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Application of Water Quality Index for the Assessment the Water Quality in River Lepenci

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ABSTRACT

The physicochemical parameters of water play an important role in determining aquatic life and its development. In this study, the water quality index is used in order to assess the water quality in river Lepenci River. For the calculations of this index, eighteen physicochemical parameters were analysed, which were measured in 3 years during the years 2009, 2010 and 2014 in three stations of the main flow of river Lepenci during all months of the years. From the results, it is concluded that the better quality of water was in station SP1- Brezovica with a WQI value of 83 and it belongs to the Good category, lower quality of water has been shown in station SP3- Hani Elezit with a WQI value of 53 belonging to the marginal category. The average value for all measurement periods resulted in 70.44 which has shown that the water quality of the river Lepenci, based on the physicochemical parameters, belongs to the Fair category. Based on these results, we conclude Water quality impairment is mainly associated with an increase in population, urbanization, industrialization, and agricultural production, among others, and the development of ecotourism and hospitality in high areas near the source areas.

Keywords: water quality index, physicochemical parameters, Kosovo.

INTRODUCTION

Water quality may change as a result of natural and anthropogenic processes occurring in the environment. some of these processes are the cause of changes in water quality due to rising temperatures, biochemical oxygen consumption, chemical oxygen consumption, increased nitrogen and phosphorus compounds (Saravanan et al., 2003; Guo and Wang, 2013; Duda et al., 2020)

Recently years, water pollution in the Republic of Kosovo has become a very big problem and includes the chemical, physical and biological components of water. The availability and quality of water either surface or ground, have been deteriorated due to some important factors such as increasing population, industrialization, urbanization etc. (Tygi et al., 2013; Effendi, 2016). Surface water quality in recent years in Kosovo deteriorates tremendously after discharges of urban and industrial wastewater, pollutions from agriculture.

Water resources are very important for maintaining an adequate food supply and a productive environment for all living organisms and it are highly essential for the survival of mankind

(Kılıç, 2020; Nighojkar and Erd, 2014). Many people worldwide suffer from the lack of safe and quality water, which is essential for population needs. In many countries, water resources are depleted faster than they can be renewed and not enough for the demands of modern human life. This problem is getting worse day by day due to demographic growth sputtering, which is directly related to the contamination of water sources. But population growth and industrial development should not be factors of water pollution. Pollution becomes only due to carelessness and ignorance, or the desire of owners of enterprises for greater earnings. For very long period river waters are used for drinking, domestic use, irrigation, in industrial processes, for recreation and sports, etc. Today, pollution of water with different contaminants presents a serious problem and often limits their use, there for continuous monitoring of water is important to evaluate their quality.

The current state of water is best described by physico-chemical parameters and according to the research of (Bytyçi et al., 2020; Anbarasu and Anbuselvan, 2017). It has been proven that they affect the biodiversity distribution of flora and fauna in aquatic ecosystems and other living things.

The monitoring of water quality is an important component of water management (Bouslah et al., 2017). The gained information from the monitoring is essential for the water quality assessment (Bytyçi et al., 2018). Therefore, the effective monitoring and the assessment of surface water quality are crucial in protecting the live of the living world of the water and the health of humans since the consumption of polluted water is one of the main causes of diseases (Bytyçi et al., 2018). This way, with a preventive approach, the water quality can be managed. A very powerful tool for this aim is the Water Quality Index (WQI). WQI serve to collect large amounts of data of the water quality in simple conditions (for example good, bad) to reporting the management and public in a consistent way (Durmishi et al., 2012; Bytyçi et al., 2018). WQI represents a simple number from 0–100 where a higher value shows better quality of water and vice versa (Bytyçi et al., 2018). Numerous researches in Kosovo have been conducted on water quality assessment using WQI (Bytyçi et al., 2018).

The aim of this study is the assessment of water quality of river Lepenci through measuring of some physicochemical parameters and WQI.

MATERIAL AND METHODS

Study area

The river Lepenci is located in the southeast of the Republic of Kosova, is a river that gravitates to the Aegean Sea basin and is a tributary of the Vardar. Lepenci originates on the northern slopes of Mount Sharr in Oshllaku at 2,212 m. Lepenci in the territory of Kosovo is 53 km long, the basin area is 607 km^2, and the average annual flow is 7.9 m^3/s (MESP 2015). The samples are taken monthly during 3 years the years 2009, 2010 and 2014 in three stations of the main flow of river Lepenci (Figure 1).

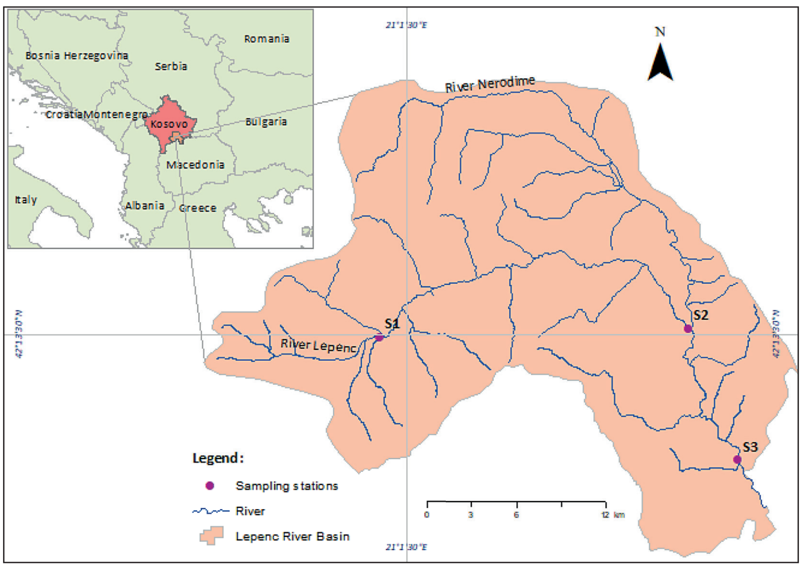

Figure 1. Geographical position of the study

The water sample collection, stations and the methods used for analysis

The analyzes of physicochemical parameters (water temperature (WT), turbidity (TUR), electric conductivity (EC), total dissolved solids (TDS), the hydrogen ion concentration (pH), the dissolved oxygen (DO) and oxygen saturation (OS), the total suspended solids, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), the total organic carbon (TOC), detergents (DET), phosphates and the total phosphorus (TP), nitrates and sulfates) is made on the basis of standard ISO 5667-6 (ISO, 2014), which determines the principles to be applied in designing the programs in sample collection, the techniques of sample collection and the treatment of water samples from rivers and flows for the physical and chemical assessment (ISO, 2014). The analysis of water samples taken from the river Lepenci is realized in the laboratory of the Hydro-meteorological Institute of Kosova. The stations of water sample collection were: SP1 (Brezovicë), SP2 (Kaçanik), and SP3 (Hani Elezit). The water quality parameters are determined using quite sophisticated measuring equipment, which are contemporary and conform to international standards. The values of the measured parameters are compared with the (Bratli, 2000; Directive 75/440/, 1975; standard of the Republic of Romania for the assessment of the ecological status of surface waters (GD161).

