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Groundwater Quality Assessment for Irrigation: Case Study in the Blinaja River Basin, Kosovo

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Abstract

Groundwater is an important source for a drink and irrigation in the Blinaja river basin. Understanding knowledge of irrigation water quality is critical to the management of water for long-term productivity. Historically for this study area there is no data and information regarding the quality and use of water for irrigation needs. Therefore, there was a need to assess water quality based on data analysed from eight sampling points. The purpose of this paper is to evaluate, relying on analytical results, the quality of groundwater in the Blinaja river basin for the purpose of its use for irrigation of agricultural crops. For this purpose, in the Blinaja River Basin in different months during 2015, 2016, 2018 and 2019, 28 water samples were taken to assess the quality of groundwater for irrigation. Water samples were analysed in a laboratory for some of the key quality indicators; pH, EC, hardness (TH), Ca, Mg, Na, K, HCO_3, SO_4, Cl, etc. and then irrigation water quality indices were calculated such as: percentage of Na (% Na), SAR (Sodium Adsorption Ratio), PI (Permeability index), KR (Kelly's ratio), etc. The overall objective of this study was to assess the quality of water to be used by the inhabitants of the area for irrigation of agricultural crops. Analytical procedures for the laboratory determinations of water quality have been given in several publications (USDA Handbook 60 by Richards, 1954; FAO Soils Bulletin 10 by Dewis and Freitas1970; APHA 2005).

Keywords: Groundwater; Quality; Basin; Water Quality; Blinaja; Physico-chemical Parameters.

1. Introduction

Groundwater quality assessment for drinking water and irrigation has become an indispensable and important task for integral management and social and economic development. Quality assessment as a necessary task stems from the growing trend of deteriorating surface and groundwater quality in the study area. Therefore, for this purpose was undertaken this research which started in 2015 until 2019 with the main focus of analyzing the physico-chemical parameters of water and calculating the indices to see that this water meets the conditions to be used for irrigation. This study aims to provide a basis for the establishment of a permanent water quality monitoring system in this river basin with the results achieved and the conclusions drawn. Historically for this study area there is no data and information regarding the quality and use of water for irrigation needs. This paper is of scientific research importance in at least two aspects, firstly it manages to highlight based on field study data and laboratory work related to groundwater quality in this study area and secondly it creates a database and information which hitherto did not exist. The contribution and importance of the work lies in the recognition of water quality and the increase of the degree of safety to be used by farmers for the irrigation of agricultural crops. The groundwater quality is influenced by several other factors like

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rainfall, topography relief, mineral solubility, mineral dissolution, ion exchange, oxidation and mineralogy of the watersheds and aquifer's structure and geology [1]. Preliminarily, there is no or very little data about the groundwater quality in this basin. On the other hand, groundwater traditionally has been considered a safe source in terms of their quality and are used by the community in this basin to meet their needs for drinking water, irrigation and other purposes.

However, the growing demand for more water, as well as the increasing rate of pollution last decade emphasize the need to undertake steps for this study. This study, which covers a period of time between 2015-2019, is focused mainly on field researches, water sampling, their laboratory analysis and also interpretation and drawing conclusions regarding groundwater quality. Groundwater quality fluctuates from place to place along with their depth. The coverage of the study area is as follows: 64.86% forest, 17.37% agricultural land, 9.21 mountain pastures, 5.02% residential area, 2.32% meadows, 0.86% road infrastructure and 0.14 water area [2]. Water flows to the springs range from 0.1 to 7 l/s and as matter of a fact the average depth of the wells is 12.5 m, while the static water level fluctuates from 0.50 to 25.6 m [2]. The physico-chemical analysis of groundwater in this basin is undertaken in order to have a more accurate picture of groundwater quality, to supplement the national database with data and information and to provide more reliable information to the community about water quality and to highlight whether or not it can be used for irrigation. Another goal for this study is to be a guide for the development of other research projects in the Blinaja River Basin. The Paleozoic rocks (represented by: quartzite, quartz-conglomerate, sandstone, sericitic, quartz-sericitic, oak-quartz, biotitic, gneiss and marble), Jurassic (serpetntinite, dunite, peridotite) are involved in the geological construction of the study area. harcburigite), Neogene (clay sand, clay), and Quaternary (alluvium, proluvion, and vegetative soil) [3]. From the hydrogeological point of view, groundwater is located in three types of aquifers: aquifer type with intergranular porosity, aquifer type with cracking and cracking porosity and aquifer type built on Paleozoic rocks [4].

2. Research Methodology

The study area is located in the central part of the Republic of Kosovo (Figure 1), between geographical coordinates 20º57'30", 21º04'00" and 42º28'20", 42º33'50". Consequently, it is comprised of an area of 31.43 km^2. The minimum negative air temperature during this monitoring period (2001-2019) was shown in 2001 in December with a value of -5.70°C, the positive minimum was shown in 2014 in December with a value of 1.80 °C. The maximum value of air temperature for this period was shown in 2015, in July with a value of 24.40 °C, while the average annual value of air temperature for this period was shown in 2013, with a value of 11.90 °C. Rainfall monitoring for the period 2001-2019, showed that the average annual rainfall ranges from 402.5 (year 2011) to 890 mm (year 2016) with an average annual value of 659.58 mm [5]. Morphologically speaking, it is distinguished by the mountain range with altitude from 670 to 1100 m (west), and the plain with altitude from 530 to 670 m (east) [2].

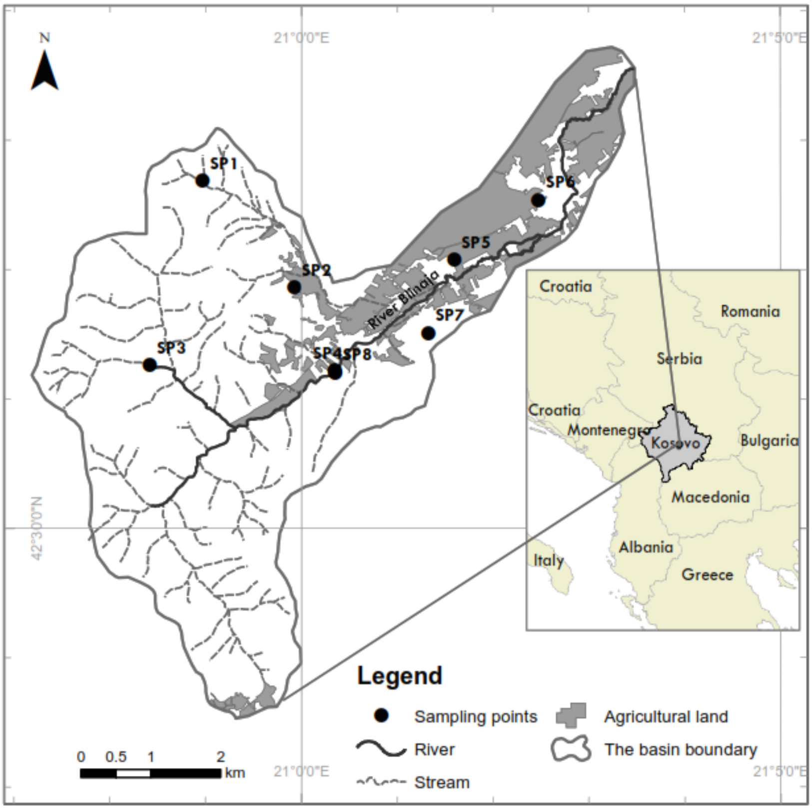


Figure 1. The position of the study area

Twenty (28) groundwater samples (samples) were taken at three springs and five wells (Figure 1), in the period April, August, 2015-January, 2016, February 2018, three water samples were taken in two wells (SP4, SP7), and one at source (SP8), and in September 2019 samples were taken at all sites (Table 1.), to analyze the physico-chemical parameters. The study area has different geological structure, respectively formations with different lithologies, as well as with different hydrogeological characteristics. Therefore, based on the lithology and hydrogeological characteristics of the study area, the selection of water sampling points (water sampling) was done with the sole purpose that the representation is as good and realistic as possible. Nevertheless, in order to achieve this goal, there has been used a research methodology comprised of three main phases is followed: field studies, laboratory analysis, result-writing interpretation, and paper interpretation (Figure 2).

