ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230, **ISSN (online):** 2412-3986, **DOI: http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

Influence of Ion Pairs and Activity on the Index of Irrigation Water Quality Relying on Some Modern Terms in Erbil Governorate. *

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A B S T R A C T:
The research was done in Erbil governorate, Iraqi Kurdistan Region in both times of sampling (June and October 2020) to determine a quality index of irrigation water (IWQI) for 354 water samples depending on (EC, SAR, $CROSS_o$, MCAR, SP, RSC) parameters before and after correcting ion pairs and ion pairs plus activity. The results indicated the effect of correcting ion pairs and activity on the values of the above parameters which caused an increase in the values of SAR and $CROSS_o$ for different water resources in both wet and dry seasons. On the other hand, the above corrections caused a decrease in MCAR, SP, and negative value of RSC, for the water of rivers, springs, and wells in both seasons of sampling. The studied water resources were classified using IWQI depending on the above parameters in both seasons. The results indicated that 74 and 55 water samples have excellent class before correcting ion pairs and activity for wet and dry season respectively, while the water for 77 and 54 samples had excellent class after correcting ion pairs plus activity for both seasons respectively. While (27, 39) and (28, 39) water samples had the good class before and after correcting ion pairs and activity for both seasons respectively. Water samples for (14, 10) and (15, 5) locations have an average class for the wet and dry season before and after correcting ion pairs plus activity. The 62 and 73 water samples had poor class in wet and dry seasons before correcting ion pairs plus activity respectively and 57 and 79 samples had the same class after correcting ion pairs plus activity for both seasons respectively.

KEY WORDS: Water Classification; Ion pairs; IWQI; Water Resources; Irrigation Water.
DOI: http://dx.doi.org/10.21271/ZJPAS.34.2.9
ZJPAS (2022) , 34(2);118-128 .

1.INTRODUCTION :

Water is the most precious natural resource and it has an important role for life sustain. In recent years water becomes one of the most demanded due to the increase in population, urbanization, and intense agriculture. The water resources in the Iraqi Kurdistan region include (rivers, lakes, springs, and wells). The freshwater consumed by world agriculture is nearly 70% withdrawn per year, however, users in the studied area rely on freshwater for agricultural activities as reported by (UNESCO 2001).

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Article History:
Received: 20/12/2021
Accepted: 07/02/2022
Published: 13/04 /2022

(Adams 1971) described ion pairs as the phenomenon of approaching cations and anions in water to each other for a distance less than 5 angstroms while each ion keeps its hydration shell. The amount and kinds of ions included in water are important to limit the type and amount of ion pairs which may cause changing water class depending on global classifications for irrigation water. (Esmail 2001, Sarkar and Hassan 2006, Salih 2008, and Alani 2015). WQI gives a single indicator of water quality depending, on important parameters (Vinod et al., 2013) or we can say WQI to give one value that represents whole water quality parameters for a certain site and time depending on the selected terms. Irrigation Water Quality Index is a method to cumulative different water properties to one value then explain their suitability for irrigation. In 10 years before, the classification of groundwater mainly depended on (IWQI). There are numerous studies about water quality and irrigation water quality index which were conducted by (Shekha, 2008, Hanna et al.,2019, Meireles et al., 2010, Maia and Rodrigues, 2012, Rajab 2015 and, Ameen 2019, etc.…) but, most of them do not include the combined effect of parameters such as ($CROSS_o$, MCAR, SP, SAR, and RSC) on irrigation water quality index or water class, IWQI calculations use the most commonly measured parameters as mentioned before, on the other hand, there are no studies about the effect of correcting ion pair and ion pair plus activity on irrigation water quality index. however, some studies included the effect of correcting ion pairs and ion pairs plus activity on the conversion of water class from class to other, but they depended on one parameter only for example RSC or SAR or SP, for this reason, this study was selected to focusing on the role of correcting of ion pairs and ion pairs plus activity on IWQI using five parameters which included the main cations and anions. Since the season or climate that affecting on the chemical composition of water due to the mentioned reasons, this investigation was selected to explain the influence of ion pairing and activity in the classification of water resources in the Kurdistan region depending on (CROSSo, MCAR, SP, SAR, and RSC) parameters using irrigation water quality index (IWQI). Ghope et al., (2019) studied IWQI for 36 locations in India the results indicated that 28 samples had moderately restricted class for irrigation while 8 of them had highly restricted for irrigation. Al-Saffawi et al., (2020) studied the classification of groundwater quality Al-Kasik district northeastern of Mosul city using IWQI depending on (EC, SAR, HCO_3^-, Na^+, and Cl^-) the results indicated that the studied water had low to the severe restriction for irrigation purposes, Othman and Ibrahim (2021) studied WQI in some locations in Erbil depending on numerous physical and chemical parameters but they focused only on drinking purpose.

