J. Int. Environmental Application & Science, Vol. 4 (3): 285-292 (2009)

The Monitoration of Water Quality of Shkumbin River and Its Impact on the Soil[#]

Ardian Maci[1], Magdalena Cara[1,*], Ardian Doko[2], Jordan Merkuri[1], Miranda Huta[2], Agelda Ajazi[1]

[1]*Faculty of Agriculture and Environment, Agriculture University of Tirana, Tirana, Albania;* [2]*The Agriculture Transfer Technology Centre in Fushe Kruja, Albania*

Received May 06, 2009; Accepted July 28, 2009

Abstract: The Shkumbin River is one of the most important rivers in Albanian economy and its outlet is in the Adriatic Sea, in the southern part of Karavasta lagoon. The aim of the study is to monitor and estimate the quality of waters used for irrigation and the impact it has on agricultural soil. During four years (2004 – 2005) we have monitored in Sinabellaj, the Cengelaj dam, the Rrogozine Bridge, these water parameters: salts contents, pH, electrical conductivity, cations and anions (Ca^{2+}, Mg^{2+}, Na^+, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, nutrient elements: N (as NO_3^- and NH_4^+, PO_4^{3-}, K^+; different factors: acidity, Na absorption ratio, dry residue, heavy metals: Zn, Pb, Mn, Fe, Cu, Cr. In the same time we took samples from agricultural soil were we monitored pH, humus, organic mass, N, P, K, Na, Ca, Mg etc, as well as microelements: Cu, Ni, Zn, Cr, Co, Pb etc. Through analytic monitoring of water, our purpose was to assess optimal parameters in the function of the evaluation of the quality of irrigation water, and the impact on the macro and microelements available for plant in the irrigation soil.

Key words*: irrigation, water quality, plant nutrients, soil, parameters*

Introduction

Regarding to the position and its characteristics, the Shkumbin river has always been part of agricultural and environmental strategies of Albania. The river in the hydrological map of the Republic of Albania is one of 6 bazenet reservoir of our country (VKKU Nr.5 date 22.12.1098, amended by VKKU Nr.5 dated 16.04.2004). Under irrigation, soil and water compatibility is very important. If they are not compatible, the applied irrigation water could have an adverse effect on the chemical and physical properties of the soil. A basic understanding of soil/water/plant interactions will help irrigators efficiently manage their crops, soils, irrigation systems and water supplies. Irrigating with poor quality water usually doesn't have an immediate deleterious effect on plants. Rather, it results in a long-term hazard in which salts or sodium in the water accumulate in the soil and eventually decrease soil productivity.

Material and Methods

Shkumbin River and soil sorrounded has been carried out for the 2 years in the middle valley where commercial irrigated of the fields. The sampling locations are Sinabellaj, Diga Cengelaj, Ura e Rrogozines. Water sampling for water quality analysis was carried from 2004 -2005. We evaluated the irrigation water qualtiy based on the following critera: Total soluble salt content (salinity hazard), Relative proportion of sodium cations (Na^+) to other cations (sodium hazard). (An ion is an electrically charged atom or groups of atoms. Cation carry a positive charge, and anion have a negative charge.) Excessive concentration of elements that causes ionic imbalance in plants or toxicity. Bicarbonate anion (HCO_3^-) concentration as related to calcium (Ca^{2+}) plus magnesium (Mg^{2+}) cations. Salinity was measured as Siemens per metre (dS/m). The convert dS/m to other units: 1 dS/m = 1000 EC units = 1000 µS/cm = 640 ppm. Sodium adsorption ratio (SAR), was calculated by formula 1, along with pH, characterize salt-affected soils. It is an easily measured property that gives information on the comparative concentrations of Na^+, Ca^{2+}, and Mg^{2+} in soil solutions. The equation used to calculate SAR is given as follows:

[*] *Coresponding: E-mail: magdacara@gmail.com; Tel.: 00355686061156; Fax.: 0035552232789*

