fall they were again obtained at S1 station and had a value of 0.217 mg/L and 0.097 mg/L. The recommended value for NH_4^+ according to the GD161 standard is <3.20 mg/L. Twenty-three NH_4^+ values were above the GD161 recommended value, which indicates that Sitnica River water is polluted with NH_4^+ and is ranked below the fifth class. The annual average value with the standard deviation for NH_4^+ was 5.52 ± 4.53 mg/L.

Nitrite (NO_2^-)

According to our measurements the lowest values were registered at S1 station during the three seasons (spring 0.028, summer <0.01 , and fall 0.054 mg/L), whereas the highest values during the spring were 0.540 mg/L at S4 station, in summer they were 0.877 mg/L at S9 station, and in fall they were 0.610 at S6 station. The recommended value for NO_2^- according to GD161 is <0.30 mg/L. Twenty NO_2^- values were

above the recommended value of GD161 Regulation: 0.404; 0.54; 0.429; 0.358; 0.367; 0.355 mg/L (S3; S4; S5; S8; S9 and S10 in spring), 0.807; 0.572; 0.868; 0.838; 0.877; 0.779 mg/L (S5-S10 in summer); 0.37, 0.348, 0.364, 0.402, 0.61, 0.45, 0.416 mg/L (S2; S3; S4; S5; S6; S8; S9 and S10 in fall). This clearly shows that the analyzed river water is polluted with this pollutant and is consequently ranked below the fifth class. The average annual value with standard deviation for NO_2^- was $0.46 \pm 0.24 \text{ mg/L}$.

Fig.-7: Variation of Average Values of NO_2^- and SO_4^{2-} .

Sulfate (SO_4^{2-})

Sulfate is widely distributed in nature and its amount in natural waters varies. The results of our measurements show that the sulfate ions are present in all three monitoring seasons, where based on our research findings it was noticed that the difference of the sulfate values between the monitoring seasons at all stations is constant. From the observed values, the lowest value was obtained in spring at 9,103 mg/L whereas the highest value was obtained in fall at 100.7 mg/L. The recommended value for SO_4^{2-} according to GD161 standard is <300 mg/L. All SO_4^{2-} values in Sitnica River water resulted to be within the recommended values of the regulation. The average annual value with standard deviation for SO_4^{2-} was $53.23 \pm 25.99 \text{ mg/L}$.

Correlation Coefficients of the Analyzed Chemical and Physical Parameters of Sitnica River Water

The correlation coefficient which measures the degree of association between two variables helps researchers describe how the parameters relate to each other and influence water quality in the way that appropriate water management strategies or options could be instituted¹⁹. Correlation coefficients between the parameters of Sitnica River water are outlined in Table 4. From the results and the analysis of the physico-chemical parameters correlation, the highest positive correlations were found between: EC - TDS ($r = 0.9847$), BOD_5 - TOC ($r = 0.9844$), DO - OS ($r = 0.9665$), COD - BOD_5 ($r = 0.9499$), WT - NH_4^+ ($r = 0.7383$), and PO_4^{3-} - NH_4^+ ($r = 0.7312$), whereas the highest negative correlation was found between: DO - PO_4^{3-} ($r = -0.7418$), EC - OS ($r = -0.7192$), OS - PO_4^{3-} ($r = -0.7092$), WT - DO ($r = -0.6913$), TDS - OS ($r = -0.6896$) and EC - DO ($r = -0.6850$).

Water Quality Assessment of Sitnica River based on WQI

WQI is defined as a rating that reflects the composite influence of different water quality parameters²⁰. WQI is used to relate a group of parameters to a common scale and combining them into a single number.²¹ WQI is defined as a rating that reflects the composite influence of water quality parameters²⁰ (Puri et al., 2015). WQI is used to connect a set of parameters on a common scale combining them into a single number.²¹ In order to reflect the findings with regard to Physico-chemical parameters and water quality assessment of Sitnica River according to WQI, we applied the Canadian method, according to which there are six water quality classes as outlined in Table-1.

The WQI calculation for Sitnica River water is done using the Water Quality Index Desktop software developed by Ramadani et al. in 2017, according to literature CCME¹².

The results for F1, F2, F3 frequencies and WQI for ten stations are presented in Table-6 and Fig.-8.