RESULTS AND DISCUSSION

The results of this research are presented in Table 1, 2 and 3 and in Figures 2–13.

Water temperature

WT is an important factor that affects the chemical, biochemical and biological characteristics of waters. It is a critical parameter for the aquatic life and has an impact on other parameters of water quality. Chemical reactions depend on the WT and that controls the metabolic and reproductive processes of the aquatic species (Durmishi, 2013). Some factors can have an impact on the WT, for example the vegetation amount, the water flow scale, the surface of the ground, thermal discharges, underground water, etc. WT affects distribution, health and survival of aquatic organisms (Osman and Kloas, 2010).

The recommended value of WT according to the standard GD161 is <30 °C. In the station, Brezovica (S1) in the period 2009, 2010, and 2014 were taken 6 water samples for laboratory analysis. In this case, the temperature parameter turned out to be in the range from 5.9 °C minimum to 15.2 °C maximum while the average value is 10.9 ºC. In the stations Kaçanik (S2) and Hani i Elezit (S3) in the period 2009, 2010 and 2014, 60 samples (samples) were taken for laboratory analysis. At Hani i Elezit station at the temperature of life results in the range from 3 minimum to 22.7 °C maximum, while the average value is 12.5 °C. At Kaçanik station the temperature turns out to be in the range from 3 °C minimum value up to 20.9 °C maximum when the average value is 11.9 ºC. WT has had an increasing trend on the lower flow of the river (Fig. 2).

Electrical conductivity

The recommended value for EC according to standard GD161 is <2000 µS/cm. At Brezovica station the electrical conductivity parameter turned out to be in the range from 148 µS/cm minimum to 314 µS/cm maximum while the average value is 212.8 µS/cm. At Kaçanik station the electrical conductivity parameter turned out to be in the range from 20 µS/cm minimum value up to 91.8 µS/cm maximum value while the average value is 66.1 µS/cm. While in Brezovic it turned out to be in the range from 166 µS/cm minimum value up to 395 µS/cm maximum value while the average value is 272.0 µS/cm. From the results it can be seen that in source stations the values of EC were lower, while the higher ones have been in stations where the pollution is higher (Fig. 3).

Formally, a correlation coefficient is defined between two random variables. Has a value between [-1 and 1]. They are greater than zero for positive correlation and less than zero for negative correlation. Table 2 shows that some of the

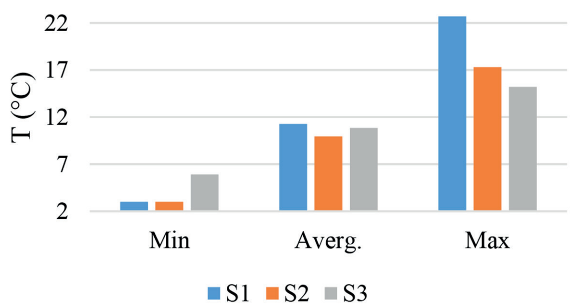

Fig. 2. Variation of values of WT

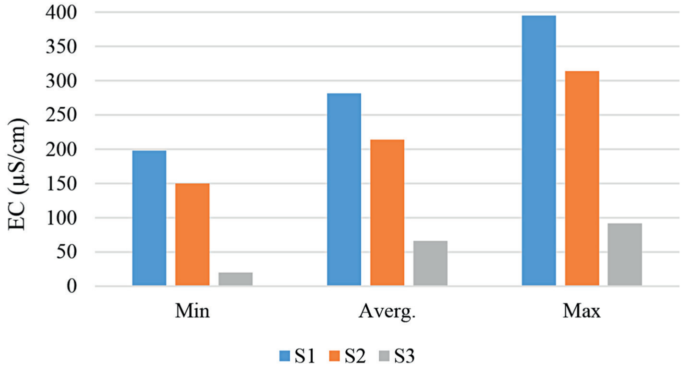

Fig. 3. Variation of values of EC (µS/cm)

physico-chemical parameters analyzed in the waters of the Lepenc River have good correlational relationships. So good relationships ($R = 0.90$) are shown between Biochemical Oxygen Demand and turbidity, as well as total organic carbon and the Chemical Oxygen Demand. The best correlation (R = 0.86) is also shown between nitrites and total organic carbon, then between TDS and EC (R = 079). Also the correlation (R = 0.77) is shown above the parameters total organic carbon and biochemical oxygen demand.

Total dissolved solids

Total dissolved solids comprise inorganic salts and small amounts of organic matter that are dissolved in water. The principal constituents are usually the cations calcium, magnesium, sodium and potassium and the anions carbonate, bicarbonate, chloride, sulphate and, particularly in groundwater, nitrate (from agricultural use). Total dissolved solids is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The most important aspect of TDS with respect to drinking water quality is its effect on taste. The palatability of drinking water with a TDS level less than 600 mg/L is generally considered to be good. Drinking water supplies with TDS levels greater than 1200 mg/L are unpalatable to most consumers. Concentrations of TDS above 500 mg/L result in excessive scaling in water pipes, water heaters, boilers and household appliances. An aesthetic objective of ≤500 mg/L should ensure palatability and prevent excessive scaling. However, it should be noted that at low levels TDS contributes to the palatability of drinking water. In the study area the TDS values have turned out to be as follows. At S2 station this parameter ranged from 100 mg/L (min) to 228 mg/L (max) with a mean value of 145.50 mg/L. At S3 station it fluctuated from 70 mg/L (min) to 106.96 mg/L (max) with a mean value of 157 mg/L, whereas at S1 station it ranged from 7.87 mg/L (min) to 47.2 mg/L (max) with a mean value of 27.56 mg/L. The results show that the lowest values are found at S1 station, which is located upstream the river. In general, it turns out that the TDS values in the study area are within the standard values shown above (Figure 4).

pH

pH measurement indicates the acidity or alkalinity of water. Naturally occurring fresh

