



Quality of Water Suitable for Irrigation In ShirinTagab(in Faryabprovince) and Sholgara(in Balkh province)

By: M. Hassan Saffi, Senior Hydro geologist
Ahmad Jawid, Hydro geologist

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Paikob-e-Naswar, Wazirabad, PO Box 208, Kabul, Afghanistan
Phone: (+93) (020) 220 17 50, Mobile (+93) (0)70 28 82 32
E-mail: dacaar@dacaar.org, Web site: www.dacaar.org

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Symbols and Abbreviation

B	Boron
Cl	Chloride
dS/m	Deci-Siemens/meter
DW	Dug Well
EC	Electrical Conductivity or Salinity
FAO	Food and Agriculture Organization.
gr/l	Gram per litre
GW	Groundwater
m	Meter
m ³	Cubic meters
meq/L or meq/l	milli equivalents per litre
mg/l or mg/L	Milligram per litre
MH	Magnesium Hazard
mm	Millimeters
mmhos/cm (mS/cm)=	millimohos/cm at 25 degree Celsius
mmol/l	millimol per liters
Na	Sodium
NO ₃	Nitrate
ppb	Part per billions
ppm	Part per millions
RSC	Residual Sodium Bicarbonate
SAR	Sodium Adsorption Ratio
SW	Surface Water
TD	Total depth
TDS	Total Dissolved Solid (mg/l or gr/l)
TW	Tube Well
WP	Water point
μ	micro
μg/l	Micrograms per litre
μS/cm	Micro-Siemence per centimeter

1. Introduction

Water quality suitable for irrigation agriculture is complex and affected by the following:

- a) Salinity (Electrical conductivity) hazard
- b) Permeability or sodium hazard(SAR)
- c) Toxicity or specific ions toxicity (Sodium, Boron and Chloride)
- d) Miscellaneous
- e) pH - acid or basic
- f) Others (Sodium percentage, residual sodium bicarbonate or residual alkalinity, permeability index, magnesium hazards).

Therefore, we analysed water samples of groundwater(GW) and surface water (SW) from ShirinTagab and Sholgara district to discover if the water is suitable for irrigation according to the above limitations. This is a pilot chemical and physical analysis of water samples for suitability of water quality for irrigation. We will develop these observations via chemical analysis of more water samples and soil salinity for selection of tolerant crops according to the suitability of water quality and soil characteristics in the future.

Figure 1 and figure 2 indicate the study area for suitability of water quality for irrigation.