At S1 station the WQI value resulted to be 95 since 1 parameter (TUR) and 1 test (61.00 NTU, summer) failed to meet the recommended value of the regulation.

At S2 station the WQI value resulted to be 68 since 7 parameters (TUR, DO, OS, DET, phosphates, ammonium ion, and nitrites) and 10 tests: 1 TUR test (31,000 mg/L, summer); 1 DO test (1.900 mg/L, summer); 1 OS test (26,000 mg/L, summer); 1 DET test (1.100 mg/L, spring); 3 phosphate tests (0.589 mg/L, spring), (0.778 mg/L, summer), and (0.737 mg/L, fall); 2 ammonium ion tests (4.545 mg/L, spring), (6.878 mg/L, summer), and 1 nitrite test (0.370 mg/L, fall) failed to meet the recommended values of the regulation.

Table-1: An Outline of the Results of Physical and Chemical Parameters Analyzed During the Spring Season

Parameters	Symbols	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Water Temperature	WT	6.4	10.1	12.7	13	12.5	14.0	13.2	12.4	12.6	12.7
Turbidity	TUR	9.5	5.7	3.3	5.9	9.8	64	7.7	3.5	4.0	2.9
Electrical Cond.	EC	262	532	645	708	720	884	831	612	616	618
TDS	TDS	131	270	324	355	361	446	415	360	310	310
Conc. of H ⁺ Ion	pH	7.99	7.76	7.75	7.69	7.71	7.69	7.80	7.78	7.76	7.71
Dissolved Oxygen	DO	10.51	5.73	5.48	4.01	6.18	2.81	0.53	4.82	6.76	6.78
O Saturation	OS	93.3	55.6	55.2	40.7	63.8	30.7	5.5	50.5	69.1	68
BOD	BOD ₅	8.5	2.0	17	11.3	12.5	29.2	13.9	5.4	5.5	20.6
COD	COD	18.0	3.8	30	24.4	27.2	60.5	26.4	11.3	12.8	44.0
Total Organic Carbon	TOC	5.6	1.6	9.4	7.6	8.4	19.8	9.8	3.3	3.8	13.7
Nitrate	NO ₃ ⁻	<0.1	<0.1	4.3	1.8	8.0	<0.1	<0.1	6.5	6.7	6.2
Detergents	DET	<0.1	1.1	0.4	0.2	<0.1	2.0	1.4	<0.1	<0.1	<0.1
Phosphate ion	PO ₄ ⁻	0.018	0.589	0.549	0.483	0.867	1.564	1.482	0.595	0.438	1.148
Ammonium ion	NH ₄ ⁺	0.568	4.545	1.945	5.542	4.457	5.675	5.174	3.939	4.226	1.455
Nitrite ion	NO ₂ ⁻	0.028	0.194	0.404	0.540	0.429	0.876	0.603	0.358	0.367	0.355
Sulfate ion	SO ₄ ²⁻	9.103	20.30	27.29	24.98	46.53	78.86	98.15	40.82	54.51	54.10

Table-2: An Outline of the Results of Physical and Chemical Parameters Analyzed During the Summer Season

Water Temperature	WT	14.9	20.1	21.2	21.9	23.5	22.2	19.9	21.6	22.2	22.6
Turbidity	TUR	61	31	14.4	10.9	7.5	31	17.2	5.2	5.4	85
Electrical Conductivity	EC	280	530	560	540	670	770	660	680	640	640
TDS	TDS	140	260	280	270	330	345	330	340	320	320
Conc. of H ⁺ Ion	pH	7.85	7.30	7.25	7.31	7.32	7.48	8.27	7.78	7.48	7.47
Dissolved Oxygen	DO	7.4	1.9	1.6	1.7	2.8	1.9	2.4	1.7	3.5	3.8
O saturation	OS	95	26	22	23	39	27	34	24	49	53
BOD	BOD ₅	1.9	9.2	34.5	25.2	8.4	26.2	31.0	29.4	43.6	59.8
COD	COD	4.2	28.8	57.0	48.0	20.6	83	56	72.5	93	134
Total Organic Carbon	TOC	1.3	6.9	27.6	20	4.2	20	24.8	22.8	28.2	41.4
Nitrates	NO ₃ ⁻	<0.1	<0.1	<0.1	<0.1	5.6	<0.1	2.4	5.9	9.9	10
Detergents	DET	<0.1	0.7	<0.1	0.5	<0.1	2.4	1.6	<0.1	<0.1	<0.1
Phosphate ion	PO ₄ ⁻	0.16	0.778	1.778	1.587	2.114	2.75	1.220	1.235	1.084	1.244
Ammonium ion	NH ₄ ⁺	0.217	6.878	12	10.15	10.13	21.5	12.5	9.45	8.5	5.90
Nitrite ion	NO ₂ ⁻	<0.01	0.295	0.305	0.310	0.807	0.572	0.868	0.838	0.877	0.779
Sulfate ion	SO ₄ ²⁻	39.8	19.34	26.06	30.76	29.69	50.12	70.45	72.78	70.73	80.56