2-MATERIALS AND METHODS:

2.1. Water sampling

The water samples were taken in the dry and wet season from 177 locations which included (41 water samples from rivers, 36 springs, and 100 wells) the total number of water samples was 354. as shown from the figure (1).

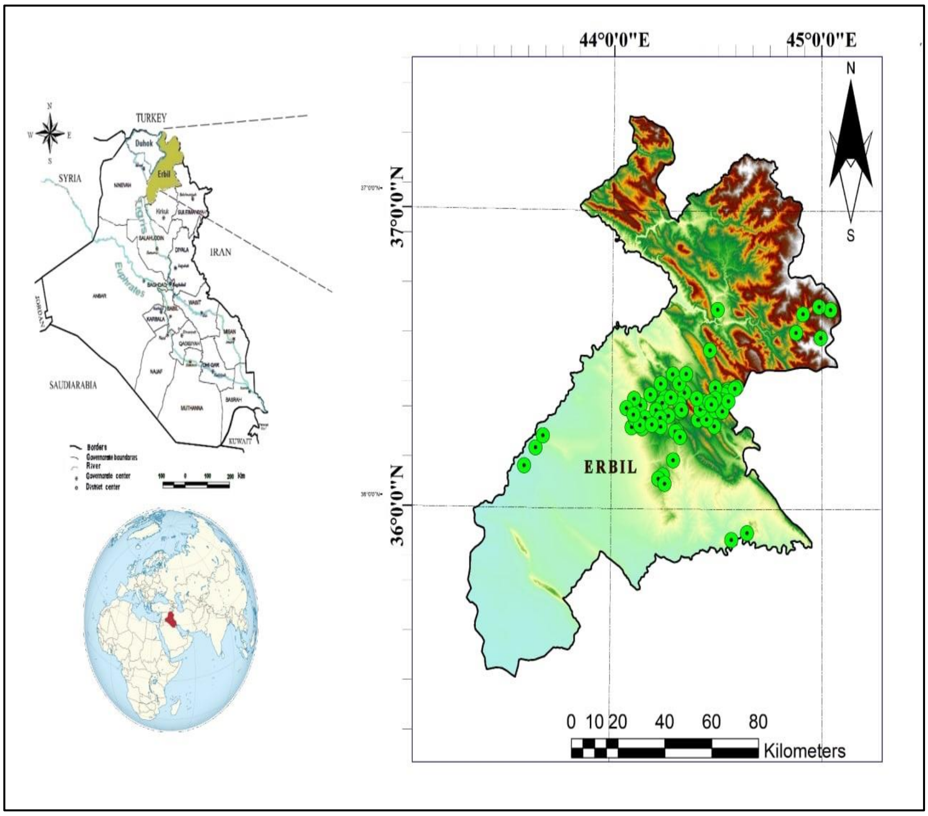

Figure 1. Map for the studied locations.

2.2. Water chemical analysis:

The water chemical properties (EC, pH, main cations, and anions) were determined according to APHA (2001), their means and ranges were shown in table (1).

Table 1. Explains range and mean for the water studied parameters in wet and dry seasons.