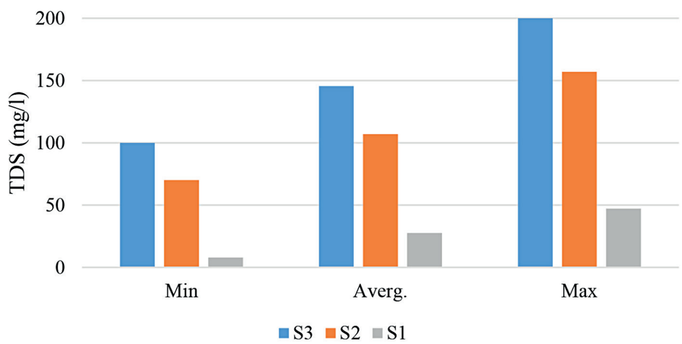

Fig. 4. Variation of values of TDS

Table 1. Results of physico-chemical parameters (monitoring station: Hani i Elezit, Kaçanik and Brezovica)

Stations	Dates	W.T. (°C)	Turbidity	EC (µS/cm)	TDS	pH	DO	Oxygen saturation	TSS	COD	BOD_5	TOC	Nitrate	Nitrites	Ammonium	Orthophosphate
Hani i Elezit	Feb 2009	4.30	149.00	322.00	163.00	8.22	13.33	102.38	8.20	8.90	4.88	1.30	2.30	0.09	1.49	0.44
	Mar 2009	10.90	41.00	198.00	100.00	8.08	11.29	102.17	63.50	21.60	2.81	4.50	0.60	0.07	1.11	0.19
	Apr 2009	18.70	27.00	260.00	228.00	8.33	9.93	106.43	32.00	50.00	4.00	9.20	3.50	0.33	1.03	0.49
	Aug2009	22.70	19.20	387.00	193.00	8.08	8.01	92.92	8.33	25.80	6.91	10.00	4.30	0.62	1.31	0.52
	Sep 2009	16.40	103.00	395.00	198.00	8.02	9.76	99.57	120.00	148.00	6.42	23.60	3.80	0.56	1.89	1.02
	Oct 2009	9.90	19.50	308.00	154.00	8.15	11.33	100.17	8.80	29.60	4.72	9.50	1.90	0.23	1.04	0.47
	Nov 2009	8.70	12.80	250.00	125.00	8.21	11.54	99.14	4.00	105.00	3.65	16.60	2.60	0.13	0.53	0.13
	Dec 2009	5.10	92.80	274.00	138.00	7.88	11.62	91.20	42.00	34.00	9.39	9.50	1.20	0.06	1.91	0.15
	Mar 2010	9.50	7.44	260.00	132.00	8.05	10.67	93.46	31.00	23.40	4.89	5.50	1.40	0.20	0.32	0.06
	Nov 2010	8.30	19.00	262.00	134.00	8.13	8.50	72.34	nil	0.90	0.40	0.10	1.40	0.20	1.03	0.43
	Dec 2010	3.00	19.80	251.00	125.00	7.96	7.75	57.58	22.00	28.60	6.60	4.50	3.40	0.10	0.41	0.07
	Feb 2014	9.40	10.30	325.00	162.00	8.34	8.55	72.90	25.40	6.10	2.70	1.90	1.80	0.11	2.26	0.63
	Mar 2014	11.80	9.90	309.00	155.00	7.78	9.90	89.40	1.60	26.00	12.20	8.10	1.60	0.16	4.28	0.58
	Apr 2014	11.80	9.90	215.00	108.00	7.69	9.63	95.40	0.15	32.00	15.20	10.10	0.15	0.13	0.08	0.21
	Jun 2014	15.00	10.30	210.00	105.00	8.08	9.45	99.70	1.60	2.10	0.70	1.00	1.50	0.23	0.11	0.05
	Aug 2014	18.50	22.00	380.00	190.00	7.80	8.51	94.40	0.15	12.10	5.30	3.70	9.80	0.99	0.73	0.42
	Sep 2014	11.50	17.30	250.00	120.00	7.92	9.37	97.70	0.15	24.40	11.50	7.60	1.50	0.25	0.70	0.26
	Oct 2014	13.40	3.60	310.00	150.00	8.02	8.96	99.60	7.70	2.00	0.80	0.60	5.00	0.45	0.57	0.34
	Nov 2014	10.80	1066.00	200.00	100.00	7.95	9.56	97.70	11.90	104.00	48.50	32.50	7.60	0.47	0.41	1.21
	Dec 2014	5.8	108	260	130	7.61	10.7	93.8	0.15	0.15	0.15	0.15	1.5	0.234	0.12	0.06
Kaçanik	Feb 2009	4.20	15.70	254.00	129.00	8.32	13.97	107.04	6.80	150.00	2.95	23.80	nil	0.02	0.43	0.08
	Apr 2009	9.20	20.00	160.10	83.20	8.08	11.74	102.08	57.00	9.30	1.86	1.40	nil	0.03	0.22	0.07
	Jul 2009	17.30	79.00	211.00	110.00	8.23	10.26	106.76	92.33	100.00	1.46	15.80	1.80	0.07	0.49	0.11
	Sep 2009	16.80	117.00	314.00	157.00	8.16	10.50	108.13	164.00	196.00	3.79	31.00	0.40	0.13	0.71	0.18
	Octe 2009	9.70	15.50	240.00	120.00	8.29	12.07	106.15	32.40	26.40	3.08	7.00	1.00	0.20	0.42	0.12
	Nov 2009	8.90	9.51	199.00	100.00	8.01	11.51	99.36	4.00	17.60	4.88	4.00	0.60	0.07	0.23	0.10
	Dec 2009	5.10	27.00	235.00	117.00	7.82	12.22	95.91	9.50	137.00	3.96	32.00	3.30	0.16	1.89	0.46
	Febr 2010	6.70	141.00	182.00	91.00	7.92	nil	94.85	104.00	97.00	3.04	15.40	1.10	0.10	0.09	0.14
	Mar 2010	9.50	13.60	212.00	106.00	8.13	11.37	97.93	18.00	25.80	2.80	4.00	0.60	0.29	0.19	0.05
	Nov 2010	9.00	21.00	200.00	100.00	8.23	8.70	75.26	3.90	4.90	1.10	0.80	0.30	0.20	0.23	0.10
	Dec 2010	3.00	41.00	205.00	102.00	8.00	7.80	57.95	59.00	73.00	16.20	11.60	2.20	0.07	0.18	0.07
	Febr 2014	9.30	11.90	248.00	124.00	8.34	7.80	85.40	20.20	7.00	3.00	2.10	1.40	0.04	1.42	0.11
	Mar 2014	7.80	11.00	248.00	124.00	7.67	11.41	100.30	2.30	25.20	11.80	7.80	1.10	0.05	2.37	0.09
	Apri 2014	11.60	44.00	172.00	86.00	7..74	9.52	93.90	0.15	45.00	21.20	14.20	0.15	0.08	0.08	0.12
	Jun 2014	14.50	10.40	150.00	70.00	7.96	9.43	98.20	1.10	1.60	0.90	0.30	0.15	0.05	nil	0.03
	Agu 2014	16.90	18.20	270.00	130.00	7.77	8.90	98.60	7.10	2.70	1.10	0.80	2.50	0.17	0.08	0.33
	Sep 2014	10.90	5.60	190.00	100.00	7.78	8.92	94.70	0.15	25.60	12.00	8.00	0.15	0.14	0.53	0.18
	Octe 2014	13.40	7.30	230.00	110.00	8.10	9.98	101.10	0.70	2.50	1.10	0.70	1.10	0.18	0.01	0.17
	Nov 2014	10.10	998.00	160.00	80.00	7.83	9.33	95.80	8.60	24.00	11.20	7.40	3.40	0.19	nil	0.28
	Dec 2014	5.00	103.00	200.00	100.00	7.85	9.08	77.80	5.40	1.80	0.70	0.50	3.70	0.09	0.01	0.03
Brezovicë	Apr 2009	7.40	17.50	77.80	38.30	8.15	11.93	99.25	nil	nil	nil	nil	nil	0.03	0.09	0.04
	Agu 2009	14.50	10.60	79.00	39.00	7.71	nil	nil	2.50	20.40	nil	3.20	nil	0.23	0.40	0.00
	Jun 2010	8.20	nil	91.80	47.20	7.88	12.10	102.78	3.00	nil	nil	nil	nil	0.07	0.11	nil
	Agust 2010	13.90	163.00	81.00	7.87	7.80	7.34	71.00	nil	nil	nil	nil	nil	0.07	0.17	0.01
	Apri 2014	5.90	0.30	47.00	23.00	6.76	10.77	89.30	0.15	0.90	0.40	0.20	nil	0.07	0.36	0.00
	Agust 2014	15.20	1.10	20.00	10.00	8.80	9.70	94.00	0.15	16.60	7.80	5.20	nil	0.06	0.05	0.58
Min		3.00	0.30	20.00	7.90	6.80	7.30	57.60	0.20	0.20	0.20	0.10	0.20	0.02	0.01	0.00
Averg		10.6±4.5	81.6±209.9	224.0±84.4	113.4±46.8	8.0±1.2	10.1±2.6	93.6±18.2	23.0±35.7	39.4±47.6	6.4±8.1	8.3±8.8	2.2±2	0.2±0.2	0.7±0.8	0.2±0.3
Max		22.7	1066	395	228	8.8	14	108.1	164	196	48.5	32.5	9.8	1	4.3	1.2
Cv		0.43	2.57	0.38	0.41	0.15	0.26	0.19	1.55	1.21	1.27	1.06	0.93	0.99	1.15	1.05