Table-3: An Outline of the Results of Physical and Chemical Parameters Analyzed During the Fall Season

Water Temperature	WT	10.2	13.2	14.7	15.2	15.0	16.5	15.5	14.6	15.0	15.5
Turbidity	TUR	9.2	19.7	9.7	5.5	7.5	8.2	9.1	16.5	17.0	17.4
Electrical Conductivity	EC	270	540	680	710	770	760	610	570	610	610
TDS	TDS	135	270	340	355	385	390	300	280	304	305
Conc. of H ⁺ Ion	pH	8.20	7.61	7.54	7.62	7.66	7.77	7.58	7.66	7.56	7.61
Dissolved Oxygen	DO	9.37	4.02	3.03	2.49	3.15	3.31	2.84	3.21	4.17	4.25
O saturation	OS	93.5	41.5	32.0	26.1	32.9	35.9	29.6	38.7	43.1	46.0
BOD	BOD ₅	<0.1	18.8	22.6	23.8	11.4	34.9	24.3	32.9	42.3	32.5
COD	COD	<0.1	36.2	65.5	57.5	33.8	106	58.2	76.9	105.4	95.8

Total Organic Carbon	TOC	<0.1	10.5	18.5	16.7	9.5	28.6	16.7	21.7	30.4	26.6
Nitrates	NO ₃ ⁻	<0.1	2.4	0.3	<0.1	9.0	3.5	<0.1	6.3	11.2	11.5
Detergents	DET	<0.1	<0.1	0.6	1.0	<0.1	0.7	1.3	<0.1	<0.1	<0.1
Phosphate ion	PO ₄ ⁻	0.0	0.737	1.236	1.470	1.416	1.364	0.831	1.080	1.463	1.162
Ammonium ion	NH ₄ ⁺	0.097	1.448	4.950	4.825	3.268	5.585	4.295	3.720	1.136	1.546
Nitrite ion	NO ₂ ⁻	0.054	0.370	0.348	0.364	0.402	0.610	0.596	0.450	0.416	0.448
Sulfate ion	SO ₄ ²⁻	18.60	40.73	39.88	73.14	100.7	82.20	92.86	59.92	72.90	71.14