[#]*This study has been presented at 24-25 April 2009-Alblakes'09, Pogradec- Albania.*

$$SAR = \frac{[Na^+]}{\sqrt{\frac{1}{2}([Ca^{2+}]+[Mg^{2+}])}} \qquad [1]$$

Formula 1, Sodium Adsorption Ratio (SAR). Where $[Na^+]$, $[Ca^{2+}]$, and $[Mg^{2+}]$ are the concentrations in mmol/L of sodium, calcium, and magnesium ions in the soil solution. Concentrations of sodium, calcium, and magnesium are determined by first extracting the ions from the soil into solution. The solution is then analyzed to determine concentrations of the selected ions. Na^+, Ca^{2+}, and Mg^{2+} concentrations are commonly determined using Atomic Absorption Spectrometry (AAS). The SAR of a soil extract takes into consideration that the adverse effect of sodium is moderated by the presence of calcium and magnesium ions. When the SAR rises above 12 to 15, serious physical soil problems arise and plants have difficulty absorbing water.

Sampling and Analytical Methods

The soil sampling was implemented according to ISO10381-1993. For parameter measures we have used contemporary methods of determination such as: spectrometric method, AAS and interfrequently classical standard methods of analysis. Determination of effective cation exchange capacity and base saturation level using barium chloride solution (ISO 11260-94).

Determination of total nitrogen - modified Kjeldahl methods, determination of phosphorus spectrometric determination of phosphorus soluble in sodium hydrogen carbonate, determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc-flame and atomic absorption spectrometric methods, determination of the specific electrical conductivity, determination of carbonate content-volumetric methods.

The water quality sampling was implementing according to ISO 5667 -1-1980. Determination of Kjeldahl nitrogen, determination of ammonium distillation and titration methods, determination of calcium content - EDTA titrimetric methods, determination of cadmium by AAS, determination of sum of calcium and magnesium – EDTA titrimetric methods determination of electrical conductivity, determination of nitrate, determination of sulphate gravimetric methods using barium chloride, determination of cobalt zinc cadmium, nickel, lead by flame atomic absorption spectrometric, determination of pH determination of ammonium- manual spetrometric methods, determination of chlorine titrimetric methods using diethyl-1.4 phenylenediamine, determination of chloride -silver nitrate titration with chromate indicator Mohr's methods.

Investigated Area

Albania has a Mediterranean climate with the coastal plains experiencing hot and dry summers, and frequent thunderstorms. The source of the Shkumbin River is in the mountains southwest of Lake Ohrid, in the southwestern corner of the Pogradec District. The Shkumbin River initially flows north, then northwest, through Qukës, Librazhd, where it turns west and continues through Polis, Elbasan, Cërrik, Peqin and Rrogozhinë. It flows into the Adriatic Sea northwest of Divjakë.

The Shkumbin river has a catchment surface of 2445 km². Along its course the river receives tributaries of secondary importance like Rapuni, Gostima, and Zaranika etc. Basic characteristics are as follows: annual discharge volume: 1,900 million m³, specific discharge: 26 l/s.km², ratio wettest month (February) to driest month (August-September).

The length of this river is 181 km. The river usually boasts an average flow of 61 cubic meters per second (m^3/s). The Shkumbin River's segment from the Rrogozhine Bridge to his flowing point has been an interesting space of investigations in the context of a sustainable management of natural resources. The river has a catchment of 2445 km ² surfaces. Along its course Shkumbin receives tributaries of Secondary importance like Rapuni, Gostima, and Zaranika. Basic characteristics are neither follows: annual discharge volume: 1,900 million m³, specific discharge: 26 1 / s.km², ratio wettest month (February) to driest month (August-September).

Figure 1. Shkumbin River

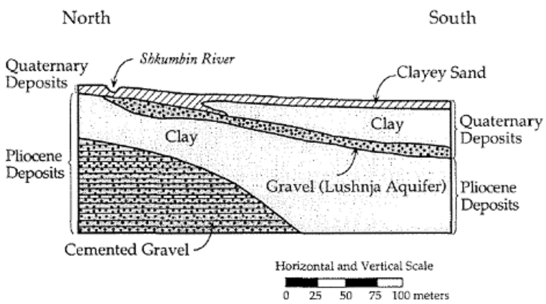

Figure 2. Hydro geological cross section near Shkumbin River. (Source: Eftimi, 1982)

Figure 3. Two different view of Shkumbin River

Results

The water and soils samples were analyzed for various parameters. The results are presented in Tables and Graphics.