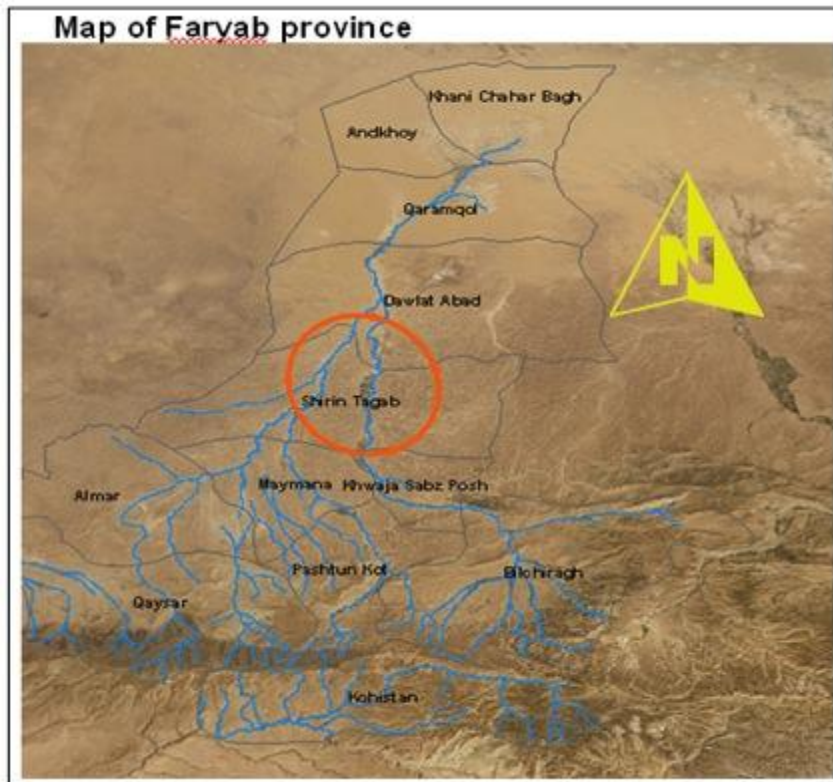


Figure 1 Location of ShirinTagab District

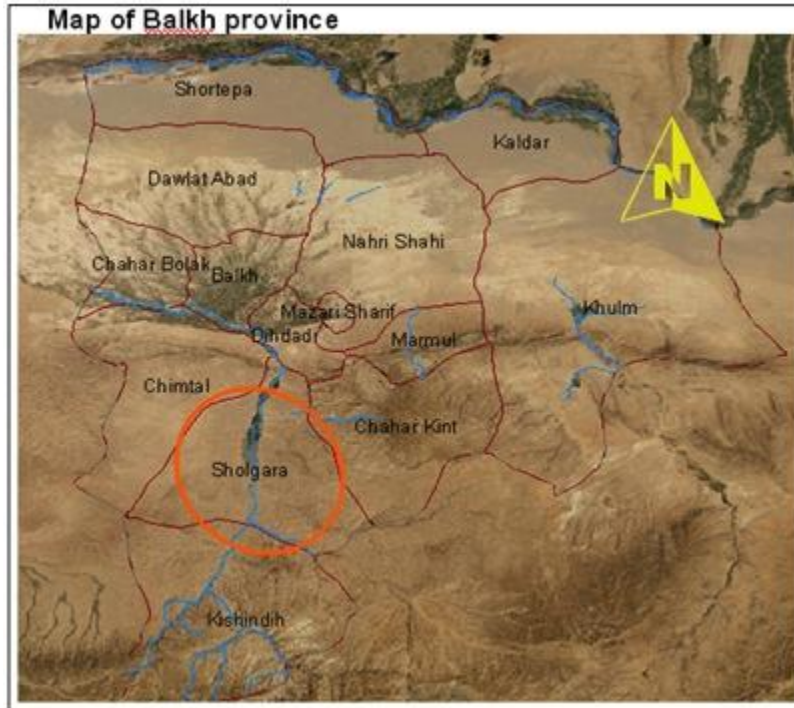


Figure 2 Location of Sholgara district

Key words: Physico-chemical characteristics; surface water and groundwater; suitability; irrigation; agriculture.

2. Objectives

The main objectives of this study are:

- Evaluate water quality concern parameters for suitability of groundwater and surface water for irrigated agriculture.
- Select crops which are tolerant for mentioned parameters.
- Present management alternative that can be expected to improve production of adapted crops with availability of groundwater and surface water for irrigation.

3. Guideline for suitability of water quality

The suitability criteria for water that can be used for agricultural are indicated in table 1 to 8.

Table 1 Guideline for assessment of salinity hazard of irrigation water

Potential problem	Limitation/degree of problem on use		
	Non	Slight-moderate	Sever
EC (dS/m)	<0.75	0.75-3.00	> 3
TDS (mg/L)	<400	450 - 2000	> 3

Source: Water quality for irrigation (FAO, 1985)

Table 2 Guidelines for assessment of sodium versus salinity hazard of irrigation water

Salinity and permeability problem (evaluate using EC and SAR)	Limitation/degree of problem on use		
	Non	Slight-moderate	Sever
SAR	EC (dS/m)		
0 – 3	> 0.7	0.7 – 0.2	< 0.2
3 – 6	> 1.2	1.2 – 0.3	< 0.3
6 – 12	> 1.9	1.9 – 0.5	< 0.5
12 - 20	> 2.9	2.9 – 1.3	< 1.3
20 - 40	> 5	5 – 2.9	<2.9

Source: Water quality for irrigation (FAO, 1985)

Table 3 Guideline for assessment specific ion toxicity of irrigation water

Specific ion toxicity(affects sensitive crops)	Limitation/degree of problem on use		
	Non	Slight-moderate	Sever
Sodium or SAR(surface irrigation)	< 3	3 - 9	> 9
Boron (mg/L)	< 0.7	0.7 - 3	> 3
Chloride (meq/L)	< 4	4 - 10	> 10

Source: Water quality for irrigation (FAO, 1985)

Table 4 Classification of irrigation water: Boron concentration in relation to plant tolerance

Classification	Sensitive plant	Semi-tolerant plant	Tolerant plant
Boron concentrations (ppm)			
Good	< 0.3	< 0.6	< 1.0
Fair	0.4 – 0.6	0.7 – 1.3	1.1 – 2
Poor	0.7 – 1.0	1.4 – 2.0	2.1 – 3.0
Poor	1.1 – 1.3	2.1 – 2.5	3.1 – 3.8
Unsuitable	> 1.3	> 2.5	> 3.8

Source: <http://www.osueextra.com>

Table 5 Chloride classification of irrigation water

Chloride (ppm)	Effect on Crops
Below 70	Generally safe for all plants.
70-140	Sensitive plants show injury.
141-350	Moderately tolerant plants show injury.
Above 350	Can cause severe problems.

Source: Mass (1990) Crop Salt Tolerance. **Agricultural Salinity Assessment and Management Manual**. K.K. Tanji (ed.). ASCE, New York. pp 262-304.