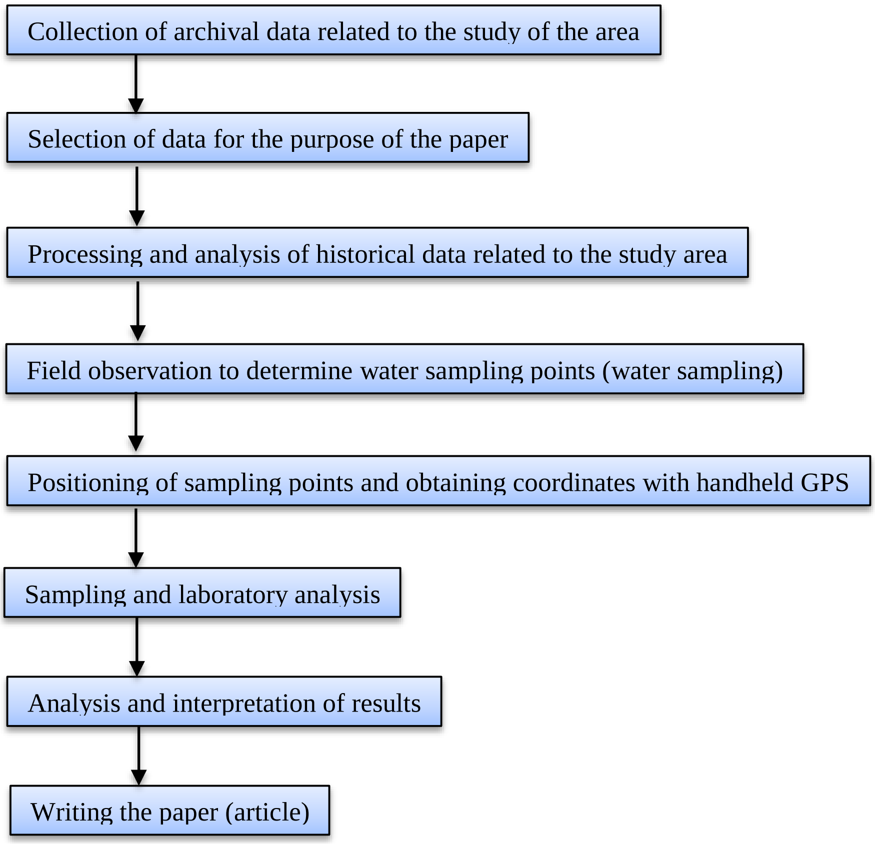


Figure 2. Flowchart of work methodology

The Garmin 79C Global Positioning System (GPS) was used for coordinate recording and altitude reading. Before each measurement the GPS was calibrated to a polygonal point with previously known coordinates and altitude. Water samples were taken in polyethylene bottles, with a volume of 1 litter, closed with pressured cork and fillet cap. The bottles were filled, leaving a space under the compressed cap, about 1 mm, to eliminate the possibility of the pollution of the water of the sample. Samples taken in the field are stored in the field refrigerator in order to preserve natural conditions until the same sample is sent to the laboratory. Water parameters were analyzed in the laboratory for main anions and cations, while physico-chemical parameters such as temperature, pH, electrical conductivity and dissolved oxygen in water, were measured directly in the location where the samples are taken. The laboratory analyses are conducted at the Faculty of Natural Sciences-Department of Chemistry.

The determination of the electrical conductivity, pH value and temperature of the water is made with the device ISOLAB-Cond-Temp, by applying as described in the relevant manual. Before each measurement it is made its calibration by certified standard solution for PE with 1413 µS/cm. For the pH value the calibration of the device is made with buffer solution, the acidic buffer (pH=4:01), neutral buffer (pH=7.0) and basic buffer (pH=10.0). The total alkalinity is determined by standard solution HCl 0.155 mol/dm^3, using the methodology of the US Geological Service. For the determination of total hardness, it is applied the method with complexometric titration with EDTA (K III) 0.05 mol/dm^3 with water are taken 100 cm^3 for analysis in Erlenmeyer flasks are added 5 cm^3 buffer ammonia in the presence of the indicator Eriochrome Black, where the **color** from pink passes to blue. Ion Ca^{2+} is determined also by titration of 100 cm^3 of the sample with the same standard solution of EDTA between strongly basic 5 cm^3 2 mol/dm^3 solvent of NaOH, in the presence of indicator HSN where the **color** light pink passes to the open blue. Ion Mg^{2+} is determined by counting the difference of the overall strengths and Calcium, Cl is determined with the photometric method which is analogous method with the standard method as EPA 325.1 and US-Standard Methods 45000-Cl-E. The determination of SO_4^{2-} is made with the photometric method ISO 8502-11. Joni nitrate (NO^{3-}) is defined in H_2SO_4 and H_2PO_4 with 2.6-Dimetilfenol (DMF) and 4.6-Dimetilfenolphotometric method which is analogous to the standard method ISO7890/1.

The Arc Map 10.5 program was used to build the maps, while the Inverse distance weighted (IDW) interpolation method was used. Interpolation is a method to predict an unknown from known values. From the definition, we need some known values to do an interpolation using any interpolation method. The known values which is commonly called sampling point, can be gathered from some measurements and site investigation like drilling, surveying, etc. Using the known value from some locations, we are trying to predict a value of other neighborhood location that is close to the known location. The main problem in implementing the IDW interpolation into a software algorithm is to define how many sampling points will be used in the calculation. This can be done with two approaches, using a number of points and radius distance from a point to be determined (point x).

For the first approach, a user can define how many points around x point will be used in the calculation process, so it needs an algorithm to calculate a number of closest points to the x point. The second one, a user can specify a radius distance from point x, then the algorithm must select a number of sampling points within the specified radius. Excel is used for descriptive statistics, correlation and other calculations of physico-chemical parameters. The sampling points were selected based on the geological construction and hydrogeological characteristics in order to make the samples as representative as possible throughout the study area. At these sites (well and well), one liter of water is poured into standard plastic bottles. The water samples are stored in a field refrigerator for the purpose of preserving the natural conditions of the water until treated in the laboratory. Water parameters were analyzed in the laboratory for major anions and cations (Table 1), while physicochemical parameters such as temperature, pH, electrical conductivity and dissolved oxygen in water were measured directly in the field. All methods used in determining the physico-chemical parameters are in accordance with the standard DIN, ISO and EN methods.