Irrigation Water Analysis

Three different sources of irrigation water were selected in Shkumbin River. These sources were analyzed for pH, EC and heavy metal contents (Cu, Pb, Zn, Fe, Mn, Cd, Ni and Cr).

pH Measurement

The natural waters rarely time have pH under 5.5. Soft surface waters witch characterize with carbonate hardness and heave free CO_2, have pH 7.5 – 8 pH amount of industrial waters and impure urban waters hang extremely from: amount of free CO_2 in water, organic acids and humic acids which is followed from polluted industrial regions with SO_2 etc.

Samples of waters were analyzed, and they have different amount of pH = 7.4 – 8. Lowest value were 7.4 in the Rrogozhines Bridge whereas higher value of pH were 8 in three samples places.

Electrical Conductivity (EC)

The average electrical conductivity of the river irrigation water range from 0.17 to 0.79 dSm^{-1}. The lower value 0.17 dS/cm where measured in Sinabellaj, whereas the highest value 0.79 dS/cm where measured in February in the same place Sinabellaj. All the water samples were found non-saline and will not contribute any harmful effect to agricultural land and crop. Hameed et al. (1966) stated that waters having electrical conductivity of 1.5 dSm^{-1} were safe for irrigation, those having 1.5 to 3.0 dSm^{-1} were marginal and waters having EC values more than 3.0 dSm^{-1} were unsafe.

Dry residue

The values of dry residue are from 0.15 g/L (the Cengelaj dam) in 2004 to 0.34 g/L (Sinabellaj) in 2004.

SAR

The infiltration problem is expressed in terms of SAR (Sodium Absorption Ratio). As we mention in material and methods, SAR is calculated from the ratio of sodium to calcium and magnesium. The calculated values of SAR: Minimum value is the 0.28 milliequivalents/liter in Sinabellaj and maximum values calculated are 0.81 milliequivalents/liter in Cengelaj dam in 2004.

Table 1. Physico-chemical parameters of water samples in Shkumbin River on the trials: Sinabellaj, Ura e Rrogozhines, Diga Cengelaj. (2004 & 2005)

Parameters	Unit	Limits	Sinabellaj		Ura e Rrogozines		Diga Cengelaj	
Years			2004	2005	2004	2005	2004	2005
pH	-log $[H^+]$	6.0-8.5	8	8	7.4	8	7.7	8
Conductivity (ECW)	(dS/m)	0-3	0.79	0.17	0.64	0.73	0.49	0.79
Dry matter	gr/l		0.34	0.26	0.29	0.294	0.15	0.216
SAR	m.e/l	0-15	0.28	0.33	0.39	0.51	0.81	0.27

Sodium

Medium to high levels of sodium in water with low levels of calcium and magnesium can result in toxicity of some sensitive plants such as fruit trees and woody ornamentals. Annual crops are usually not affected except for sodium's affect on salinity and sodium build up in soil. Sodium concentration in water has been in Sinabellaj 0.12 mg/L (2004) and in Diga Cengelaj 0.77 mg/L (2005). The mean value it has been 0.50 mg/L.

Calcium and magnesium

These minerals exist as positively charged ions in water, and they counteract the deleterious effect of sodium. Their concentrations are used in the calculation of SAR. Calcium concentration in water of River Shkumbini it has been from 1.9mg/L to 3.8 mg/L. Lowest value 1.9 mg/L has been in Sinabellaj (2004), whereas the highest value 3.8 mg/L has been measured at the Rrogozhine's bridge. The mean value has been 2.52 mg/L. Magnesium concentration in water has been from 0.91 to 4.15 mg/L. Lowest value 0.91 mg/L has been in Ura e Rrogozhines (2004), whereas the highest value 4.15 mg/L has been measured at the Diga Cengelaj (2004). The mean value has been 2.75.