W. R	W. P	Wet season		Dry season	
		(Maximum – Minimum)	Mean ±SE	(Maximum – Minimum)	Mean ±SE
River	Ca^{2+}	2.439 - 0.479	1.107±0.073	3.000 - 0.920	1.508±0.076
	Mg^{2+}	2.997 - 0.368	1.128±0.095	2.936 - 0.573	1.476±0.094
	K^{+}	0.366 -0.005	0.045±0.011	0.135 - 0.008	0.036±0.004
	Na^{+}	4.917 -0.022	0.540±0.161	4.565 - 0.043	0.503±0.158
	Cl^{-}	2.157 -0.263	0.579±0.073	2.326 - 0.409	0.888±0.076
	SO_4^{2-}	2.090 -0.125	0.664±0.087	3.595 - 0.140	1.073±0.132
	HCO_3^{-}	8.785 -1.360	3.101±0.239	6.753 - 2.032	3.411±0.153
	CO_3^{2-}	0.00	0.00	0.00	0.00
	EC	1.390 - 0.240	0.506±0.044	1.670 - 0.350	0.650±0.043
	pH	7.580 - 6.990	7.226±0.028	7.550 - 6.730	7.161±0.026
Spring	Ca^{2+}	12.156-0.887	2.339±0.507	13.200-0.973	2.721±0.573
	Mg^{2+}	5.600-0.632	1.735±0.210	7.094-0.580	2.056±0.272
	K^{+}	0.857-0.005	0.104±0.034	0.925-0.003	0.082±0.029
	Na^{+}	11.700-0.035	1.083±0.403	9.043-0.043	1.004±0.346
	Cl^{-}	7.344-0.276	0.917±0.230	5.089-0.352	1.065±0.164
	SO_4^{2-}	7.605-0.090	1.118±0.316	9.775-0.140	1.326±0.341
	HCO_3^{-}	27.192-1.754	5.962±1.000	30.356-2.098	6.831±1.227
	CO_3^{2-}	0.00	0.00	0.00	0.00
	EC	3.680-0.320	0.935±0.156	4.210-0.370	1.066±0.176
	pH	7.690-5.720	6.779±0.064	7.620-5.570	6.765±0.076
Well	Ca^{2+}	29.142-0.240	2.759±0.401	29.510-0.370	3.279±0.430
	Mg^{2+}	19.895-0.479	2.414±0.289	18.481-0.510	2.667±0.299
	K^{+}	1.269-0.005	0.107±0.015	1.483-0.005	0.102±0.017
	Na^{+}	43.478-0.039	6.582±0.996	44.217-0.057	6.167±0.947
	Cl^{-}	120.500-0.211	3.962±1.301	110.946-0.381	4.115±1.204
	SO_4^{2-}	35.105-0.075	3.972±0.681	38.225-0.160	4.577±0.727
	HCO_3^{-}	10.818-1.442	4.771±0.168	10.897-1.639	4.570±0.158
	CO_3^{2-}	0.00	0.00	0.00	0.00
	EC	14.250-0.390	1.710±0.223	13.750-0.370	1.798±0.222
	pH	8.650-0.012	7.353±0.081	8.620-6.240	7.329±0.033

2.3. Calculation

The following parameters were determined according to Maia et al., (2020):

- Cations Ratio of Soil Structural Stability Optimizing
- $CROSS_o = \frac{Na+0.335K}{\sqrt{(ca+0.0758\,Mg)/2}}$
- Monovalent Cation Adsorption Ratio

$$MCAR= \frac{Na+K}{\sqrt{(Ca+\,Mg)/2}}$$

- Sodium Adsorption Ratio

$$SAR =\frac{Na}{\sqrt{(Ca+Mg)/2}}$$

- Salinity potential

$$SP = Cl^{-} + 1/2\ SO_4^{2-}$$

- "Residual sodium carbonate"

RSC= "{(CO_3^{2-} + HCO_3^{-}) – (Ca^{2+} + Mg^{2+})}"

The ionic strength (I) of water samples was calculated ed by the following expression:

$I=\frac{1}{2}\sum Ci\, Zi^2$……………………. (1)

Where:

Ci = actual individual ion concentration in the water (mmol L^{-1}).

Zi = Ion's charge number

The important role of ionic strength was explained in the Debye- Huckel equation as follow:

$-\log \gamma = \frac{AZi^2\sqrt{I}}{1+Bd\sqrt{I}}$ ……….. (2)

Where:

γ = Activity coefficient of ion.