waters have a pH range between 6.0 and 8.0 (Osman et al., 2010). The pH of water is very important because it affects the solubility and availability of nutrients and their utilization by aquatic organisms (Osman et al., 2010). The neutral to slightly alkaline pH, probably is related to carbonate nature of the sediment (Barakat et al., 2012).

The recommended value for pH according to standard GD161 is 6.5–8.5. At the Hani i Elezit station in the period 2009, 2010, and 2014, 30 water samples were taken for laboratory analysis. In

Table 2. Correlation of parameters in station S1

Parameter	Water temperature	Turbidity	Electrical conductivity μS/cm	Total dissolved solids	pH	Dissolved oxygen	Oxygen saturation	Chemical Oxygen Demand	Biochemical Oxygen Demand	Total organic carbon	Nitrate	Nitrites	Ammo-nium	Ortho-phosphate
Water temperature	1.00													
Turbidity	-0.08	1.00												
Electrical conductivity μS/cm	0.41	-0.28	1.00											
Total dissolved solids	**0.55**	-0.27	**0.79**	1.00										
pH	0.10	-0.10	0.10	0.32	1.00									
Dissolved oxygen	-0.43	0.05	-0.18	-0.13	0.11	1.00								
Oxygen saturation	0.42	0.13	-0.02	0.14	0.03	**0.56**	1.00							
Chemical Oxygen Demand	0.16	0.44	0.08	0.13	0.10	0.12	0.25	1.00						
Biochemical Oxygen Demand	0.00	**0.90**	-0.29	-0.29	-0.24	-0.06	0.09	0.46	1.00					
Total organic carbon	0.19	**0.70**	-0.03	0.00	-0.03	0.05	0.27	**0.90**	**0.77**	1.00				
Nitrate	0.43	0.45	0.40	0.36	-0.06	-0.37	0.08	0.25	0.38	0.35	1.00			
Nitrites	**0.72**	0.17	**0.59**	**0.51**	-0.17	-0.45	0.22	0.19	0.15	0.24	**0.86**	1.00		
Ammonium	0.04	-0.14	0.44	0.37	0.08	0.08	-0.11	0.06	-0.02	0.04	-0.13	-0.11	1.00	
Orthophosphate	0.34	**0.63**	0.36	0.35	0.17	-0.16	0.12	**0.56**	**0.60**	**0.68**	0.49	0.43	0.37	1.00

this case, the pH parameter turned out to be in the range from 7.61 minimum value to 8.34 maximum, while the average value is 8.0. At Kaçanik station the pH parameter turned out to be in the range from 7.67 minimum value to 8.43 maximum, while the average value is 7.5. While at the Brezovice station the pH turned out to be in the range from 6.76 minimum to 8.8 maximum, while the average value is 7.8. The values obtained for pH at the stations were compared with the values of the GD161 standard, and according to this comparison, it turns out that the river water at this station is within the standard values. During the monitoring it is noticed a narrow variation of pH values and this shows that there is no large effect of anthropogenic and industrial discharges in the river water. pH values of all the measured stations have been within the recommended value of the standard GD161 and belong to the first class (Fig. 5).

Dissolved oxygen

Dissolved oxygen content is a very important qualitative parameter, which determines the 'health status' of water. This is so for its content determines the quantity and types of living organisms in an aquatic environment (Bode 2012). It is estimated that fish cannot live in waters with dissolved oxygen below 4 mg/L, whereas waters with a content below 2 mg/L are considered to have very high rates of eutrophication and are considered as highly polluted.

The recommended value for DO according to standard GD161 is <25 mg/L. At the Brezovica station the dissolved oxygen parameter turned out to be in the range from 6.76 mg/L minimum value to 8.8 mg/L maximum value while the average value is 7.9 mg/L.