Table 2. Calcium, Magnesium and sodium concentrations

Parameters	Sinabellaj		Ura e Rrogozines		Diga Cengelaj		Mean
Years	2004	2005	2004	2005	2004	2005	
Ca^{2+}	1.9	2.4	3.8	2.2	2.1	2.7	2.52
Mg^{2+}	3	2.9	0.91	3.9	4.15	1.8	2.75
Na^+	0.12	0.44	0.44	0.57	0.68	0.77	0.50

Anions concentration

Levels of anions in water are determined: The concentration of sulfate ions in water is calculated to be in high levels, such as (10.9 m.e / L) in the Rrogozhine Bridge and lower in the Cengelaj dam. Concentration of carbonate ions, hydrogen and sulphate in water was high (3.53 m.e / L) in Sinabellaj and low in the Rrogozhine Bridge (2.24 m.e / L). Concentration of carbonate ions in water are calculated to be in high levels, such as (0.47m.e / L) in the Rrogozhine Bridge and lower (0.24 m.e /L) in the Cengelaj dam. Concentration of chlorine ions in water was higher (1.24 m.e / L) in Sinabellaj and lower (0.4 m.e / L) in the Rrogozhine Bridge.

Nutrient elements

Levels of nourishing elements in generally are low, for NO_3^--N (the average is 0672 mg / L), for N - $NH4^+$ (the average is 0616 mg / L), PO_4^{3-}(1.31 mg / L) and K^+ (the average is 2.75 mg / L). Concentration of potassium ions in water, in different samples analysis are calculaded to be in high levels (over the standards) such as in Sinabellaj and in the Cengelaj dam (2004 & 2005). Regarding to the phosphates concentration, they are calculaded to be near the standard limits.

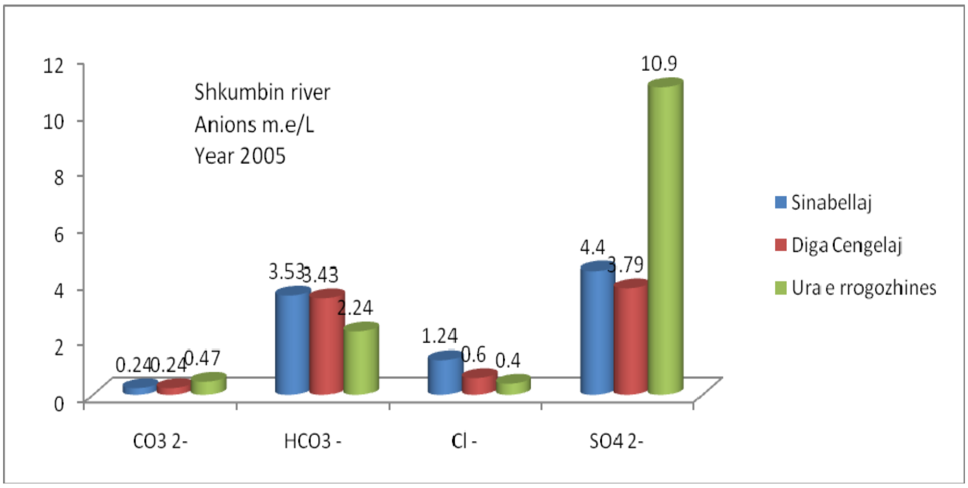

Figure 4. Shkumbin River Anions (Year 2005) m.e/L

Table 3. Nutrient levels in Shkumbin river waters in Year 2004 & 2005

	Unit	Limits	Sinabellaj		Rrogozhine Bridge		Cengelaj Dam	
			2004	2005	2004	2005	2004	2005
N- NO_3^-	mg/l	0-10	0.56	1.12	0.56	-	0.28	0.84
N- NH_4^+	mg/l	0-5	0.84	0.28	0.28	-	0.28	1.4
PO_4^{3-}	mg/l	0-2	-	-	0	-	-	1.31
K^+	mg/l	0-2	5.66	1.67	1.67	1.83	2.5	3.16

The heavy metals, the range of the heavy metals detected in Shkumbin river's water have been Zn<Cr<Cu<Mn<Pb<Fe.