I = Ion strength (mol L^{-1}).

A = 0.509 at 25 C° has been modified to be used up to I = 0.1 mol L^{-1}

B = 0.3285 at 25 C°, Zi = Ionic charge, d = Ion size parameter.

The relation between concentrations and the activity coefficient was described as follow:

a= γ *c…………………………… (3)

Where:

a = Activity of ions γ = activity coefficient

c = Concentration of ion

The steps for determining the value of IWQI was mentioned by Maia and Rodrigues (2012) which can be summarized by the following points:

a- Calculation of the difference between the reference values for the studied properties and Z- test was used to standardize the values depending on equation (4)

$Zi=\frac{Xi-X^-}{Standerd\ diviation}$……………… (4)

Where:

Zi = Calculated value after standardization for the studied properties.

Xi = The determined value for water samples characters.

X^- = Average for each variable from the representative or reference population.

b- The calculated index for irrigation water quality terms like ($CROSS_o$, MCAR, SP, SAR, and RSC) by using the following equations:

$IWQI=\frac{1}{2}\sum WQIi$………………… (5)

WQIi= The water properties quality index.

2.4- Data analysis

Regressing and correlation coefficient values were determined using the SPSS program, Version (26).

RESULTS AND DISCUSSION

Table (3) explains that the correction of ion pairs and ion pairs plus activity caused an increase in the value of some parameters such as (SAR and CROSSo), while the correcting of ion pairs and activity caused a decrease in MCAR, SP, and negative values of RSC. This may be due to the differing in participation of main cations and anions in ion-pairing and they are differing in activity coefficient as mentioned by (Esmail and Salih, 2014, Alani, 2015) which affected positively or negatively on the above parameters, and EC that were depended in the water resources classification using (IWQI) method. However, EC is not affected by correcting ion pairs and activity, since ion pairs are non-conductance to electrical current (Esmail, 1992). In general, the calculated values of parameters were increased in the first sampling in comparing with the dry season (second sampling) except for SP which increased in the dry season this may be due to the effect of seasonal variation in temperature and rainfall on the chemical composition of the studied water. Calcium and magnesium contribution in ion-pairing was higher than the contribution of sodium, which caused a higher decrease in their values in comparison with sodium. While the salinity potential increased in the dry season due to a high concentration of chloride which did not contribute to ion-pairing then led to a rise in SP value. On the other hand, the EC values increased in the dry season due to an increase in temperature and evaporation which caused increasing the concentration of ions and EC. The range of raw data which used in calculating the studied parameters that were dependent on classification was explained in appendices (1 a, b, and c). Table (4) shows that in general most of the water samples for rivers had excellent class for both wet and dry seasons and some of them had good class in both seasons, two samples only had average class for irrigation while 3 samples had poor class in the wet season and 4 samples had poor class for the dry season. In general, the effect of correcting ion pairs and ion pairs plus activity of both seasons haven't clear direction sometimes the correction caused an increase in conversion of class towards the better class in other cases caused the conversion of the water class towards the worst class or bad class, these results disagree with those recorded by (Esmail 1992, Salih 2008, Mam Rasul 2000 and Alani 2015). These differences or fluctuation in water classes may be due to depending this classification on all cations, anions, and parameters or scientific terms it means included whole chemical composition of samples mentioned before, this caused fluctuation the correction effect of ion pairs plus activity in conversion IWQI class to the better or worse class as shown from radar shape (figure 2). The green color is dominated in the outer circle which means the above corrections caused an increase in the IWQI** value, on the other hand, most of the blue colors towards the inner circles mean the value of IWQI is less than IWQI**. The most interesting point is that most of the water classes of wells in both seasons have poor classes and the others had excellent, good and average classes respectively, it means the quality of well water is more affected by the studied factors this may be due to higher EC in comparison with the river and spring water samples, the concentration of cations and anions values in water samples of wells which affected highly by seasonal variation in comparing with the water for springs and rivers. There is no clear direction or behavior for affecting correcting ion pairs and ion pairs plus activity on the conversion of water classes depending on IWQI. This may be due to using all studied water chemical properties in this classification, while the past classifications were depended on one or two parameters only for example Richard's classification, 1954 depended on EC and SAR, Doneen classification, 1954 depended on SP and Wilcox classification, 1955 depended on RSC. Figures (3 and 4) explain the effect of correcting ion pairs and ion pairs plus activity on the relation between EC and IWQI of whole water samples under the study in both seasons. The correcting of ion pairs and activity caused a decrease in the correlation coefficient value from 0.97** to 0.96** and 94** in the first sampling (wet season) respectively. However, in the second sampling (dry season) the correlation coefficient value(r) decreased from 0.91** to 0.90** and 0.89** after correcting ion pairs and ion pairs plus activity respectively. It means in general the above corrections caused decreases in irrigation water quality index values as mentioned before.