Table 1. Cations, anions and other measurements recommended for characterizing irrigation

Cations	Anions	Others
Calcium (Ca^{2+})	Chloride (Cl^-)	Total dissolved solids (TDS)
Magnesium (Mg^{2+})	Nitrate (NO_3^-)	Electrical conductivity (EC)
Sodium (Na^+)	Sulphate (SO_4^{2-})	Sodium adsorption potential or sodium hazard (SAR)
Potassium (K^+)	Bicarbonate (HCO_3^-)	Acidity/Alkalinity (pH)

All chemical parameters are expressed in [mg/l] except pH and EC.

All laboratory determinations were performed according to standard analysis methods (APHA). Water samples were interpreted by comparing the values derived from the study with those of the FAO, WHO, International Standards for drinking water, Geneva (2011) (Table 2).

3. Results and Discussions

Above all, it is of key importance to have a clear comprehension of irrigation water quality is critical to the management of water for long-term productivity. Irrigation water quality is related to its effects on soils and crops and its management. The water quality evaluation in the area of study was carried out to determine their suitability for agricultural purposes. The results pertaining to the suitability of underground water for irrigation were analyzed and shown in the (Table 3). The values of the parameters analyzed were compared with the standard values of the FAO guideline and other standards.

Table 2. Standards for drinking water WHO and FAO standards for irrigation

Chemical Constituents (mg/l)	WHO (1984)		Study area values		
	Highest desirable limit	Maximum permissible limit	Minimum	Maximum	Average
pH	7.0-8.5	6.5-9.2	5.92	8.03	7.12
TDS	500	1500	106.88	844.16	426.26
TH	100	500	60.24	830.06	412.22
Ca^{2+}	75	200	14	146.4	71.02
Mg^{2+}	50	150	3.1	141.5	57.1
K^+	200	600	0.046	31.08	6.34
Cl^-	200	600	0.71	77.4	23.31
SO_4^{2-}	200	400	3.905	269	96.86

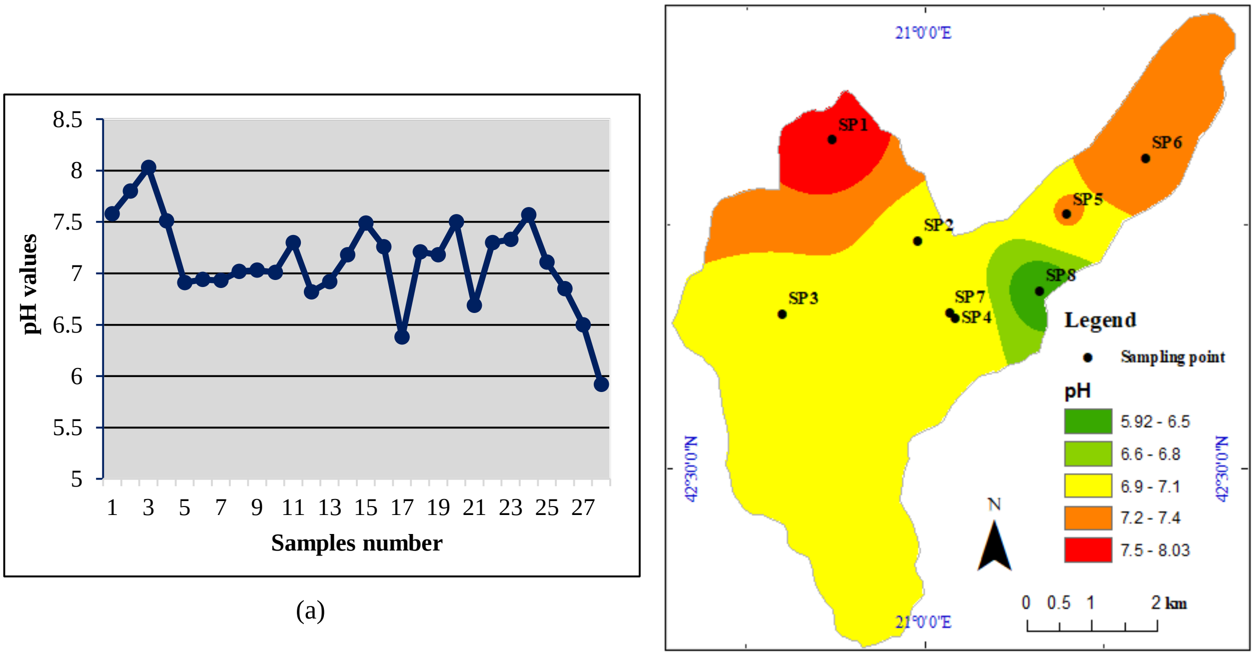
This table is a continuation of Table 2

Categories	Parameter	Unit	FAO (Standard)	Min, Mean, Max values of the parameters in the study area		
				Min	Average	Max
Salinity	EC	µS/cm	0-3000	167	666.04	1319
	TDS	mg/l	0-2000	106.88	426.26	844.16
Cations	Ca^{2+}	meq/l	0-20	14	71.02	146.4
	Mg^{2+}	meq/l	0-0.5	3.1	57.1	141.5
	Na^{+}	meq/l	0-40	1.121	13.55	38.4
	K^{+}	meq/l	0-20	0.046	6.34	31.08
Anions	HCO_3^{-}	meq/l	0-10	0.08	353.05	683
	Cl^{-}	meq/l	0-30	0.71	23.31	77.4
	SOz^{2-}	meq/l	0-20	3.905	96.86	269
Other	pH	1 to 14	6.0-8.5	5.92	7.12	8.03
	SAR	meq/l	0-15	0.024	0.29	0.73