Table 4. The mean values of the heavy metals concentrations found in Shkumbin River's water in Year 2004

Heavy metals (mg/l)	Standard	Sinabellaj	Rrogozine Bridge	Cengelaj Dam	The mean
Zn	0.5	0.011	0.016	0.007	0.011
Pb	0.2	0.033	0.083	0.024	0.047
Mn	2	0.045	0.080	0.014	0.046
Fe	2	0.035	0.620	0.032	0.229
Cu	0.1	0.029	0.046	0.028	0.034
Cr	2	0.019	0.027	0.020	0.022

Results in the soil samples

The results of Soil Texture analysis:

Table 5. Some of the most important parametes monitored in agricultural soils near the Shkumbin River.

Place of samples	pH	K	Humus	N	M.O.	P	K	Ca	Mg	Na	KKK
		ppm		%		ppm		m.eq./100 gr soil			
Sinabellaj 2004	8.1	108	1.01	0.078	4.55	4.4	-	17. 3	2.71	0.16	20.56
Cengelaj 2005	8.2	65	1.3	0.131	5.83	10.8	0.17	16. 6	2.26	0.11	24.78
Rrogozhine 2005	8.1	113	1.1	0.102	9.15	8.8	0.29	24.9	3.9	0.17	32.17

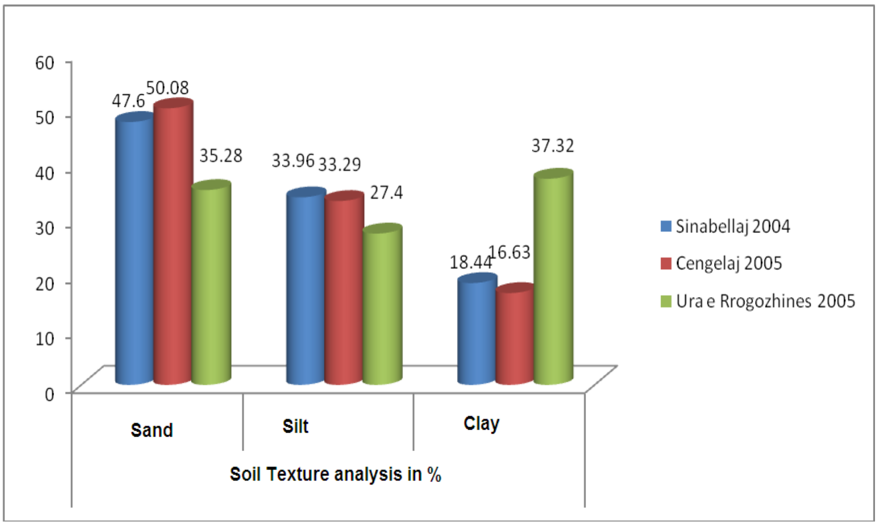

Figure 5. Soil Texture analysis in Sinabellaj, Cengelaj, Ura e Rrogozhines (2004 & 2005).