Table 2. Irrigation water classification by Maia and Rodrigues (2012).

IWQI	Water use restriction
1= Excellent	IWQI≤ 1.96
2=Good	1.96 < IWQI ≤ 5.88
3=Average	5.88 < IWQI ≤ 9.80
4=(Poor)	IWQI > 9.80

Table 3. Effect of correcting ion pairs and ion pairs + activity on the mean of the studied parameters used in water classification depending on (IWQI).

W. R	Wet season						Dry season					
	parameters	Values	Parameters	values	parameters	values	parameters	values	parameters	Values	parameters	Values
River	EC	0.51	EC	0.51	EC	0.51	EC	0.65	EC	0.65	EC	0.65
	SAR	0.31	SAR*	0.32	SAR**	0.36	SAR	0.26	SAR*	0.28	SAR**	0.31
	$CROSS_o$	0.45	$CROSS_o$*	0.47	$CROSS_o$**	0.52	$CROSS_o$	0.26	$CROSS_o$*	0.38	$CROSS_o$**	0.42
	MCAR	0.56	MCAR*	0.56	MCAR**	0.51	MCAR	0.52	MCAR*	0.52	MCAR**	0.46
	SP	1.24	SP*	1.13	SP**	0.95	SP	1.96	SP*	1.73	SP**	1.42
	RSC	-1.37	RSC*	-1.07	RSC**	-0.14	RSC	-2.56	RSC*	-2.05	RSC**	-0.67
spring	EC	0.94	EC	0.94	EC	0.94	EC	1.07	EC	1.07	EC	1.07
	SAR	0.52	SAR*	0.55	SAR**	0.61	SAR	0.45	SAR*	0.48	SAR**	0.53
	$CROSS_o$	0.73	$CROSS_o$*	0.78	$CROSS_o$**	0.88	$CROSS_o$	0.64	$CROSS_o$*	0.69	$CROSS_o$**	0.70
	MCAR	1.13	MCAR*	1.13	MCAR**	0.99	MCAR	1.04	MCAR*	0.47	MCAR**	0.50
	SP	2.03	SP*	1.73	SP**	1.37	SP	2.39	SP*	2.03	SP**	1.60
	RSC	-2.14	RSC*	-1.31	RSC**	0.61	RSC	-2.72	RSC*	-1.63	RSC**	0.67
Well	EC	1.71	EC	1.71	EC	1.71	EC	1.80	EC	1.80	EC	1.80
	SAR	2.63	SAR*	2.92	SAR**	3.35	SAR	2.32	SAR*	2.63	SAR**	3.00
	$CROSS_o$	3.48	$CROSS_o$*	3.90	$CROSS_o$**	4.47	$CROSS_o$	3.00	$CROSS_o$*	3.40	$CROSS_o$**	3.92
	MCAR	6.65	MCAR*	6.53	MCAR**	5.44	MCAR	2.03	MCAR*	2.28	MCAR**	2.56
	SP	7.93	SP*	6.97	SP**	5.36	SP	6.40	SP*	7.51	SP**	5.69
	RSC	-5.58	RSC*	-3.67	RSC**	-0.61	RSC	-7.32	RSC*	-4.97	RSC**	-1.31

Parameters= parameters before correcting ion pairs and activity.
Parameters with one star * = parameters after correcting ion pairs.
Parameters with double stars ** = parameters after correcting ion pairs plus activity.