Table 6 Suitability of groundwater and surface water for irrigation based on percentage sodium

% Na	Water class
< 20	Excellent
20 - 40	Good
40 - 60	Permissible
60 - 80	Doubtful
>80	Unsuitable

Sources: Advances applied science research, 2011.

Table 7 Suitability of groundwater and surface water for irrigation: residual sodium carbonate (RSC)

RSC (meq/l)	Remark on quality
<1.25	Good
1.5–2.5	Doubtful
> 2.5	Unsuitable

Sources: Advances applied science research, 2011.

Table 8 Suitability of groundwater and surface water for irrigation: magnesium hazard (MH).

MH (meq/l)	Remark on quality
< 50	Good
> 50	Unsuitable

Sources: Advances applied science research, 2011.

4. Evaluation of water quality ShirinTagab district

Two water samples were collected (from groundwater and surface water) from Gurzad village of ShirinTagab district in Faryab Province). The location of water samples and summary of water quality concern parameters for irrigation is indicated in the figure 3.

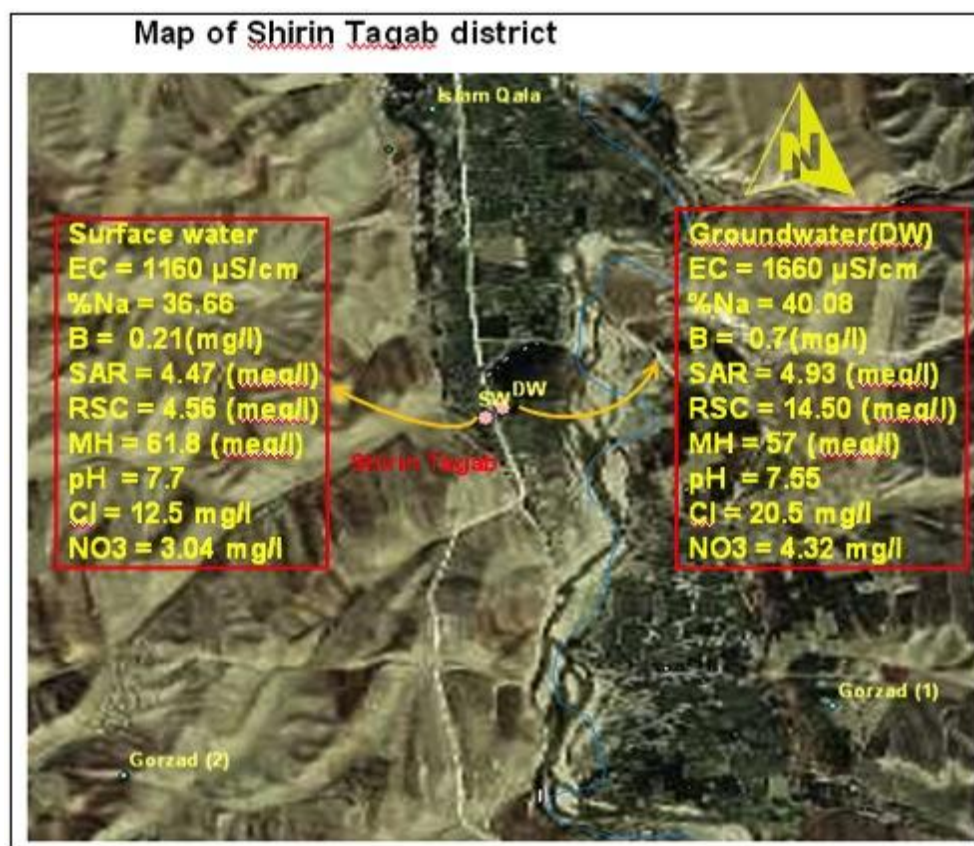


Figure 3 Location of water samples in Gurzad village

4.1 Summary of water quality concerns

The summary of surface and ground water quality parameters and remarks on suitability of water for irrigation are indicated in the tables 9 and 10 for water of surface in table 9 and for groundwater in table 10.

Table 9 Summary of water quality in Gurzad village

Parameters	Symbol	Unit	Values	Remarkable on water quality
Electrical Conductivity/Salinity	EC	$\mu\text{S/cm}$	1160	Moderate problem for irrigation
pH			7.7	Normal for irrigation
Sodium	Na	%	36.66	Good for irrigation
Sodium Adsorption Ratio	SAR	meq/l	4.47	Excellent for irrigation
Residual Sodium Bicarbonate	RSC	meq/l	4.56	Unsuitable for irrigation and need soil modification
Boron	B	mg/l	0.2	Good for sensitive plant
Magnesium Hazard	MH	meq/l	61.8	Harmful for irrigation and need soil modification
Chloride	Cl	mg/l	12.5	Safe for all plants
Nitrate	NO ₃	mg/l	3.04	Excellent for irrigation