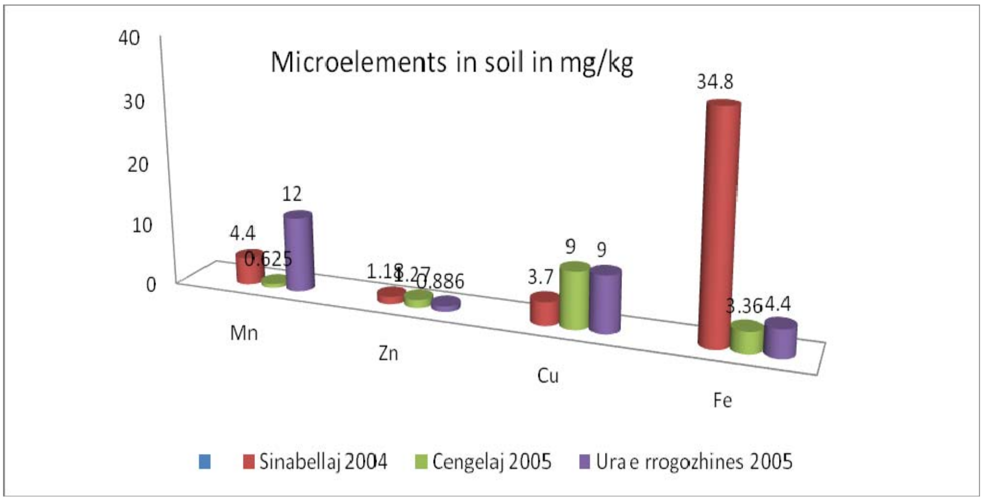

Figure 6. Microelements in the soil in mg/kg

Discussion

The aim of the study is to determine the impact of irrigating water in the soils near the Shkumbini River. Because constituents in water are deposited onto the soil, interpreting water analysis is inextricably tied to soil properties. Sandy soils are less likely to accumulate salts or sodium than finely textured soils, and they can be more easily leached to remove salts or sodium. Soils with a high water table or poor drainage are more susceptible to Salt or sodium accumulations (Ayres, RS et al. 1976). A soil pH above 8 typically indicates that a problem exists sodium. Referring to different guides and standards of FAO, EU and the U.S., we are able to determine not only the (physical/chemical) water conditions and its impact on land, but also to recommend the required plants that can be grown in these characteristiced soils.

According to FAO, suitable water for irrigation is in the pH intervals 6.0-8.5, while according to U.S. Spectrum Analytic, Inc. (Guide to interpreting irrigation water analysis) is in the intervals of pH = 5-7. Analysis performed (texture) in our land have resulted relatively light silt-sand soil, so they can support calculated pH values. In accordance with the cations capacity, they result in sodium tendency. In general these soils have deficiency in nourishing elements. Sulfate in water exists as a negatively charged ion. It contributes to the total Salt content. The maximal level is calculated in the Rrogozhine Bridge (10.9 m.e/L) in 2005.

However, many factors including soil texture, organic matter, crop type, climate, irrigation system and management impact how sodium in irrigation water affects soils. Additionally, at the same

SAR, water with low EC_w (salinity) has a greater dispersion potential than water with high EC_w. Sodium in irrigation water can also cause toxicity problems for some crops, especially when sprinkler applied. Crops vary in their susceptibility to this type of damage as shown in Table 6.

Table 6. Guidelines for interpretation of irrigation water quality problem. (Ayers, et.al. 1994; FAO irrigation and drainage paper)

Water parameter	Symbol	Unit[1]	Usual range in irrigation water	
SALINITY				
Salt Content				
Electrical Conductivity	EC_w	dS/m	0- 3	dS/m
(or)				
Total Dissolved Solids	TDS	mg/l	0- 2000	mg/l
Cations and Anions				
Calcium	Ca^{2+}	meq/l	0- 20	me/l
Magnesium	Mg^{2+}	meq/l	0- 5	me/l
Sodium	Na^{+}	meq/l	0- 40	me/l
Carbonate	$CO^{2-}{}_3$	meq/l	0- 0.1	me/l
Bicarbonate	HCO_3^-	meq/l	0- 10	me/l
Chloride	Cl^-	meq/l	0- 30	me/l
Sulphate	SO_4^{2-}	meq/l	0- 20	me/l
NUTRIENTS[2]		meq/l		
Nitrate-Nitrogen	NO_3^- - N	meq/l	0- 10	mg/l
Ammonium-Nitrogen	NH_4^- - N	meq/l	0- 5	mg/l
Phosphate-Phosphorus	PO_4^{3-}P	meq/l	0-2	mg/l
Potassium	K^+	meq/l	0- 2	mg/l
MISCELLANEOUS				
Boron	B	meq/l	0- 2	mg/l
Acid/Basicity	pH	1–14	6.0- 8.5	
Sodium Adsorption Ratio	SAR	(meq/l)[1, 2]	0- 15	

[1]dS/m = deciSiemen/metre in S.I. units (equivalent to 1 mmho/cm = 1 millimmho/centi-metre) mg/l = milligram per litre ≅ parts per million (ppm). meq/l = milliequivalent per litre (mg/l ÷ equivalent weight = me/l); in SI units, 1 me/l= 1 millimol/litre adjusted for electron charge.