Table-4: Correlations of the Analyzed Physical and Chemical Parameters

Correlations	WT	TUR	EC	TDS	pH	DO	OS	COD	BOD ₅	TOC	NO ₃	DET	PO ₄ ³⁻	NH ₄ ⁺	NO ₂ ⁻	SO ₄ ²⁻
WT	1.0000															
TUR	0.2659	1.0000														
EC	0.2990	-0.033	1.0000													
TDS	0.2414	-0.063	0.9847	1.0000												
pH	-0.577	-0.129	-0.261	-0.220	1.0000											
DO	-0.691	-0.0495	-0.685	-0.650	0.5360	1.0000										
OS	-0.5308	0.0948	-0.7192	-0.6896	0.4918	0.9663	1.0000									
COD	0.4901	0.3179	0.3078	0.2580	-0.2481	-0.3752	-0.3116	1.0000								
BOD ₅	0.5222	0.3474	0.2643	0.2257	-0.2396	-0.3884	-0.3133	0.9499	1.0000							
TOC	0.5404	0.3178	0.2719	0.2328	-0.221	-0.425	-0.356	0.9553	0.9844	1.0000						
NO ₃	0.1963	0.2916	-0.123	-0.125	-0.347	0.1822	0.3068	0.398	0.383	0.354	1.0000					
DET	0.2566	0.6139	0.4920	0.3656	0.2109	-0.368	-0.312	0.307	0.331	0.297	-0.018	1.0000				
PO ₄ ³⁻	0.6804	0.0967	0.6529	0.5762	-0.5448	-0.7418	-0.7092	0.4787	0.4379	0.4746	0.2179	0.6895	1.0000			
NH ₄ ⁺	0.7383	0.0582	0.4052	0.3258	-0.3478	-0.6173	-0.5511	0.2268	0.2375	0.2846	-0.2436	0.6115	0.7312	1.0000		
NO ₂ ⁻	0.6174	0.3578	0.6735	0.6487	-0.1034	-0.5738	-0.4700	0.4519	0.4943	0.4598	0.0585	0.5681	0.4926	0.4561	1.0000	
SO ₄ ²⁻	0.2089	0.1473	0.6131	0.6054	0.0340	-0.4575	-0.4379	0.5219	0.4781	0.4824	0.5353	0.4973	0.3826	0.0318	0.5880	1.0000

Table-5: Categorization of Water Quality According to WQI Values and Description.

Class	WQI Value	Description
Excellent	95-100	Water quality is protected with a virtual absence of impairment; conditions are very close to pristine levels. These index values can only be obtained if all measurements meet recommended guidelines virtually all the time.
Very good	89-94	Water quality is protected with a slight presence of impairment; conditions are close to pristine levels.
Good	80-88	Water quality is protected with only a minor degree of impairment; conditions rarely depart from desirable levels.
Fair	65-79	Water quality is usually protected but occasionally impaired; conditions sometimes depart from desirable levels.
Marginal	45-64	Water quality is frequently impaired; conditions often depart from desirable levels.
Poor	0-44	Water quality is almost always impaired; conditions usually depart from desirable levels

At S3 station the WQI value resulted to be 60 since 8 parameters (DO, OS, COD, BOD₅, DET, phosphates, ammonium ion, and nitrite) and 15 tests: 2 DO tests (1,600 mg/L, summer) and (3,030 mg/L, fall)); 1 OS test (22.00%, summer); 2 COD tests (57,000 mg/L, summer), and (65,500 mg/L, fall); 2 BOD₅ tests (34,500 mg/L, summer), and (22,600 mg/L, fall); 1 DET test (0.600 mg/L, fall); 3 phosphate tests (0.549 mg/L, spring), (1.778 mg/L, summer), and (1.236 mg/L, fall); 1 ammonium ion test (12,000 mg/L, summer), and 3 nitrite tests (0,404 mg/L, spring), (0,305 mg/L, summer), and (0,348 mg/L, fall) failed to meet the recommended values of the regulation.

At S4 station the WQI value resulted to be 59 since 8 parameters (DO, OS, COD, BOD₅, DET, phosphates, ammonium ion, and nitrite) and 17 tests: 2 DO tests (1,700 mg/L, summer) and (2,490 mg/L,

fall), 2 OS tests (23.00 mg/L, summer) and (26.100 mg/L, fall); 1 COD test (57.500 mg/L, fall); 2 BOD₅ tests (25.200 mg/L, summer) and (23.800 mg/L, fall); 1 DET test (0.500 mg/L, summer); 3 phosphate tests (0.483 mg/L, spring), (1.587 mg/L, summer) and (1.470 mg/L, fall); 3 ammonium ion tests ((5.542 mg/L, spring), (10.150 mg/L, summer) and (4.825 mg/L, fall) and 3 nitrite tests (0.540 mg/L, spring), (0.310 mg/L, summer) and (0.364 mg/L, fall).

At S5 station the WQI value resulted to be 71 since 4 parameters (DO, phosphates, ammonium ion, and nitrite) and 11 tests: 2 DO tests ((2,800 mg/L, summer) and (3,150 mg/L, fall); 3 phosphate tests (0.870 mg/L, spring), (2.110 mg/L, summer), and (1.420 mg/L, fall); 3 ammonium ion tests (4.460 mg/L, spring), (10.130 mg/L, summer) and (3.270 mg/L, fall), and 3 nitrite tests (0,430 mg/L, spring), (0,810 mg/L, summer), and (0,400 mg/L, fall)) failed to meet the recommended values of the regulation.