Table 10 Summary of water quality concern in groundwater Gurzad village

Parameters	Symbol	Unit	Values	Remarkable on water quality
Electrical Conductivity/Salinity	EC	$\mu\text{S/cm}$	1660	Moderate problem for irrigation
pH			7.55	Normal for irrigation
Sodium	Na	%	40.08	Good for irrigation
Sodium Adsorption Ratio	SAR	meq/l	4.93	Excellent for irrigation
Residual Sodium Bicarbonate	RSC	meq/l	14.50	Unsuitable for irrigation and need soil modification
Boron	B	mg/l	0.7	Fair for semi-tolerant plant
Magnesium Hazard	MH	meq/l	57	Harmful for irrigation and need modification
Chloride	Cl	mg/l	20.5	Safe for all plants
Nitrate	NO ₃	mg/l	4.32	Excellent for irrigation

4.2 Graphic evaluation of sodium and salinity hazard by Wilcox plot

Wilcox plot is indicated in figure 4 evaluating the sodium and salinity hazard for surface and groundwater.

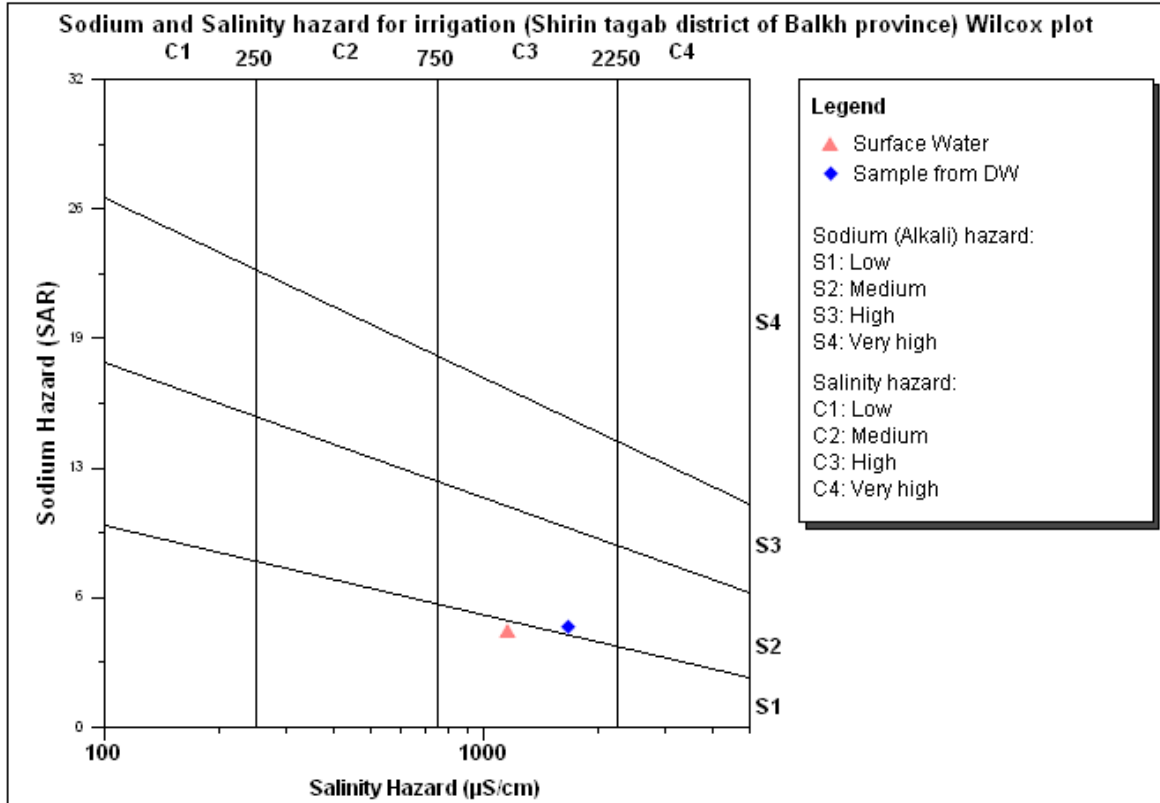


Figure 4 Graphic evaluation of sodium (SAR) and salinity (EC) hazard for irrigation

The sample from surface water is plotted in C_3S_1 which is indicating high salinity hazard and low sodium hazard. It can be used for irrigation of almost all types of soil with little hazard for exchangeable sodium concentration. The sample from groundwater is plotted in C_3S_2 which is indicating high salinity hazard and moderate sodium hazard. It can be used for irrigation with moderate sodium hazard and high salinity hazard.

4.3 Summary of water quality parameters analyzed and calculated data

The summary of water quality parameters analyzed and calculated data of surface and ground water are indicated in the table 11 and 12.