Table 3. Physico-chemical parameters

No.	Station/Source	Date of Sampling	pH	EC (µS/cm)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	HCO_3^{-} (mg/l)	SO_4^{2-} (mg/l)	Cl^{-} (mg/l)
1	SP1 (Spring)	13 Apri.2015	7.58	457	48.9	82.06	1.741	0.046	408.7	117	6.44
2		08 Aug. 2015	7.8	543	26.9	108.6	1.449	nil	457.6	76.4	28.6
3		08 Jan. 2016	8.03	531	34.5	72.43	1.121	nil	427	62	8.6
4		22 Sept.2019	7.51	579	14.0	73.1	2.06	0.055	402.7	10.7	4.615
5	SP2 (Well)	13 Apri.2015	6.91	529	60.9	44.57	12.04	1.939	244	129	8.59
6		08 Aug.2015	6.94	461	56.9	33.4	10.25	2.028	221.6	110	8.59
7		08 Jan. 2016	6.93	312	64.2	30.87	13.22	4.231	233	112	11.46
8		22 Sept.2019	7.02	437	43.7	22.1	11.9	2.77	195.2	41.4	9.23
9	SP3 (Spring)	13 Apri.2015	7.03	353	82.2	10.13	2.462	0.688	213.5	76	4.3
10		08 Aug.2015	7.01	598	146.4	8.1	2.377	0.829	393.2	69	10.7
11		08 Jan. 2016	7.3	189	44.9	3.89	3.8	2.2	122.0	58.0	4.3
12		22 Sept.2019	6.82	773	143.6	12.6	9.746	0.904	512.4	11.5	3.55
13	SP4 (Well)	13 Apri.2015	6.92	565	97.8	31.4	18.53	31.08	274.5	169	34.01
14		08 Aug.2015	7.18	577	67.4	37.8	13.6	24.2	229.3	129	17.54
15		08 Jan. 2016	7.49	642	87.4	34.2	15.27	27.38	250	145	32.9
16		17 Feb. 2018	7.26	930	95.8	38.9	9.59	23.5	6.6	25.56	36.1
17		22 Sept.2019	6.38	517	50.7	27.8	12.8	5.1	298.9	11.5	16.33
18	SP5 (Well)	13 Apri.2015	7.21	802	72.2	108.2	18.72	0.732	436.8	161	47.98
19		08 Aug. 2015	7.18	1008	75.8	122.6	19.26	0.881	512.4	174	15.18
20		08 Jan. 2016	7.5	1038	69.8	106.21	21.18	4.315	491	159	60.87
21		22 Sept.2019	6.69	1092	57.6	89.3	38.1	5.56	500.2	90.5	49.7
22	SP6 (Well)	13 Apri.2015	7.3	972	97.4	113.4	26.44	1.948	640.5	179	41.53
23		08 Aug.2015	7.33	1044	99.4	141.5	25.11	3.11	664.9	248	16.6
24		08 Jan. 2016	7.57	1319	115.9	121.3	32.8	5.42	683	269	40.8
25		22 Sept.2019	7.11	1164	89.3	80.6	38.4	3.47	585.6	43.31	77.4
26	SP7 (Well)	17 Feb 2018	6.85	866	107.9	30.9	7.625	4.85	396.5	19.88	36.5
27	SP8 (Spring)	17 Feb. 2018	6.5	184	18.0	9.7	4.76	3.07	0.08	3.905	19.5
28		22 Sept.2019	5.92	167	19.0	3.1	4.99	4.55	84.2	11.3	0.71
Minimum			5.92	167	14	3.1	1.121	0.046	0.08	3.905	0.71
Maximum			8.03	1319	146.4	141.5	38.4	31.08	683	269	77.4
Average			7.12	666.04	71.02	57.10	13.55	6.34	353.05	96.86	23.31
Standard deviation			0.44	314.05	34.87	42.92	10.86	9.02	188.57	72.74	19.69
Coefficient of variation			6.16	47.15	49.10	75.16	80.15	142.25	53.41	75.10	84.46

pH: The term pH is used to express the acidic or alkaline condition of solution. The acidity or basicity of irrigation water is expressed as pH (< 7.0 acidic; > 7.0 basic). The effect of pH has not been generally included in evaluations of impacts of irrigation water on infiltration water However, it has been demonstrated that pH, independent of SAR, has an important effect on hydraulic conductivity [6]. The normal pH range for irrigation water is from 6.5 to 8.4 [7] and [8]. Water with a low pH can be corrosive while with a high pH might be scale-forming [9]. The pH values in the groundwater of the Blinaja river basin range from 5.92 to 8.03, with an average value of 7.12, which result to be within normal values for the water used for drinking and irrigation. The Figure 3 shows graph and map the variation of pH values in the groundwater of the Blinaja river basin.



(a)

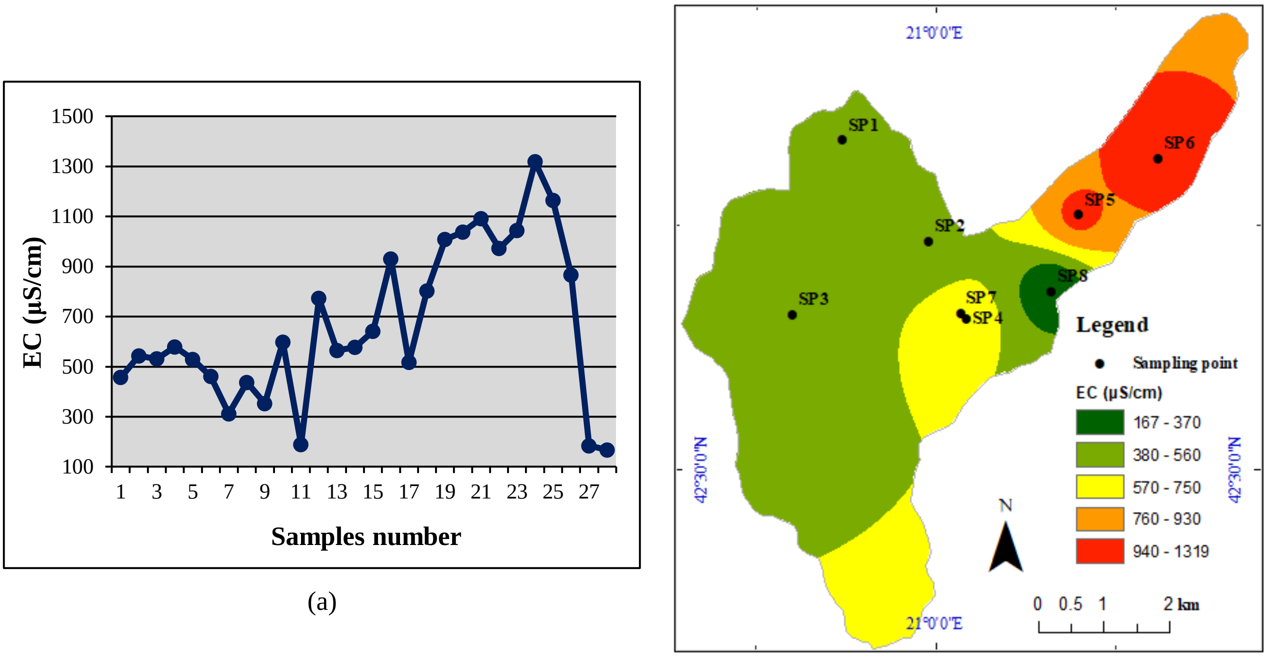
(b)

Figure 3. Graph (a) and map (b) of pH variation in groundwater in the river basin Blinaja

Electrical Conductivity (EC): It measures the capacity of substance or solution to conduct electric current. The electrical conductivity of groundwater increases with the boost in temperature and varies with the amount of TDS. EC is a good measure of salinity hazard to crops as it reflects the TDS in groundwater. The electrical conductivity in the groundwater samples of the stady area (basin Blinajë) ranges from 167 µS/cm to 1319 µS/cm, with an average value of 666.04 µS/cm (Figure 4.). The higher electrical conductivity, the less water is available to plants [10]. In the stady area, the classification for electrical conductivity is given [11] in Table 4. Thus, the Table 4. shows that groundwater in the Blinaja river basin belongs to the classes with low, medium and high electrical conductivity, but the highest percentage belongs to the middle class (see Table 4.).