Table 4. Effect of correcting ion pairs and activity on water classes (W.C) depending on IWQI values calculated from SAR, CROSSo, MCAR, SP, and RSC values.

Water resources	Season	W.C	Excellent	Good	Average	Poor
		IWQI value	≤ 1.96	>1.96 ≤ 5.88	>5.88 ≤ 9.80	> 9.80
		Number of samples				
Rivers	Wet	IWQI	28	9	1	3
		IWQI*	27	9	1	4
		IWQI**	30	7	0	4
	Dry	IWQI	29	8	0	4
		IWQI*	13	23	2	3
		IWQI**	29	8	0	4

Springs	Wet	IWQI	22	4	1	9
		IWQI*	22	4	1	9
		IWQI**	22	4	1	9
	Dry	IWQI	18	8	2	8
		IWQI*	18	10	0	8
		IWQI**	21	7	0	8
Wells	Wet	IWQI	24	14	12	50
		IWQI*	23	16	13	48
		IWQI**	25	17	14	44
	Dry	IWQI	8	23	8	61
		IWQI*	9	21	8	62
		IWQI**	4	24	5	67

IWQI = IWQI before correcting ion pairs and activity.
IWQI * = IWQI after correcting ion pairs.
IWQI ** = IWQI after correcting ion pairs plus activity.

5. CONCLUSION

The results indicated to increase in some studied parameters after correcting ion pairs and ion pairs plus activity and a decrease in other parameters. The results of water classification indicated that the mean percentage of the studied water before and after correcting ion pairs plus activity (42.66, 15.54, 8.19, and 33,61 %) had C1, C2, C3, and C4 classes in the wet season which equivalent to (151,55,29 and 119) water samples respectively. While (30.79, 22.03, 22,03,4.24, and 42.94%) of studied water resources had C1, C2, C3, and C4 classes in the dry season which equivalent (109, 78,15 and 152) samples respectively, most of the water samples of wells had C4 class while most of river and spring samples had C1 class and the remain samples had C2 and C3 class.