At S6 station the WQI value resulted to be 46 since 9 parameters (TUR, DO, OS, COD, BOD₅, DET, phosphate, ammonium ion and nitrites) and 24 tests: 2 TUR tests (64,000NTU, spring) and (31,000NTU, summer); 3 DO tests (2.810 mg/L, spring), (1.900 mg/L, summer) and (3.310 mg/L, fall); 1 OS test (27.00%, summer); 3 COD tests (60,500 mg/L, spring), (83,000 mg/L, summer) and (106,000 mg/L, fall); 3 BOD₅ tests (29.200 mg/L, spring), (26.200 mg/L, summer) and (34.900 mg/L, fall)); 3 DET tests (2.000 mg/L, spring), (2.400 mg/L, summer), and (0.700 mg/L, fall); 3 phosphate tests (1.564 mg/L, spring), (2.750 mg/L, summer), and (1.364 mg/L, fall); 3 ammonium ion tests (5.675 mg/L, spring), (21.500 mg/L, summer), and (5.585 mg/L, fall), and 3 nitrite tests (0.876 mg/L, spring), (0.572 mg/L, summer), and (0.610 mg/L, fall) failed to meet the recommended values of the regulation.

At S7 station the WQI value resulted to be 53 since 8 parameters (DO, OS, COD, BOD₅, DET, phosphate, ammonium ion and nitrite) and 21 tests: 3 DO tests (0.530 mg/L, spring), (2.400 mg/L, summer), and (2.840 mg/L, fall)); 2 OS tests ((5.50%, spring) and (29.60%, fall)); 2 COD tests (56,000 mg/L, summer) and (58.200 mg/L, fall); 2 BOD₅ tests (31,000mg/L, summer) and (24,300 mg/L, fall); 3 DET tests (1.400 mg/L, spring), (1.600 mg/L, summer) and (1.300 mg/L, fall); 3 phosphate tests (1,482 mg/L, spring), (1,220 mg/L, summer) and (0,831 mg/L, fall)); 3 ammonium ion tests (5,174 mg/L, spring), (12,500 mg/L, summer) and (4,295 mg/L, fall), and 3 nitrite tests (0,603 mg/L, spring), (0,868 mg/L, summer) and (0.596 mg/L, fall) failed to meet the recommended values of the regulation.

At S8 station the WQI value resulted to be 63 since 7 parameters (DO, OS, COD, BOD₅, phosphates, ammonium ion, and nitrite) and 16 tests: 2 DO tests (1.700mg/L, summer) and (3.210mg/L, fall)); 1 OS test (24.00%, fall); 2 COD tests (72.500 mg/L, summer) and (76.900 mg/L, fall); 2 BOD₅ tests (29.400 mg/L, summer) and (32.900 mg/L, fall); 3 phosphate tests ((0.595 mg/L, spring), (1.235 mg/L, summer) and (1.080 mg/L, fall); 3 ammonium ion tests ((3.939 mg/L, spring), (9.450 mg/L, summer) and (3.720 mg/L, fall)) and 3 nitrite tests ((0.358 mg/L, spring), (0.838 mg/L, summer) and (0.450 mg/L, fall)) failed to meet the recommended values of the regulation.

At S9 station the WQI value resulted to be 64 since 8 parameters (DO, COD, BOD₅, TOC, nitrates, phosphates, ammonium ion, and nitrite) and 15 tests: 1 DO test (3,500 mg/L, summer); 2 COD tests (93,000 mg/L, summer) and 105,400 mg/L, fall)); 2 BOD₅ tests (43.600mg/L, summer) and (42.300mg/L, fall); 1 TOC test (30.400 mg/L, fall); 1 nitrate test (11.200 mg/L, fall); 3 phosphate tests (0.438 mg/L, spring), (1.084 mg/L, summer) and (1.463 mg/L, fall); 2 ammonium ion tests ((4.226mg/L, spring) and (8.500 mg/L, summer)) and 3 nitrite tests (0.367 mg/L, spring), (0.877 mg/L, summer) and 0.416 mg/L, fall)) failed to meet the recommended values of the regulation.