At Kaçanik station the dissolved oxygen parameter turned out to be in the range from 7.8 mg/L (min) to 13.97 mg/L (max) while the average value is 10.2 mg/L. Whereas in Hani i Elezit station the dissolved oxygen has turned out to be in the range from 7.35 mg/L minimum to 13.33 mg/L maximum, while the average value is 9.8 mg/L (Fig. 6) The values obtained for dissolved oxygen in the stations Brezovica, Kaçanik and Hani i Elezit are compared with the values of the

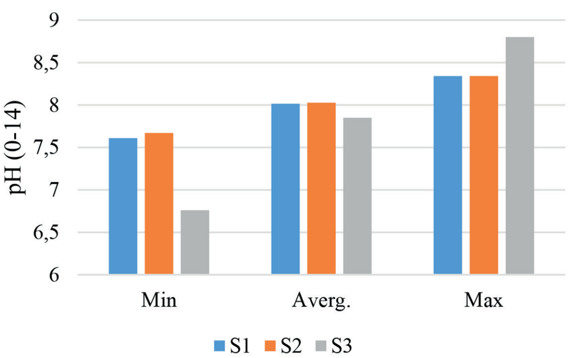

Fig. 5. Variation of pH value

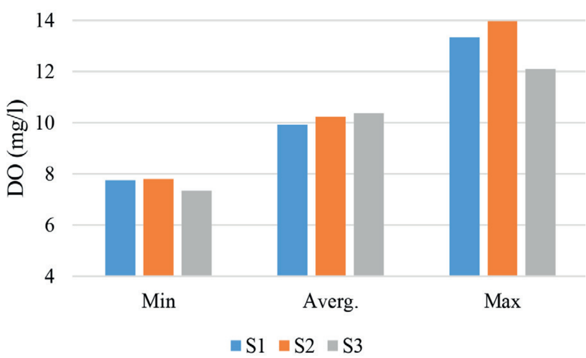

Fig. 6. Variation of Values of DO

standard GD161, and according to this comparison it turns out that the river water in this station belongs to the first class in terms of quality.

The chemical oxygen demand

Chemical oxygen demand expresses the oxygen required to oxidize all substances of organic and inorganic content, whereas the biological oxygen demand characterizes the degree of water pollution from biodegradable organic matter capable of being decomposed by microorganisms (Dakoli and Dindi 2008). In terms of the COD parameter, clean river water usually fluctuates from 4 to 8 mg/L. This parameter is an indicator of the possibility of dissolved oxygen reduction in the aquatic environment, and denotes a significant indicator of water quality, as it expresses the changes that occur in such environment as a result of various physical, chemical, and biological processes. In fact, COD is one of the indicators to assess the degree of water pollution from organic matter.

The recommended value for COD according to standard GD161 is <50 mg/L. At Brezovica station the COD parameter turned out to be in the range from 0.9 mg/L minimum value to 20.4 mg/L maximum, while the average value is 12.6 mg/L. The values obtained for COD in Brezovica station are compared with the values of standard GD161 and according to the average value of COD in this station the water quality belongs to the third class of quality. In Kaçanik station has been in the range from 1.6 mg/L minimum value to 196 mg/L maximum while the average value is 48.1 mg/L (Fig.7). The values obtained for COD at Kaçanik station are compared with the values of standard GD161, and according to this comparison it results that 6 water samples or 20% of them place water in the first grade, 3 water samples or 10% of them place water in second grade, 2 water samples or 6.66% of them place water in the third grade, 7 water samples or 23.33% of them place water in the fourth grade and 13 water samples or 43.33% of them place water in the third grade fifth. However, according to the average value of COD in this station, the water quality belongs to the fourth quality class, compared to the GD161 standard. At Hani i Elezit SHKO station it turned out to be in the range from 0.15 mg/L minimum value to 180 mg/L maximum value, while the average value is 39.9 mg /L. The values obtained for COD at Hani i Elezit station are compared with the values of the GD161 standard, and according to this comparison it results that 4 water samples or 13.33% of them place water in the first grade, 6 water samples or 20% of them place water in the second grade, 2 water samples or 6.66% of them put the water in the third grade, 11 water samples or 36.66% of them put the water in the fourth grade and 7 water samples or 23.33% of them put the water in fifth grade. However, according to the average value of COD in this station, the water quality belongs to the fourth quality class, compared to the GD161 standard (Fig. 7).

Biochemical oxygen demand

Among the biological indicators of pollution, it is worth mentioning the biological oxygen demand, which represents the amount of oxygen necessary for the phenomenon of biodegradation of organic substances present in water to occur in aerobic conditions. BOD is expressed in milligrams of oxygen consumed per liter of water (O_2 mg/lit) and is an indicator of the level of organic pollution in water. The higher the biological oxygen demand (BOD), the greater the amount of biologically degradable substances and the degree of their organic pollution. To characterize the biological oxygen demand (BOD) in the studies of hydrochemical characterization and water quality, two indicators are used: BOD_5 - the amount of oxygen consumed for 5 days from the sampling and FOD (final oxygen demand) - the amount of oxygen consumed for 30 days from the sampling (Çadraku, 2014).

The recommended value for BOD_5 according to standard GD161 is <20 mg/L. at Kaçanik station the BOD5 parameter turned out to be in the range from 0.7 mg/L minimum value to 21.2 mg / l maximum, while the average value is 5.3 mg/L (Fig. 9). The values obtained for BOD_5 at the Kaçanik station are compared with the values of the GD161 standard, and according to this comparison it results that 18 water samples or 60% of them place water in the first grade, 3 water samples or 10% of them place water in second grade, 6 water samples or 20% of them place water in the fourth grade, 1 water sample or 3.33% of them place water in the fifth grade. However, according to the average value, water quality belongs to the second quality class, compared to the GD161 standard. While in Hani i Elezit station BOD_5 has turned out to be in the range from 0.15 mg/ l minimum value to 48.5 mg/l maximum, while the average value is 6.8 mg/l (Fig. 8). The

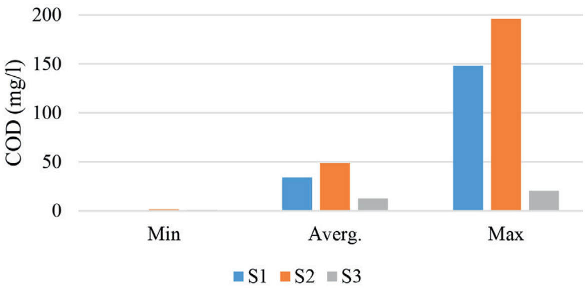

Fig. 7. Variation of values of COD

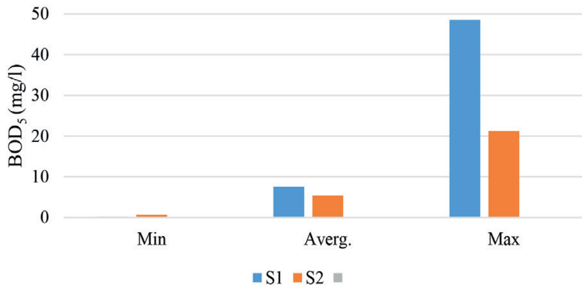

Fig 8. Variation of values of WT BOD_5

values obtained for BOD_5 at Hani i Elezit station are compared with the values of the GD161 standard, and according to this comparison it results that 8 water samples or 26.66% of them place water in the first grade, 9 water samples or 30% of them place water in the second grade, 6 water samples or 20% of them put the water in the third grade, 9 water samples or 30% of them put the water in the fourth grade and a water sample or 3.33% of them put the water in fifth grade. However, according to the average value, water quality belongs to the third quality class, compared to the GD161 standard.