[2]NO_3 -N means the laboratory will analyse for NO_3 but will report the NO_3 in terms of chemically equivalent nitrogen. Similarly, for NH_4-N, the laboratory will analyse for NH4 but report in terms of chemically equivalent elemental nitrogen. The total nitrogen available to the plant will be the sum of the equivalent elemental nitrogen.The same reporting method is used for phosphorus.

Table 7. General classification of water sodium hazard based on SAR values

SAR values	Sodium hazard of water	Comments
1-9	Low	Use on sodium sensitive crops must be cautioned
10-17	Medium	Amendments (such as gypsum) and leaching needed
18-25	High	Generally unsuitable for continuous use
≥26	Very High	Generally unsuitable for use

Refering to the recommended results in the tables and the conductivity value we can say that measured done for this place are in Average root zone salinity EC (ds/m) in range 0.95 – 1.9 so the Water or soil salinity rate from “LOW” to “Moderately sensitive crops”

Table 8. Soil and water salinity criteria based on plant salt tolerance groupings

Plant salt tolerance grouping	Water or soil salinity rating	Average root zone s alinity EC (dS/m)
Sensitive crops	Very low	<0.95
Moderately sensitive crops	Low	0.95 – 1.9
Moderately tolerant crops	Medium	1.9 – 4.5
Tolerant crops	High	4.5 – 7.7
Very tolerant crops	Very high	7.7 – 12.2
Generally too saline	Extreme	>12.2

Conclusions

According to water analysis, the pH has resulted relatively alkaline, the maximal value is 8.

Nutrient levels of water in the Shkumbin River in the three places of the samples, in both years (2004-2005) have “bad” or “very bad” status according to the NIVA classification. (Bratli L.J.2000).

All the samples of the irrigation water sources (the Shkumbin River) were found in normal concentration of heavy metals. Therefore, these sources can be used for irrigation purposes without any hazardous effect on soil and plants.

Levels of the iron in the water are high (Ura e Rrogozhines). This means that the levels of the iron in the soils are hight too, because it can be added to the soil during the irrigation. Systematic monitoring programs are urgently needed to understand the present of the irrigation state of Albanian rivers to characterize the main sources of pollution and its potential irrigation.

Both the sources of irrigation water are well suited for irrigation and can be used for irrigation without any hazardous effect to plants and soils. Zinc was found in deficient concentration in irrigation samles of water therefore, Zn fertilizer should be added to the soils irrigated with these sources.

The recommended required plants that can be grown in these characteristiced soils will be according to the state of EC (ds/m) 0.95 – 1.9 so in water or soil salinity rating “Low” and “Moderately sensitive crops”.

References

Ayers RS, Westcot DW, (1989*) Fao irrigation and drainage paper*, 29 Rev. 1, 1994.

Ayres RS, Westcot DW, (1976) Water Quality for Agriculture. Irrigation and Drainage. Paper No. 29. Food and Agriculture Organization of the United Nations. Rome.

Bratli JL, (1998) Auditing of the agricultural sector. Effect of pollution measures. Measured and modelled inputs of nutrients. Water quality status for main rivers. Norwegian Institute for Water Research. Oslo, Norway.

Bratli LJ, (2000) *Classification of the environmental quality of freshwater in Norway*. p 335-340

Cuena RH, (1989) *Irrigation System Design*. Prentice Hall, Englewood Cliffs, NJ. 552pp.

Follett RH,Soltanpour PN (1999) *Irrigation water quality criteria*. Colorado State University Cooperative Extension. 3/99.