Table 4. Irrigation water quality based on EC values

EC (µS/cm)	Class salinity	Stations and data of samples	No of samples	% Of samples	Remarks
0-250	Low	SP8 (17 Feb. 2018, 22 Sept.2019), SP3 (08 Jan. 2016)	3	10.71	Can be used safely
251-750	Medium	SP1, SP2, SP3 (13 Apri.2015, 08 Aug.2015), SP4 (13 Apri.2015, 08 Aug.2015, 08 Jan. 2016, 22 Sept.2019)	14	50	Can be used with moderate leaching
751-2250	High	SP3 (22 Sept.2019), SP4 (17 Feb. 2018), SP5, SP6, SP7 (17 Feb. 2018)	11	39.29	Can be used for irrigation purposes with some management practices
2251-6000	Very High				Cannot be used for irrigation purposes



(a)

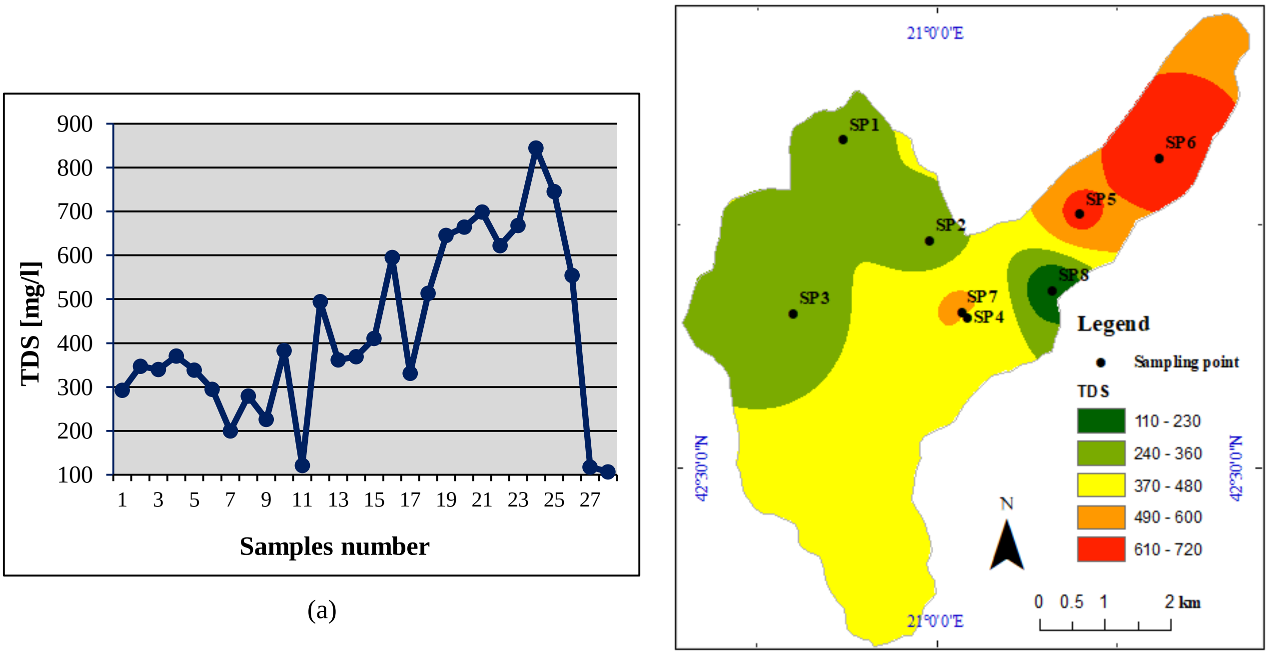
(b)

Figure 4. Graph (a) and map (b) of EC (electrical conductivity) in groundwater in the river basin Blinaja

Total Dissolved Solid (TDS): Is defined as the residue of filtered water sample after evaporation. In natural water TDS contains of minerals, nutrients that have dissolved in water and also includes major ions si: Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, HCO$_3^{-}$, SO$_4^{2-}$, Cl^{-} , etc. For irrigation the TDS has been classified as TDS < 450 mg/l and is preferres for irrigation and TDS from 450 to 2000 mg/l is slight to moderate and TDS > 2000 mg/l is unsuitable for agricultural purpose [12, 13]. Acording to Hem (1959) TDS was calculated using the Equation 1;

$$TDS\left(\frac{mg}{l}\right) = 0.64 \times EC\left(in\frac{micromhos}{cm}\right) \tag{1}$$

In the study area the calculated TDS values based on the formula given by Hem (1959) showed a minimum value of 106.88 mg/l, a maximum of 844.16 mg/l, and an average value of 424.26 mg/l. The obtained values were compared with the values given in Table 5, given by Carroll (1962) (Figure 5). TDS values in all water samples remain within the values of 0-1000 mg/l, ranking the groundwater of this basin to fresh water. So based on Carroll's (1962) division the waters in this study area are freshwater.



(a)

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Figure 5. Graph (a) and map (b) of TDS in groundwater in the river basin Blinaja

Table 5. Water quality classification based on TDS content by Carroll (1962)

TDS (mg/l)	Water Quality	No of samples	% Of samples
0-1000	Fresh water	28	100
1000-10 000	Brackish water		
10 000-100 000	Salty water		
> 100 000	Brine		

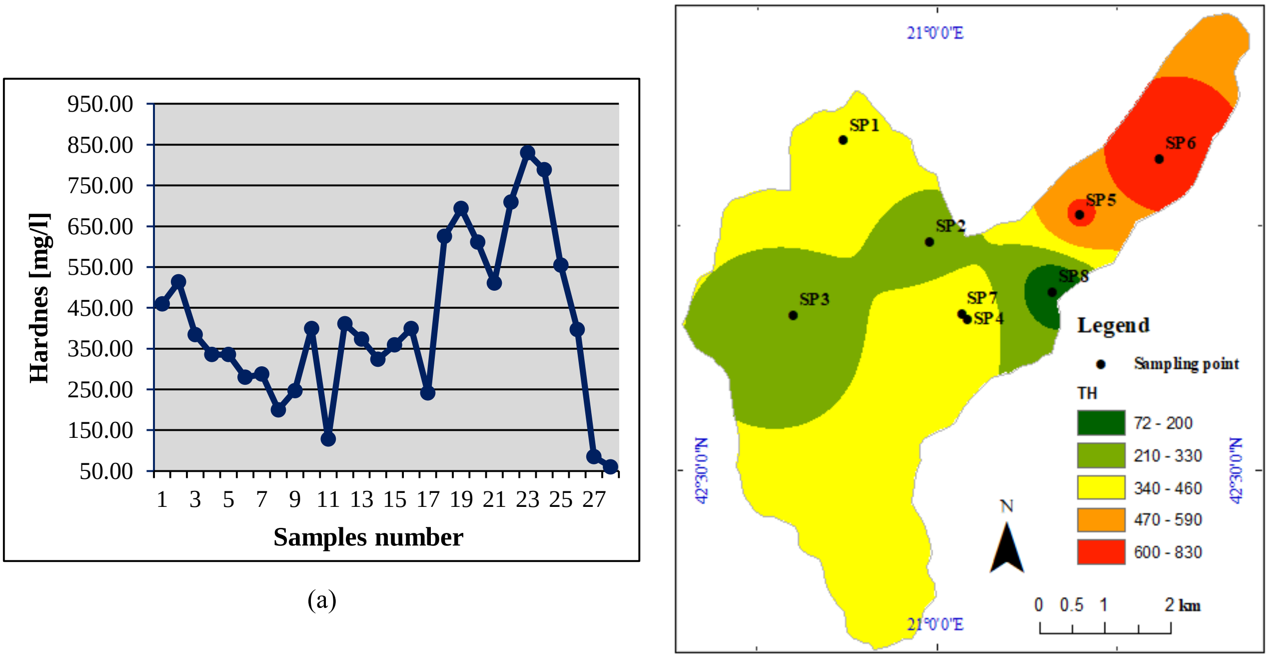
Total hardness (TH): Total hardness as $CaCO_3$ in the stady area (basin of Blinaja) ranges from 60.24 mg/l to 830.07 mg/l with an average value of 412.22 mg/l (Figure 6). Groundwater exceeding the limit of 300 mg/l $CaCO_3$ is considered to be very hard [14]. The total hardness of groundeater is measured using the Equation (2).