Nitrates

There are various opinions in the literature regarding the limit values of nitrates (NO_3^-) in natural waters. The recommended value for NO^{3-} according to standard is <25 mg/L. According to the results of the analysis in the study area it results as follows. At Brezovica station Nitrite has been found to be in the range from 0.061 mg/L minimum value to 0.23 mg/L maximum, while the average value is 0.1 mg/L (Fig. 9). The values obtained for Nitrite at the Brezovica station are compared with the values of the GD161 standard and according to the average value of Nitrite at this station the water quality belongs to the fourth quality class. At the Kaçanik station Nitrite has been found to be in the range from 0.041 mg/L minimum value to 0.29 mg/L maximum, while the average value is 0.1 mg/L. The values obtained for Nitrite at the Kaçanik station are compared with the values of the GD161 standard and according to the average value of Nitrite at this station the water quality belongs to the fourth quality class. At Hani i Elezit Nitrates station it turned out to be in the range from 0.15 mg/L minimum value to 9.8 mg/L maximum, while the average value is 2.6 mg/L. The values obtained for Nitrates at Hani i Elezit station are compared with the values of the GD161 standard and according to the average value of Nitrates at this station the water quality belongs to the first quality class. There is also a trend of water quality deterioration in the direction downstream of the river. The nitrate content in the waters of the study area is mainly of urban and agricultural origin (from discharges of liquid urban, livestock, and agricultural fertilizers). These end up in waters from soil leaching and erosion. In principle, high values of nitrates in water promote eutrophication, fostering algal blooms and decomposition processes; this is accompanied by consumption of saturated oxygen and other difficulties in further progress in life.

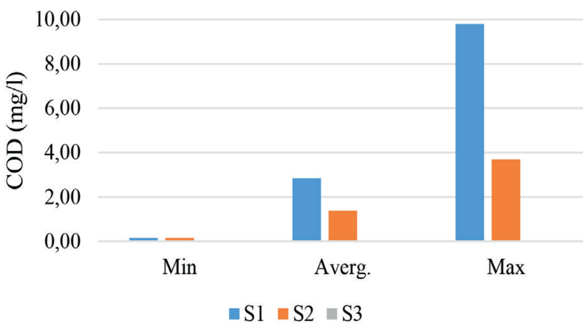

Fig. 9. Variation of values of NO_3^-

Phosphate

Increasing the concentration of phosphates (PO_4^{3-}) above the values required for biomass production poses a risk, promoting planktonic algae and turning water into a eutrophic, or even a dystrophic state. The main sources of phosphates in natural waters are detergents and phosphatic fertilizers. According to the EU directive, the limit of the PO_4^{3-} parameter varies between 0.2 mg/L for salmonid waters and 0.4 mg/L for cyprinid waters.

The recommended value for PO_4^{3-} according to GD161 standard is <0.190 mg/L. In the study area the PO_4^{3-} values have turned out to be as follows. The variation of PO_4^{3-} was from 0.020 mg/L at several stations (in different season) up to 2.335 mg/L at SP7 (summer). The average values in spring, summer and autumn were 0.129, 0.956 and 0.047 mg/L respectively, while the average value with standard deviation for the three seasons for PO_4^{3-} was 0.38±0.75 mg/L. According to the average values of PO_4^{3-} during spring, summer and autumn compared with GD161 standard values the river water belongs to the first up to fifth class of quality.

Ammonium ion

The demands for the ammonium content in natural waters are quite strict. Although the ammonium ion itself (NH_4^+) is not toxic to fish, it does become so when converted to ammonia (NH_3). In unpolluted waters the values of ammonium are about 0.015 mg/L NH_4^+, N; when ammonia levels rise above 0.025 mg/l, trout stops growing, and at concentrations above 0.25 mg/l it goes extinct. Waters containing NH_4^+ -N above 1 mg/L are especially dangerous. Ammonia above 0.1 mg/L causes water pollution, but even in lower concentrations it is quite toxic to living organisms (Bode, 2012). The risk from ammonia in water depends on temperature, pH, oxygen, and dissolved carbon dioxide. The higher the pH and the temperature value, and the lower the amount of oxygen and carbon dioxide dissolved in the water, the more toxic the ammonia will be. Ammonia is present in many surface and groundwater and, as such, comes from the microbiological activity of decomposition of organic nitrogen compounds; therefore, its presence in water is indicative of a new organic pollution (*Çadraku*, 2014). Due to its high solubility in water, ammonia exists in the following forms: NH_3 (unionized ammonia) and NH_4^+ (ionized ammonia); together, NH_3 and NH_4^+, make up the total ammonia. The toxicity of aqueous ammonia solutions is described in the unionized form, NH_3. The presence of ammoniac nitrogen forms also depends on the pH value of the water. In most natural waters the pH value is above 7, therefore the presence of the form NH_4^+ is predominant.

The recommended value for NH_4^+ according to GD161 standard is <3.20 mg/L. At Brezovica station the Ammonia parameter turned out to be in the range from 0.052 mg/L minimum value to 0.4 mg/L maximum, while the average value is 0.4 mg/L. At the Kaçanik station Ammonia turned out to be in the range from 0.0075 mg/L minimum value to 2.36 mg/L maximum, while the average value is 0.5 mg/L (Table 1). The values obtained for Ammonia at the Brezovica and Kaçanik stations are compared with the values of the GD161 standard and according to the average value of Ammonia at this station the water quality belongs to the first quality class. At Hani i Elezit station Ammonia turned out to be in the range from 0.084 mg/L minimum value to 4.2 mg/L maximum, while the average value is 1.0 mg/L. The values obtained for Ammonia at the Hani i Elezit station are compared with the values of the GD161 standard and according to the average value of Ammonia at this station the water quality belongs to the third quality class.