At S10 station the WQI value resulted to be 56 since 8 parameters (TUR, DO, COD, BOD₅, TOC, nitrates, phosphates, ammonium ion and nitrite) and 16 tests: 1 TUR test (85,000NTU, summer); 1 DO test (3.800 mg/L, summer); 2 COD tests (134,000 mg/L, summer) and (95,800 mg/L, fall); 3 BOD₅ tests (20,600 mg/L, spring), (59,800mg/L, summer) and (32,500 mg/L, fall)); 1 TOC test (41.400mg/L, summer); 1 nitrate test (11,500 mg/L, fall); 3 phosphate tests (1.148 mg/L, spring), (1.244 mg/L, summer) and (1.162 mg/L, fall); 1 ammonium ion test (5.900 mg/L, summer)) and 3 nitrite tests (0.355 mg/L, spring), (0.779 mg/L, summer) and (0.448 mg/L, fall) failed to meet the recommended values of the regulation.

Based on the results the river water at S1 station had the best quality with a WQI value of 95 and belongs to excellent category, whereas the river water at S6 station showed the worst quality with a WQI value of 46 and belongs to marginal category. Finally, the average WQI for the entire measurement period was

63.5, which indicates that the Sitnica River water belongs to the marginal category (water quality is frequently impaired; conditions often depart from desirable levels).

Table-6: Calculated Values of F1, F2, F3, and WQI using the Water Quality Desktop Software

Stations	F1	F2	F3	WQI
S1	6.25	2.083333	4.095904	95
S2	43.75	22.91667	21.67845	68
S3	50	33.33334	32.64256	60
S4	50	35.41666	33.42852	59
S5	25	22.91667	35.02996	71
S6	56.25	50	52.60899	46
S7	50	43.75	46.71959	53
S8	43.75	33.33334	30.53653	63
S9	43.75	29.16667	31.07402	64
S10	56.25	33.33334	36.65270	56

Average WQI = 63.5

Fig. -8: WQI Values at S1-S10 Monitoring Stations

CONCLUSION

This paper, through Physico-chemical parameters, analyzed Sitnica River water at ten monitoring stations during the three seasons of the year (spring, summer, and fall). The values of the measured parameters were compared to the Romanian standard for the assessment of the ecological status of surface waters (GD161). Based on the results obtained from the research and their discussion we can draw the following conclusions:

- All the analyzed physical and chemical parameters of Sitnica River water have shown values that vary from station to station during the three periods, based on which we can conclude that the environmental condition of Sitnica River in 7 monitoring stations is significantly polluted, with the most noted pollution at S6, S7, S10, S4, and S3 stations;
- The values of WT, TUR, EC, TDS, pH, TOC, and sulfate have been in line with GD161 recommendations and are categorized in the first class;
- The values of COD, BOD₅, DET, PO₄³⁻, NH₄⁺, and NO₂⁻ parameters have resulted to be above the recommended value of the GD161 regulation and thus are categorized in the fifth class;
- The highest positive correlation was found between: EC-TDS ($r = 0.9847$), whereas the highest negative correlation was found between: DO-PO₄³⁻ ($r = -0.7418$);
- Based on the WQI calculations using the Water Quality Index Desktop software it has been concluded that the river water at S1 station has the best quality with a WQI value of 95 (Category: excellent), whereas the river water at S6 station has the worst quality with a WQI value of 46 (Category: marginal); the average WQI for the entire measurement period was 63.5 (Category: marginal);
- It is recommended that the responsible institutions support the monitoring of river waters; undertake measures for the treatment of urban, agricultural, and industrial wastewater before being discharged into river flows, as an effective anti-pollution measure.