$$Total\ hardness\ \left(\frac{mg}{l}\ as\ CaCO_3\right) = Calcium\ hardness\ \left(\frac{mg}{l}\ as\ CaCO_3\right) + Magnesium\ hardness\ (\frac{mg}{l}\ as\ CaCO_3 \rightarrow TH\ = 2.5 \times Calcium\ conc.,\left(\frac{mg}{l}\ as\ Ca^{+}\right) + 4.12 \times Magnesium\ conc..,(\frac{mg}{l}\ as\ Mg^{+}) \tag{2}$$

According to Sawyer and McCarthy’s, hardness is commonly, in terms of degree of hardness (Table 6). The waters of the Blinaj river basin are compared with the classification also given in Table 6, *(after Sawyer and McCarty)*. One water sample or 3.57% of the total number of samples belongs to mild hard class water, 2 samples or 7.14% belongs to moderately strong class water, 5 samples or 17.86% belongs to hard water class and 20 samples or 71.43% of the samples belong to the very strong water class. The 71.43% of the groundwater samples fall in the very hard category.

Table 6. Hardness classification of water (after Sawyer and Mc Carty)

Hardness (mg/l) as $CaCO_3$	Water class	No of samples	% Of samples
0-75	Soft	1	3.57
75-150	Moderately hard	2	7.14
150-300	Hard	5	17.86
Over 300	Very hard	20	71.43



(a)

(b)

Figure 6. Graph (a) and map (b) of TH in groundwater in the river basin Blinaja

Sodium Adsorption Ratio (SAR): The SAR defines sodicity in terms of the relative concentration of sodium (Na^{+}) compared to the sum of calcium (Ca^{++}) and magnesium (Mg^{++}) ions in a sample. The SAR assesses the potential for infiltration problems due to a sodium imbalance in irrigation water. Sodium adsorption ratio (SAR) is a more reliable approach for determining the effect of relative cation concentrations to sodium accumulation in the soil than sodium percentage. The sodium adsorption ratio (SAR) is a measure of the sodium hazard or imbalance of sodium ions relative to calcium and magnesium. When irrigation water has a high SAR level the permeability of the soil can be reduced and result in poor structure, infiltration, aeration and drainage. When using irrigation water it is important to know the concentration of Na+, as sodium can have a negative effect on soil structure, which can then affect plant growth.SAR is an important indicator for determining the suitability of groundwater for irrigation purposes.To assess the suitability of irrigation water in the Blinaja river basin, the Sodium Adsorption Ratio (SAR) was used, and the calculation was made using the Equation (3) given by Richards (1954) as follows:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{++} + Mg^{++})}}) \tag{3}$$

The sodium adsorption ratio (SAR) values range from 0.024 to 0.73, with an average value of 0.29 (Figure 7, a). In the present stady (basin Blinaja) all the ground water sample fall within the excellent category which can be used for irrigation based on the SAR classification Table 7, [15]. Irrigation waters having high SAR levels can lead to the build-up of high soil Na levels over time, which as a result, adversely effect soil infiltration and percolation rates (due to soil dispersion).

Table 7. Classification of water based on SAR values

SAR Values	Class	No of samples	% Of samples	Category	Precaution and management Suggestions
< 10	Excellent	28	100	Low (Na) water	Little danger
10 to 18	Good			Medium (Na) water	Problem on fine texture soils and sodium sensitive plants, especially under low-leaching conditions. Soils should have good permeability.
18 to 26	Fair			High (Na) water	Problem on most soils. Good salt tolerant plants are required along with special management such as the use of gypsum.
> 26	Poor			Very high (Na) water	Unsatisfactory except with high salinity (>2.0 dS/m) high calcium levels, and the use of gypsum.

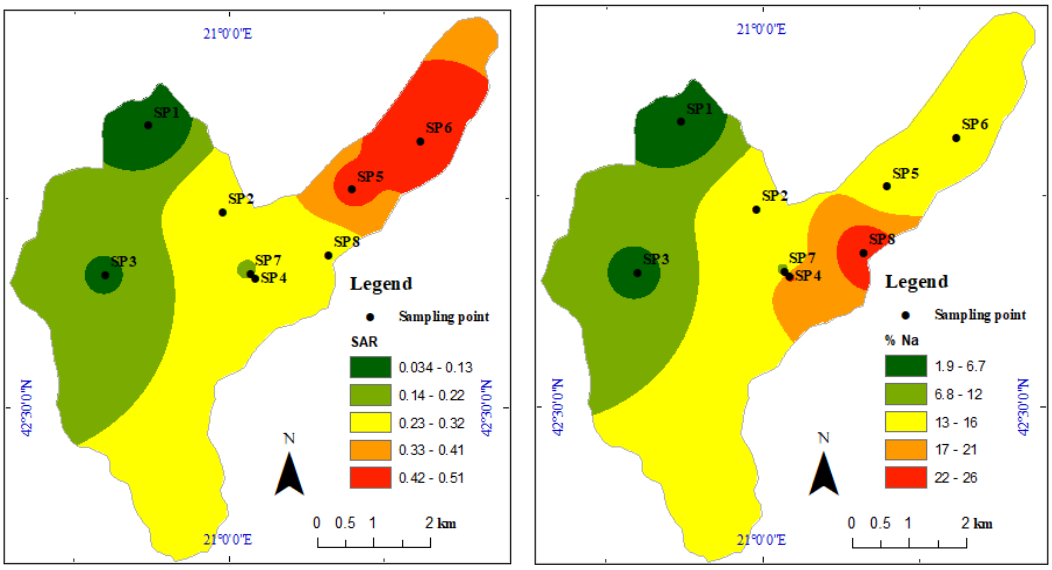
Percentage Sodium (%Na): The % Na is also used in classifying water for irrigation purpose. Na^{+} is important parameter and helps in categoriyation of any source of water for irrigation uses. Sodium-affected soil (alkaline/saline) retards crop growth [16]. Precentage sodium (Na^{+}) is also widely utilized for evaluating the suitability of water quality for irrigation [17]. The percentage sodium is computed with respect to relative proportions of cations present in water, where the concentrations of ions are expressed in (meq/l), using the following Equation (4), proposed by Doneen (1962) [18].

$$\%\mathrm{Na} = \frac{\mathrm{Na}^{+} + \mathrm{K}^{+}}{\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+} + \mathrm{Na}^{+} + \mathrm{K}^{+}} \times 100 \tag{4}$$

Groundwater containing high concentrations of sodium ions is undesirable for irrigating crops [8]. The values of percentage of sodium vary in the range of 1.35 to 30.15, with an average value of 14.35 (Figure 7, b). The classification for precentage sodium was given [19] in (Table 8). The precent sodium values fall in the range of excellent category is found at station SP1, SP2, SP3, SP4 (17 Feb. 2018, 22 Sept.2019), SP5 (13 Apri.2015, 08 Aug. 2015, 08 Jan. 2016), SP6, Sp7 (17 Feb. 2018), good category is observed at stations SP4 (13 Apri.2015, 08 Aug.2015, 08 Jan. 2016), SP5 (22 Sept.2019), SP8 (17 Feb. 2018, 22 Sept.2019).76.92% or 20 of the water samples in the Blinaja river basin categorized the water as excellent, while 23.08% or 6 samples categorized the water in the good category, based on the categorization given in the (Table 8). The whole range of the sampling stations are under excellent to good categories (Table 8). For irrigation prupose, the percentage of sodium is important, because sodium reacts with soil to reduce permeability [20].