Total phosphorus

Total phosphorus (P_{tot}) is among the elements of special biological importance because, without it, there is no organic synthesis; however, its presence in excess provokes the phenomenon of eutrophication due to the abnormal development of microorganisms. The increase of the phosphorus content, along with that of nitrogen, enables primary producers, like algae, to increase their productivity (Dakoli, 2007). The amount of phosphates entering rivers and lakes through civil discharges has greatly increased by the use of phosphate-containing detergents. Fertilizers high in phosphate content are leached from agricultural soils after rainfall and phosphate goes into nearby watercourses (Dakoli, 2007).

The recommended value for TP according to GD161 standard is <1.20 mg/L. At the Kaçanik station Phosphorus parameter the total life results in the range from 0.016 mg/L minimum value to 0.152 mg/L maximum, while the average value is 0.1 mg/L (Table 1). The values obtained for the total Phosphorus in the Kaçanik station are compared with their standard values GD161 and according to the assessment of the averages of the total Phosphorus in this station the quality of the water in the first purchase classes. At Hani i Elezit Phosphorus station the total life results in the range from 0.034 mg/L minimum value to 0.52 mg/L maximum, while the average value is 0.2 mg/L. The values obtained for total Phosphorus at Hani i Elezit station are compared with your standard GD161 values and evaluate the averages of total Phosphorus at this station water quality in the second class.

Sulphates

Sulfate ion (SO_4^{2-}) Among other indicators of pollution are to be mentioned sulfur compounds, which according to the decreasing degree of oxidation are represented by sulphates, sulphites, and sulphides. Among the sulphides, toxic sulfur dioxide (H_2S) is mainly mentioned, which is distinguished by the characteristic smell of rotten egg. Sulphites pose a concern to aquatic bodies in that they provoke anaerobic phenomena during their transformation into sulphates by consuming water oxygen (Dakoli, 2007). Their presence is evidenced by the suffocating odor of sulfur dioxide which in an acidic environment develops as a gas. Finally, sulphates, which represent the highest oxidation state of sulfur compounds, are toxic only when present in large quantities (Dakoli, 2007).

The recommended value for SO_4^{2-} according to the GD161 standard is <300 mg/L. At Brezovica Sulfate station it turned out to be in the range from 0.625 mg/L minimum value up to 132.1 mg /L maximum, while the average value is 48 mg/L. At the Kaçanik Sulfate station they have been in the range from 0.625 mg/L minimum to 80 mg / l maximum, while the average value is 11.6 mg/L (Table 1). While at Hani i Elezit Sulfate station it turned out to be in the range from 4.73 mg/L minimum value to 41.43 mg/L maximum, while the average value is 12.0 mg/L. The values obtained for Sulfates in the station Brezovica, Kaçanik and Hani i Elezit are compared with the values of standard GD161 and according to the average value of Sulfates in this station the water quality belongs to the first class of quality.

Water quality assessment of river Lepenci basin with WQI

Calculation of WQI for waters of the river Lepenci is done via a computer program "Quality Index Desktop" developed in the years 2009, 2010 and 2014 (Ramadani et al., 2017) according to Canadian Council of Ministers of the Environment. Results for frequencies F1, F2, F3 and WQI for 3 stations are given in Table 3.

Figure 10 shows correlations between physichochemical parameters mentioned in this study. Canonical correspondence analysis (CCA) (Fig. 11) is a multivariate method to elucidate the relationships between physical parameters assemblages and their environment.

Table 3. Calculated values WQI with the computer program "Water Quality Desktop".

Stations	Years	WQI
Brezovic	2009	83
Brezovic	2010	81
Brezovic	2014	79
Hani Elezit	2009	65
Hani Elezit	2010	66
Hani Elezit	2014	55
Kaçanik	2009	69
Kaçanik	2010	70
Kaçanik	2014	66
Average WQI		70.4

Figure 12 shows hierarchical clustering (Algorithm-singel linkage, Similarity index-euclidean). Figure 13 shows the similarity of the results during the measurements through different months during the three research years

CONCLUSIONS

In this research, was application of water quality index for the assessment the water quality in river Lepenci, in three monitoring stations in twelve months of years 2009, 2010 and 2014. The values of the measured parameters are compared with the standard of the Republic of Romania for the ecological status assessment of the surface waters (GD161). From the conducted research and the discussion of the results, the following conclusions can be drawn:

The most polluted waters of river Lepenci basin were in stations SP2 (Kaçanik) and SP3 (Hani Elezit).

Based on the calculations of WQI it resulted in that river water in the station SP1 had high quality with a WQI of 83 (category: excellent), lower quality has shown the river water at station SP3 with a WQI of 55 (category: marginal), while the total average WQI during the measurement period was 70.4 (category: good);

We recommend the authorities and government institutions to support the monitoring of river waters as an effective tool to evaluate their ecological status as well as for the protection from their pollution.