Table 11 Summary of water quality parameters analyzed and calculated data for Gurzad

Summary of water quality parameters analyzed and calculated data				
Sample Date	01/10/2012			
Station	ShiFar 5			
Province	Faryab			
District	Shirin Taqab			
Village	Gurzad			
Source	Sample from DW			
Location				
Geology				
Watertype	Na-Mg-HCO3-SO4-CO3			
Temperature (°C)	20			
pH	7.55			
Conductivity	1655 uS/cm			
Sum of Anions	21.07858 meq/L			
Sum of Cations	21.09735 meq/L			
Balance	4.451361E-02 %			
Total dissolved solids	1460.94 mg/L			
Total hardness	4.975979 mg/l CaCO3			
Alkalinity	14.49925 mg/l CaCO3			
Major ion composition	mg/l	mmol/l	meq/l	
Na	253	11.00489	11.00489	
K	4.8	0.1227675	0.1227675	
Ca	84	2.095913	4.191826	
Mg	70	2.880066	5.760132	
Cl	20.5	0.5782352	0.5782352	
SO4	280	2.916667	5.833333	
NO3	4.32	6.967742E-02	6.967742E-02	
HCO3	600	9.833302	9.833302	
Ratios	Comparison to Seawater			
	mg/l	mmol/l	mg/l	mmol/l
Ca/Mg	1.2	0.727731	0.319	0.194
Ca/SO4	0.3	0.7185988	0.152	0.364
Na/Cl	12.34146	19.03186	0.556	0.858
Cl/Br	15.07353	33.97302	287	648

Table 12 Summary of water quality parameters analyzed and calculated dataGurzad

Summary of water quality parameters analyzed and calculated data				
Sample ID	ShiFar 1-1			
Sample Date	03/10/2012			
Station	ShiFar 4			
Province	Faryab			
District	Shirin Taqab			
Village	Gurzad			
Source	Surface Water			
Location				
Geology				
Watertype	Na-Mg-HCO3-CO3-SO4			
Temperature (°C)	20.1			
pH	7.77			
Conductivity	1160 uS/cm			
Sum of Anions	16.50128 meq/L			
Sum of Cations	16.59587 meq/L			
Balance	0.285787 %			
Total dissolved solids	1124.075 mg/L			
Total hardness	3.660184 mg/l CaCO3			
Alkalinity	11.87704 mg/l CaCO3			
Major ion composition	mg/l	mmol/l	meq/l	
Na	210	9.134498	9.134498	
K	5.4	0.1381134	0.1381134	
Ca	56	1.397275	2.794551	
Mg	55	2.262909	4.525818	
Cl	12.5	0.3525824	0.3525824	
SO4	200	2.083333	4.166667	
NO3	3.04	4.903226E-02	4.903226E-02	
HCO3	440	7.211088	7.211088	
Ratios	Comparison to Seawater			
	mg/l	mmol/l	mg/l	mmol/l
Ca/Mg	1.018182	0.6174687	0.319	0.194
Ca/SO4	0.28	0.6706921	0.152	0.364
Na/Cl	16.8	25.90741	0.556	0.858
Cl/Br	16.23377	36.58799	287	648

5. Evaluation of water quality in Sholgara district

Three water samples were collected (one from groundwater and two surface water) from Qipchaq and Shikhha (Mula Sahib) villages of Sholgara district. The location of water samples and summary of water quality concern parameters for irrigation is in the figure 5.