Table 8. Classification of water based on percentage sodium values

%Na Values	Class	No of samples	% Of samples
< 20	Excellent	20	76.92
20-40	Good	6	23.08
40-60	Permissible		
60-80	Doubtful		
80-100	Unsuitable		



(a) (b)

Figure 7. Map of SAR (a) and %Na (b)

Kelley's Ratio (KR): Ground water for irrigation was also classified based on Kelly's ratios [21], Kelly's ratio was more than one (1) indicating an excess level of sodium in water; therefore, the water Kelly's ratio of less than one was suitable for irrigation. The following Equation 5 [21] was used to calculate the KR indicator.

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}} \tag{5}$$

The Kelley's ratio values in the stady area lie in the range from 0.01 to 0.18, with an average value of 0.08 meq/l. The values obtained for the KR indicator in the groundwater of the Blinaja river basin were compared with the water classification based on (Table 9), and in this case, it resulted that all water samples showed less than 1 value, classifying these waters by this indicator in class water suitable. The spatial distribution for KR is shown in Figure 8a.

Table 9. Classification of water based on KR values

KR Values	**Class**	**No of samples**	**% Of samples**
< 1	Suitable	28	100
1 to 2	Marginal		
> 2	Unsuitable		

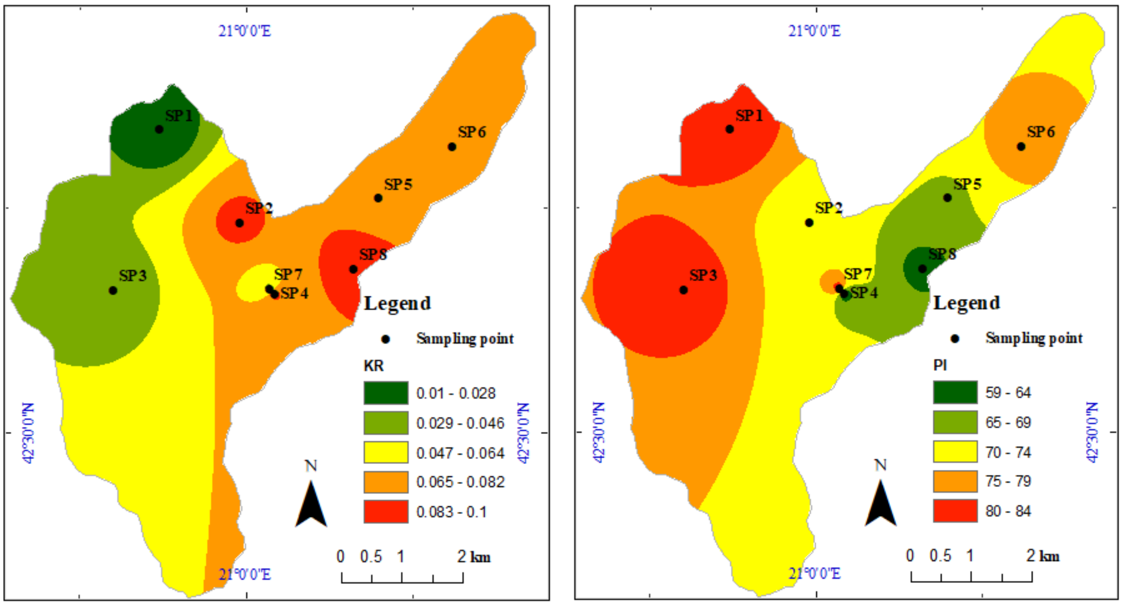
Permeability Index (PI): Permeability index of the soils can be affected by the lon term use of the irrigation water when it contains high concentrations of salts. The calculation of PI values is done by applying the following Equation (6) Doneen (1964).

$$PI = \frac{Na^{+} + HCO_3^{-}}{Ca^{2+} + Mg^{2+} + Na^{+}} \times 100\% \tag{6}$$

The values of the permeability index obtained from the present are presented in (Table 10), the values varied from 6.26 to 112.53 with an average of 72.63 %. 53.57 % of the samples fall within the class II, 42.86 % within the class I and 3. 57 % within the class III. They are within the class I and II, so this water is categorized as suitable for irrigation [22]. Most of the water samples belong to class I and II and are suitable for irrigation. The spatial distribution for PI is shown in Figure 8 b.

Table 10. Classification of irrigation water based on permeability index

PI	Class	No of samples	% of samples
> 75	I	12	42.86
25-75	II	15	53.57
< 25	III	1	3.57



(a) (b)

Figure 8. Map of KR (a) and PI (b)

Magnesium hazard (MH) or Magnesium Ratio (MR): In general, calcium and magnesium maintain a state of equilibrium in groundwater. Both Ca^{2+} and Mg^{2+} ions are linked with soil friability and aggregation, but both are also essential nurtients for the crop. The high value of Ca^{2+} and Mg^{2+} in water can increase soil pH (therefore soil converting it to saline nature of the soil [23]. According to agriculturists, excess amount to Mg^{2+} ions in waters damage the soil quality which causes low crop production [24]. Magnesium hazard is another indicator to assess the quality of water for irrigation [25]. More magnesium present in water affects the soil quality converting it to alkaline and decreases crop yield. Magnesium hazard is calculated by the following Equation (7) [26].

$$\text{Magnesium hazard (MH)} = (Mg^{2+} \times 100) / (Ca^{2+} + Mg^{2+}) \tag{7}$$

The excess concentration of magnesium in the soil causes infiltration problems and can lead to reduced crop yield [7]. MH > 50 is considered harmful and unsuitable for irrigation purpose [27], the values of magnesium hazard in the present study ranged between $\mathbf{Mg^{2+}}$ and $\mathbf{Ca^{2+}}$. If the magnesium ratio is greater than 50 percentages it is considered as suitable for irrigation purpose [28]. The spatial distribution of magnesium hazard is shown in Figure 9.