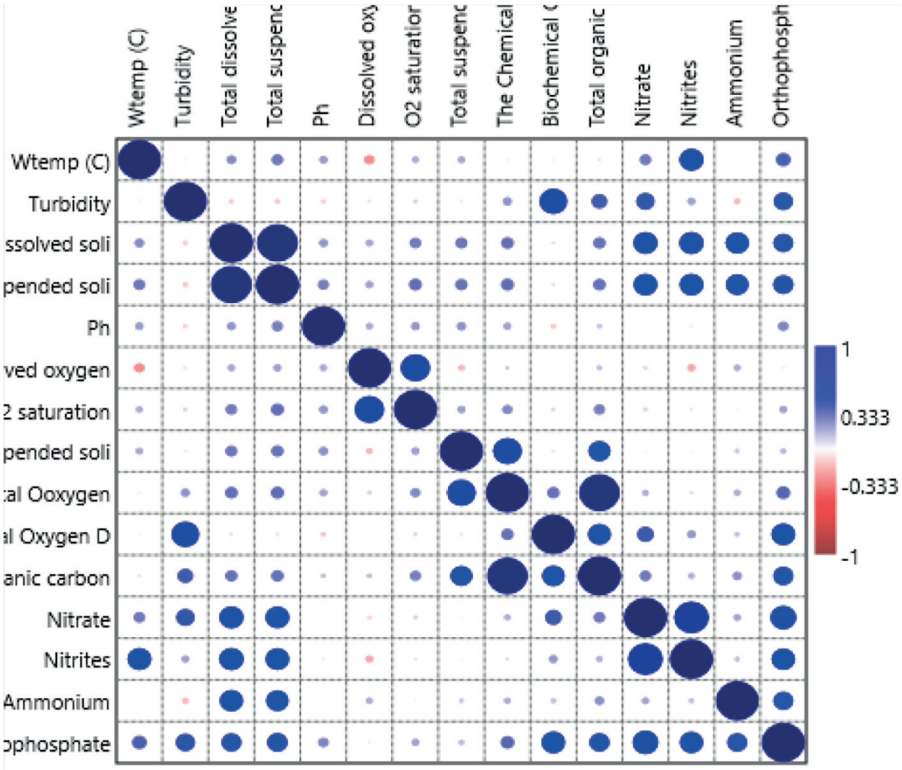

Fig. 10. Correlations between physicochemical parameters

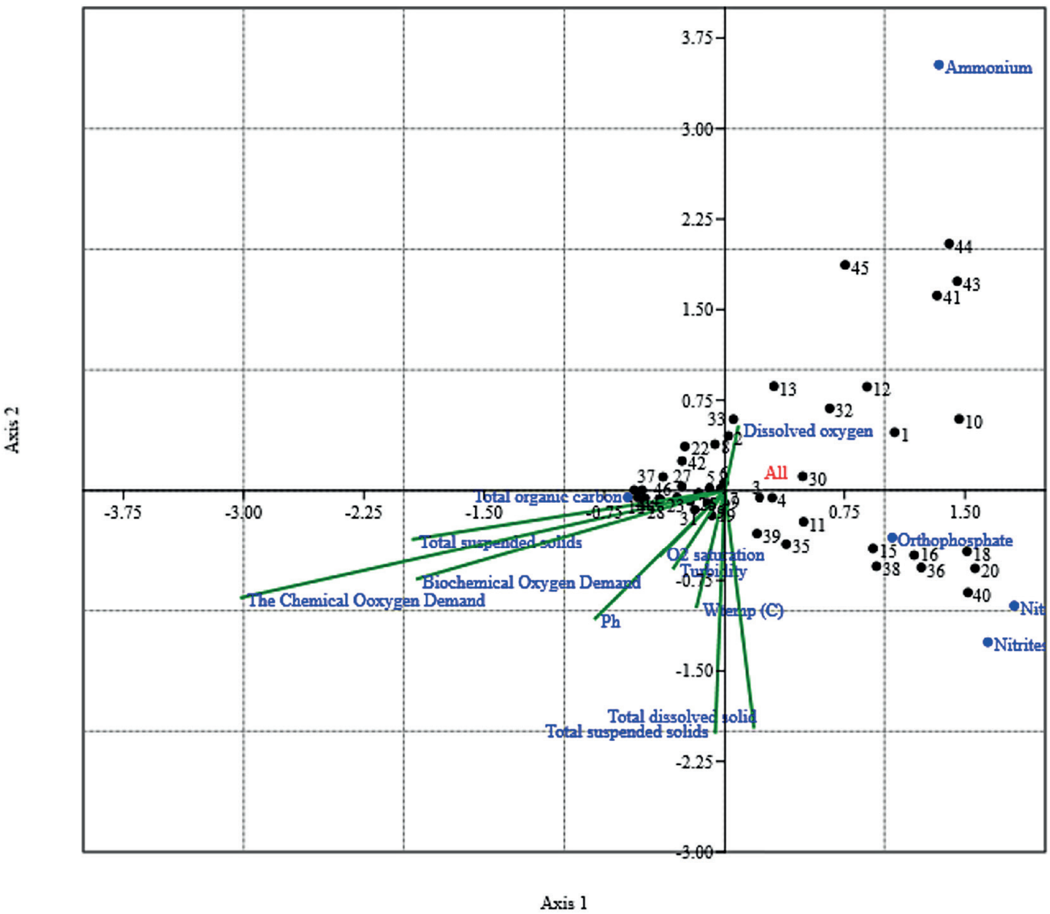

Fig. 11. Canonical correspondence analysis

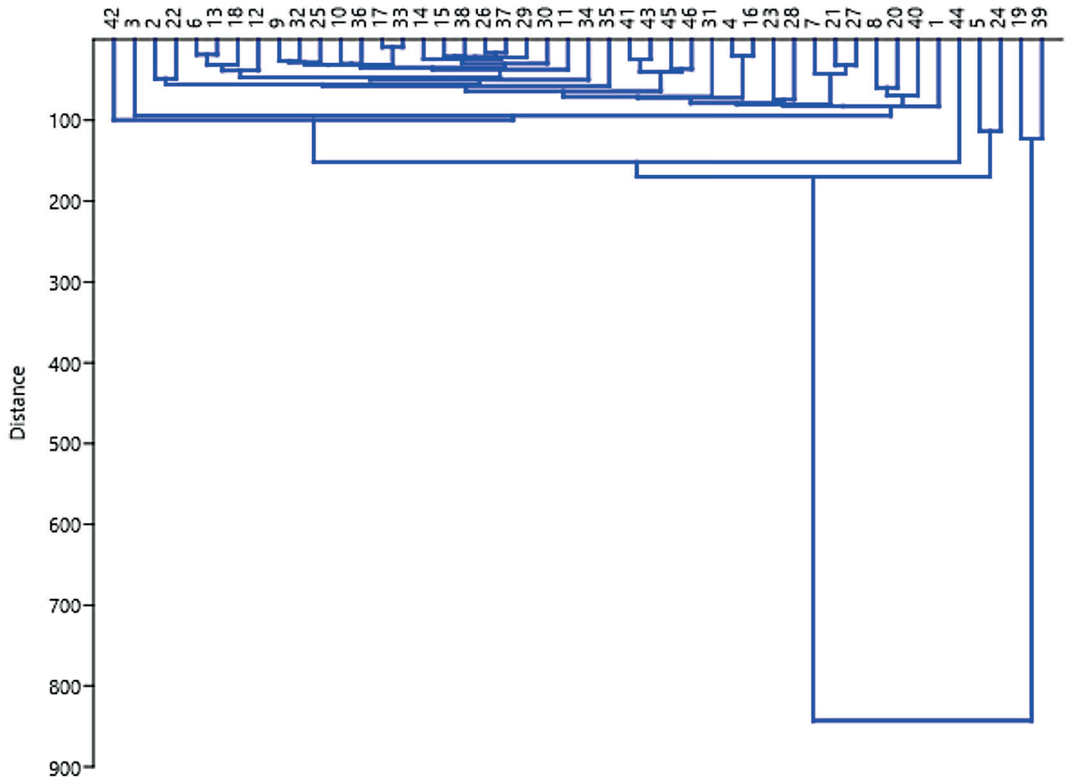

Fig. 12. Hierarchical clustering (Algorithm-singel linkage, Similarity index-euclidean)

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