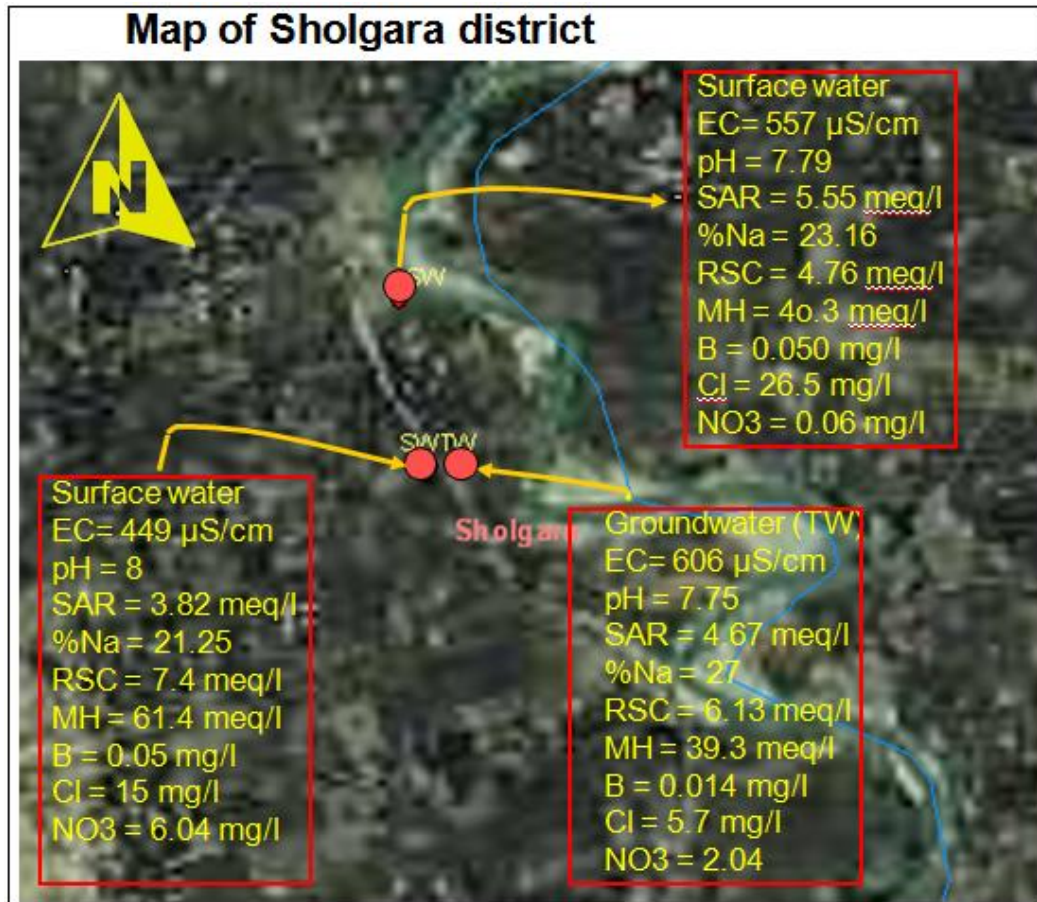


Figure 5 Location of water samples and summary of water in Sholgara district

5.1 Summary of water quality parameters

The summary of surface and ground water quality parameters and remarks on suitability of water for irrigation are indicated in the tables 13, 14, 15 & 16 (table 13& 14 for surface water and table 15 for groundwater) in Shikha village of Sholgara district of Balkh province.

Table 13 Summary of water quality for surface concern Shikha Village

Parameters	Symbol	Unit	Values	Remarkable on water quality
Electrical Conductivity/Salinity	EC	μ S/cm	557	Low and excellent for irrigation
pH			7.79	Normal for irrigation
Sodium	Na	%	23.6	Good for irrigation
Sodium Adsorption Ratio	SAR	meq/l	5.55	Excellent for irrigation
Residual Sodium Bicarbonate	RSC	meq/l	4.76	Unsuitable for irrigation and need soil modification
Boron	B	mg/l	0.05	Good for all plants
Magnesium Hazard	MH	meq/l	40.3	Not harmful for irrigation
Chloride	Cl	mg/l	26.5	Safe for all plants
Nitrate	NO3	mg/l	0.06	Excellent for irrigation

Table 14 Summary of water concern in Qipchaq village surface water

Parameters	Symbol	Unit	Values	Remarkable on water quality
Electrical Conductivity/Salinity	EC	$\mu\text{S/cm}$	449	Low and excellent for irrigation
pH			8	Normal for irrigation
Sodium	Na	%	21.25	Good for irrigation
Sodium Adsorption Ratio	SAR	meq/l	3.82	Excellent for irrigation
Residual Sodium Bicarbonate	RSC	meq/l	7.4	Unsuitable for irrigation and need soil modification
Boron	B	mg/l	0.05	Good for all plants
Magnesium Hazard	MH	meq/l	61.4	Harmful for irrigation and need modification
Chloride	Cl	mg/l	15	Safe for all plants
Nitrate	NO3	mg/l	6.04	Excellent for irrigation

Table 15 Summary of water quality in Qipchaq Village for groundwater

Parameters	Symbol	Unit	Values	Remarkable on water quality
Electrical Conductivity/Salinity	EC	$\mu\text{S/cm}$	660	Low and excellent for irrigation
pH			7.75	Normal for irrigation
Sodium	Na	%	27	Good for irrigation
Sodium Adsorption Ratio	SAR	meq/l	4.67	Excellent for irrigation
Residual Sodium Bicarbonate	RSC	meq/l	6.13	Unsuitable for irrigation need soil modification
Boron	B	mg/l	0.014	Good for all plants
Magnesium Hazard	MH	meq/l	39.3	Not harmful for irrigation
Chloride	Cl	mg/l	5.7	Safe for all plants
Nitrate	NO3	mg/l	2.04	Excellent for irrigation

5.2 Graphic evaluation of sodium and salinity hazard by Wilcox plot

Wilcox plot is indicated in figure 6 evaluating the sodium and salinity hazard for surface and groundwater.