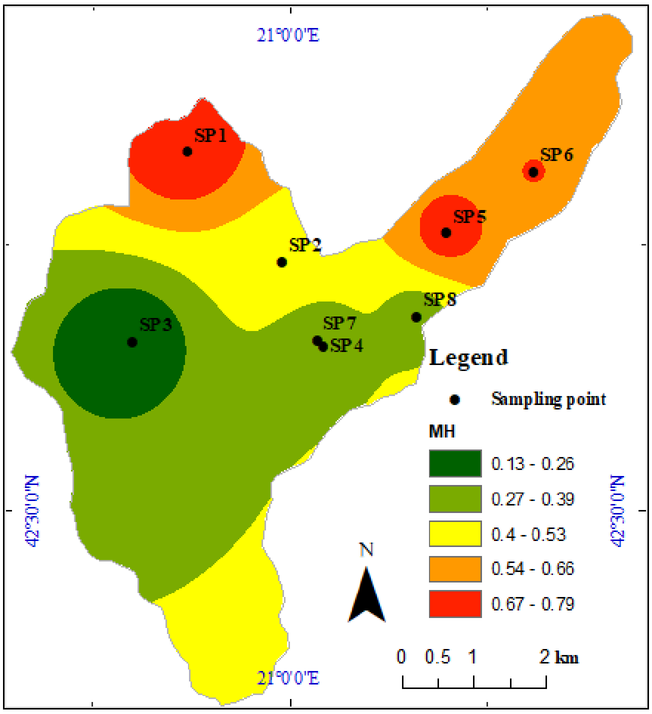
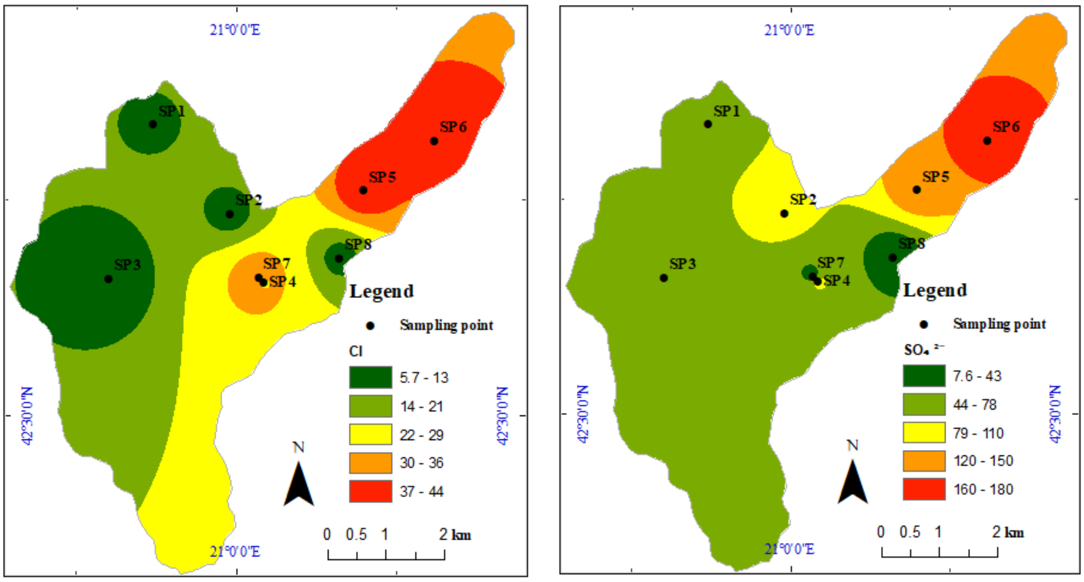


Figure 9. Map of MH

Chloride: Chlorides in water may cause problems. As a consequence, a wide variety of plants are sensitive to high chloride concentration and sometimes to high level of Na in their leaves [29]. Content of chloride ions in irrigation water increases with increase of EC and sodium ions [30]. Chloride-chloride is a common ion in basin Blinaja irrigation waters. Although chloride is essential to plants in very low amounts, it can cause toxicity to sensitive crops at high concentrations. Chloride occurs naturally in all types of water; however, its main contributing sources are runoff of inorganic fertilizers from agricultural fields, sewage discharge, etc. Chlorides are important in detecting the contamination of ground water by waste water. The water samples was found between the ranges 0.71 to 77.4 mg/l, with an average value of 23.31 mg/l. The chloride content of the sample was found to be well within the permissible levels of 250 mg/l of WHO standard.

Sulfate: The sulfate ion is a major contributor to salinity in many of irrigation water. Sulfate is an important chemical factor for water quality and has an effect on the odor and taste of water consumption. Is characteristic of shallow groundwater. In groundwater it comes from dissolution of sulphate rocks and oxidation of sulphide mineral. Also, it can enter into shallow groundwater from the decomposition of plant and animal substances which have sulphur in their composition [2]. Sulfate values in our study area ranged from 3.90 to 269 mg/l, with an average value of 96, 86 mg/l. All measured values and average value of sulfate 39.66 mg/l, in the study area showed that they are below the value of 250 mg/l, of the WHO standard. The Cl^- and $SO_4{}^{2-}$ analysis (variation) of groundwater in study area is shown in Figure 10, *a* and *b*.



(a) (b)

Figure 10. Map of Cl^- (a) and $SO_4{}^{2-}$ (b) analysis (variation) of groundwater in study area

Correlation of Parameters: In groundwater in the Blinaja river basin-as it could be expected, the best (R=0.95) correlation is between $SO_4{}^{2-}$ and EC. The good (R=0.92) correlation between Cl^- and EC. Good (R=0.86) correlation of Mg^{2+} with EC shows the dominant role of the magnesium salts. The bicarbonates corelates very well with pH (R=0.75), etc. (Table 11).

Table 11. Correlation of parameters in groundwater in the Blinaja river basin

	pH	**EC (µS/cm)**	**Ca^{2+} (mg/l)**	**Mg^2 (mg/l)**	**Na^+ (mg/l)**	**K^+ (mg/l)**	**$HCO_3{}^-$ (mg/l)**	**$SO_4{}^{2-}$ (mg/l)**	**Cl^- (mg/l)**
pH	1								
EC (µS/cm)	0.54	1							
Ca^{2+} (mg/l)	0.29	0.61	1						
Mg^{2+} (mg/l)	0.66	**0.86**	0.18	1					
Na^+ (mg/l)	0.17	**0.89**	0.53	**0.70**	1				
K^+ (mg/l)	-0.15	0.06	0.19	-0.20	0.13	1			
$HCO_3{}^-$ (mg/l)	**0.75**	**0.90**	0.52	**0.90**	0.67	-0.29	1		
$SO_4{}^{2-}$ (mg/l)	0.52	**0.95**	0.59	**0.82**	**0.92**	0.06	**0.83**	1	
Cl^- (mg/l)	0.26	**0.92**	0.40	**0.80**	**0.93**	0.22	0.69	**0.86**	1

4. Conclusion

The groundwater of the Blinaja River basin is tasteless, odorless and colorless. They showed that they have pH values from 5.92 to 8.03 which are within the values of the FAO standard. Based on this parameter these waters have no restriction on use. They generally have a slight tendency towards basic waters. This pond contains fresh groundwater. Based on electrical conductivity mainly fall into groundwater with low conductivity (50% of samples) to high (39.39% of samples). Overall strengths from 60.24 to 830.07 mg/l classifying these waters mainly hard and very strong. SAR index values indicated that these waters fall into the low category and are less hazardous. % It varies from 1.35 to 30.15 and according to the classification given by Wilcox these waters are ranked in the excellent (76.92%) sample class and the good (23.08%) sample class. Kelly's ratio ranges from 0.01 to 0.18 meq/l classifying these waters into the appropriate class. Permeability index varies from 6.26 to 112.53 mg/l, according to this index these waters belong mainly to the second class (53.57%) of samples and the first class 42.86%) of samples. Based on the parameters and indices analyzed through water samples it results that groundwater in the study area can be used for irrigation of crops. It is recommended to monitor at least twice a year in relation to the physico-chemical parameters of groundwater in order to keep their quality under control.

5. Declarations

5.1. Data Availability Statement

The data presented in this study are available in article.

5.2. Funding

The author received no financial support for the research, authorship, and/or publication of this article.

5.3. Acknowledgements

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5.4. Conflicts of Interest

The author declare no conflict of interest.

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