REFERENCES

1. Bode, A, Ph. D. Thesis, Department of Mineral Resources Engineering, Polytechnic University of Tirana, Tiran, Albania (2012).
2. S. K. Pradhan, P. Dipika, and S. P. Rout, *Indian Journal Environment*, **21**,355(2001).
3. S. Shrestha, F. Kazama, *Environmental Modelling and Software*, **22(4)**, 464(2007).
4. M. Muniyan, G. Ambedkar, *International Journal of Environmental Biology*, **1(2)**, 15(2011).
5. W. Suraj Devi, K. Rajmani Singh and N. Sony Meitei, *Universal Journal of Environmental Research and Technology*, **5(3)**, 165(2015).
6. P. Walsh, W. Wheeler, Environmental Protection Agency and National Centre for Environmental Economics, *NCEE Working Paper Series No. 12-05* (2012).
7. S. Harshan, M. Thushyanthy, J. Gunatilake, T. Srivaratharasan and K. Gunaalan, *Vingnanam Journal of Science*, **13**, 1(2016).
8. K. Yogendra and E. T. Puttaiah, Sengupta, M and Dalwani, R. (Editors), *Proceedings of Taal 2007, The 12th World Lake Conference*: 342-346 (2008).
9. Demaku, Ph. D. Thesis, Department of Chemistry, University of Prishtina, Prishtina, Republic of Kosovo (2012).
10. V. Morina, Ph. D. Thesis, Department of Biology, University of Tirana, Tiran, Albania (2014).
11. CCME. Water Quality Index 1.0 User's Manual. Canadian Council of Ministers of the Environment (2001).
12. P. Dwivedi, S. Sonar, *Pollution Research*, **23(1)**, 101(2004).
13. P. Ndimele, C. Kumolu-Johnson, *Trends in Applied Sciences Research*, **7(9)**, 724(2012).
14. B. Mushatq, R. Raina, T. Yaseen, A. Wanganeo, A. Yousuf, *African Journal of Environment Science and Technology*, **7(7)**, 624(2013).
15. P. Jain, J.D. Sharma, D. Sohu, P. Sharma, *International Journal of Environmental Science and Technology*, **2(4)**, 373(2005).
16. Alam M. J. B., M. R. Islam, Z. Muyen, M. Mamun, S. Islam, *International Journal of Environmental Science and Technology*, **4(1)**, 159 (2007).
17. R. P. Singh and P. Mathur, *Indian Journal of Environmental Science*, **9**,57(2005).
18. N. Kumar, D. K. Sinha, *International Journal of Environmental Sciences*, **1(2)**, 253(2010).
19. P. J. Puri, M. K. N. Yenkie, D. B. Rana and S.U. Meshram, *European Journal of Experimental Biology*, **5(2)**, 37(2015).
20. I. Naubi, N. Hassan Zardari, Sh. Moniruzzaman Shirazi, N. Farahen Binti Ibrahim, L. Baloo, *Polish Journal of Environmental Studies*, **25(1)**, 231(2016), DOI:10.15244/pjoes/60109
21. P. Bytyçi, O. Fetoshi, B. Durmishi, F. Zhushi-Etemi, H. Cadraku, M. Ismaili, and A. Shala-Abazi, *Journal of Ecological Engineering*, **19(5)**, 19(2018), DOI:10.12911/22998993/91273
22. The State of Water Report in Kosova, MESP, Prishtina, (2010).
23. A. Shala Abazi, F. Sallaku, P. Bytyqi, M. Hyseni Spahiu, and F. Millaku, *Journal of Ecological Engineering*, **19(5)**, 1(2018), DOI:10.12911/22998993/91275
24. S. Harshan, M. Thushyanthy, J. Gunatilake, T. Srivaratharasan, and K. Gunaalan, *Vingnanam Journal of Science*, **13(1-2)**,84(2017), DOI:10.4038/vingnanam.v13i1-2.4126
25. P. S. Bytyçi, F. N. Zhushi Etemi, M. A. Ismaili, Sh. A. Shala, M. S. Serbinovski, H. S. Çadraku, O. B. Fetoshi, *Rasayan Journal of Chemistry*, **11(2)**, 554(2018), DOI:10.31788/RJC.2018.1122087
26. P. S. Bytyçi, H. S. Çadraku, F. N. Zhushi Etemi, M. A. Ismaili, O. B. Fetoshi, A. M. Shala Abazi, *Rasayan Journal of Chemistry*, **11(2)**, 653(2018), DOI:10.31788/RJC.2018.1123015
27. A. Shala, F. Sallaku, A. Shala, Sh. Ukaj. *Geoadria*, **20(1)**, 13(2015)
28. J. Griffith, 1993, Coldwater Streams. *Inland Fisheries Management in North America*", American Fisheries Society, Bethesda, pp: 405-425, Maryland.

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