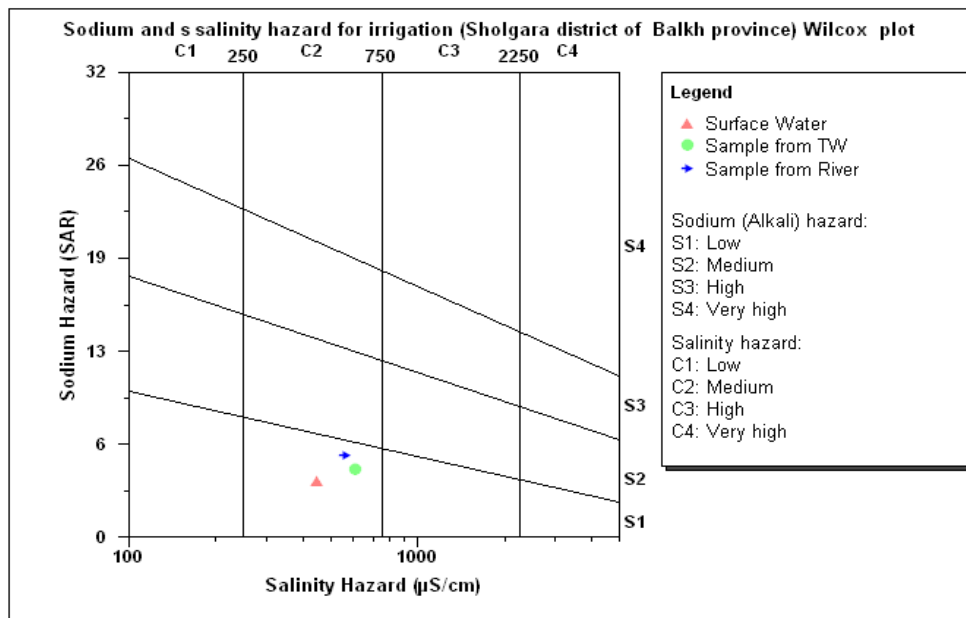


Figure 6 Graphic evaluation of sodium (SAR) and salinity (EC) hazard for irrigation

The points are plotted in C_2S_1 which are indicating low salinity hazard and low sodium hazard. Ground and surface water can be used for irrigation of all types of soil without any hazard for exchangeablesodium concentration.

5.3 Summary of water quality parameters analyzed and calculated data

The summary of water quality parameters analyzed and calculated data of surface and groundwater are indicated in the table 16, 17 and 18.

Table 16 Summary of water quality in Shikha

Summary of water quality parameters analyzed and calculated data				
Sample ID	ShoBal 1-1			
Sample Date	03/10/2012			
Station	ShoBal 1			
Province	Balkh			
District	Shoigara			
Village	Shikha (Mula Sahib)			
Source	Sample from River			
Location				
Geology				
Watertype	Na-CO3-HCO3			
Temperature (°C)	19.8			
pH	7.79			
Conductivity	557 uS/cm			
Sum of Anions	11.17365	meq/L		
Sum of Cations	11.30507	meq/L		
Balance	0.5846466	%		
Total dissolved solids	732.8959	mg/L		
Total hardness	1.838448	mg/l CaCO3		
Alkalinity	8.435384	mg/l CaCO3		
Major ion composition	mg/l	mmol/l	meq/l	
Na	173	7.525086	7.525086	
K	3.8	9.719092E-02	9.719092E-02	
Ca	44	1.097859	2.195719	
Mg	18	0.7405884	1.481177	
Cl	26.5	0.7474747	0.7474747	
SO4	88	0.9166667	1.833333	
NO3	5.54	8.935484E-02	8.935484E-02	
HCO3	230	3.769433	3.769433	
Ratios	Comparison to Seawater			
	mg/l	mmol/l	mg/l	mmol/l
Ca/Mg	2.444444	1.482415	0.319	0.194
Ca/SO4	0.5	1.197665	0.152	0.364
Na/Cl	6.528302	10.06734	0.556	0.858
Cl/Br	15.05682	33.93535	287	648

Table 17 Summary of water quality in Qipchq

Summary of water quality parameters analyzed and calculated data				
Sample ID	ShoBal 1-2			
Sample Date	04/10/2012			
Station	ShoBal 2			
Province	Balkh			
District	Sholgara			
Village	Qip Chaq			
Source	Surface Water			
Location				
Geology				
Watertype	Na-Mg-CO3-HCO3			
Temperature (°C)	19.7			
pH	8			
Conductivity	449 uS/cm			
Sum of Anions	8.387672	meq/L		
Sum of Cations	8.639903	meq/L		
Balance	1.481307	%		
Total dissolved solids	547.885	mg/L		
Total hardness	1.743425	mg/l CaCO3		
Alkalinity	6.861928	mg/l CaCO3		
Major ion composition	mg/l	mmol/l	meq/l	
Na	116	5.045722	5.045722	
K	3.5	8.951796E-02	8.951796E-02	
Ca	27	0.6736863	1.347373	
Mg	26	1.069739	2.139477	
Cl	15	0.4230989	0.4230989	
SO4	46	0.4791667	0.9583334	
NO3	6.04	9.741935E-02	9.741935E-02	
HCO3	195	3.195823	3.195823	
Ratios	Comparison to Seawater			
	mg/l	mmol/l	mg/l	mmol/l
Ca/Mg	1.038462	0.6297672	0.319	0.194
Ca/SO4	0.5869565	1.405954	0.152	0.364
Na/Cl	7.733333	11.92563	0.556	0.858
Cl/Br	15.30612	34.49724	287	648

Table 18 Summary of water quality

Summary of water quality parameters analyzed and calculated data				
Sample ID	ShoBal 1-3			
Sample Date	10/04/2012			
Station	ShoBal 3			
Province	Balkh			
District	Sholgara			
Village	Qip Chaq			
Source	Sample from			
Location	TW			
Geology				
Watertype	Na-Ca-HCO ₃ -CO ₃			
Temperature (°C)	19.7			
pH	7.57			
Conductivity	606 uS/cm			
Sum of Anions	12.42576	meq/L		
Sum of Cations	13.64493	meq/L		
Balance	4.676397	%		
Total dissolved solids	844.6191	mg/L		
Total hardness	2.509483	mg/l CaCO ₃		
Alkalinity	11.15055	mg/l CaCO ₃		
Major ion composition	mg/l	mmol/l	meq/l	
Na	170	7.394593	7.394593	
K	4.3	0.1099792	0.1099792	
Ca	61	1.522032	3.044064	
Mg	24	0.9874511	1.974902	
Cl	5.7	0.1607776	0.1607776	
SO ₄	50	0.5208334	1.041667	
NO ₃	2.04	3.290322E-02	3.290322E-02	
HCO ₃	355	5.818037	5.818037	
Ratios			Comparison to Seawater	
	mg/l	mmol/l	mg/l	mmol/l
Ca/Mg	2.541667	1.541375	0.319	0.194
Ca/SO ₄	1.22	2.922302	0.152	0.364
Na/Cl	29.82456	45.99269	0.556	0.858
Cl/Br	4.56	10.27742	287	648

6. Summary and Recommendation

The results derived from this study, carried out in ShirinTagab and Sholgara districts through analyzing and evaluating water samples from surface water and groundwater for suitability of water quality for irrigation agriculture are as below.

6.1 ShirinTagab district

- The electrical conductivity or salinity of water samples from surface water and groundwater indicates moderate hazard for irrigation. It is suggested to select crops that are tolerance for moderate salinity for increasing crop yields.
- The graphic evaluation (Figure 4) of analyzed water sample from surface water is plotted in C₃S₁ is indicating high salinity hazard and low sodium hazard. It can be used for irrigation of almost all types of soil with little hazard for exchangeable sodium. The sample from groundwater is plotted in C₃S₂(Figure 4) which is indicating high salinity hazard and moderate sodium hazard.It can be used for irrigation, but required to be monitored and care to be taken.
- The RSC values indicate that the surface and groundwater are unsuitable for irrigation. Therefore, an application is needed to modifythe soil by application of gypsum.

- The MH calculated values indicate that the groundwater is harmful and surface water is suitable for irrigation.
- The sodium concentration percentage (%Na) indicate that the surface and groundwater are good for irrigation.
- Boron concentration level indicate that the surface water is good for sensitive plants and the groundwater is fair for semi-tolerant plans during irrigation.
- The chloride and nitrate concentration levels indicate that the surface water and groundwater are safe for plants during irrigation.

6.2 Sholgara district

- The graphic evaluation (Figure 6) of analyzed water samples from surface water and groundwater are plotted in C_2S_1 which indicate low salinity hazard and low sodium hazard. Ground and surface water can be used for irrigation of all types of soil without any hazard for exchangeable sodium.
- The electrical conductivity or salinity of water samples from surface water and groundwater indicate low EC and therefore excellent for irrigation.
- The sodium concentration present (%Na) indicates that the surface and groundwater are good for irrigation.
- The RSC values indicate that the surface and groundwater are unsuitable for irrigation and need therefore soil modification. Therefore, an application is needed to modify the soil by application of gypsum.
- The MH calculated values indicates that the surface and groundwater are not harmful for irrigation.
- Boron concentration level indicates that the surface water and groundwater are safe all plans during irrigation.
- The chloride and nitrate concentration levels indicate that the surface water and groundwater are safe for all plants during irrigation.

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