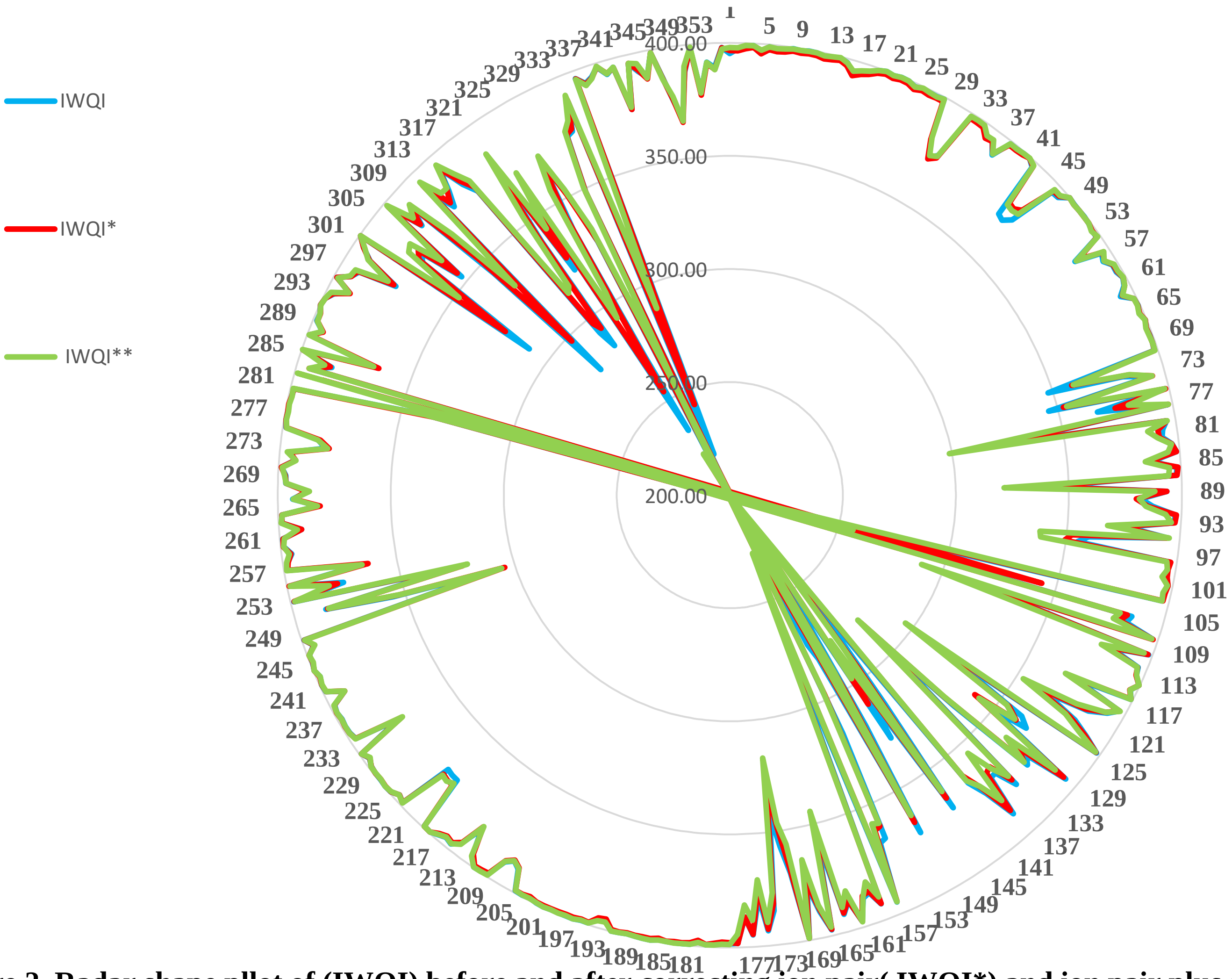

Figure 2. Radar shape pllot of (IWQI) before and after correcting ion pair(IWQI*) and ion pair plus activity (IWQI) for the studied water resources**

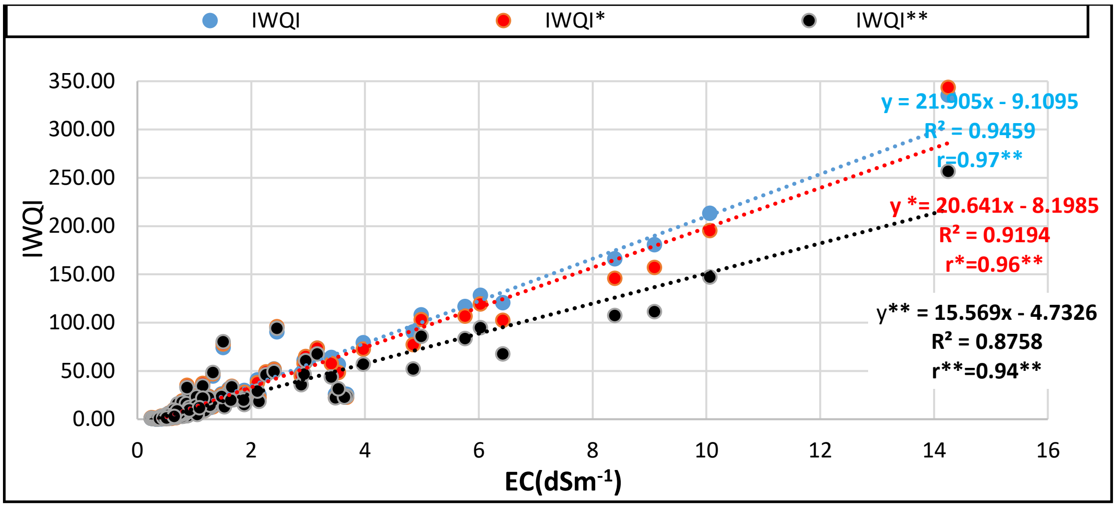

Figure 3. The relation between IWQI before and after correcting ion pairs plus activity in the wet season

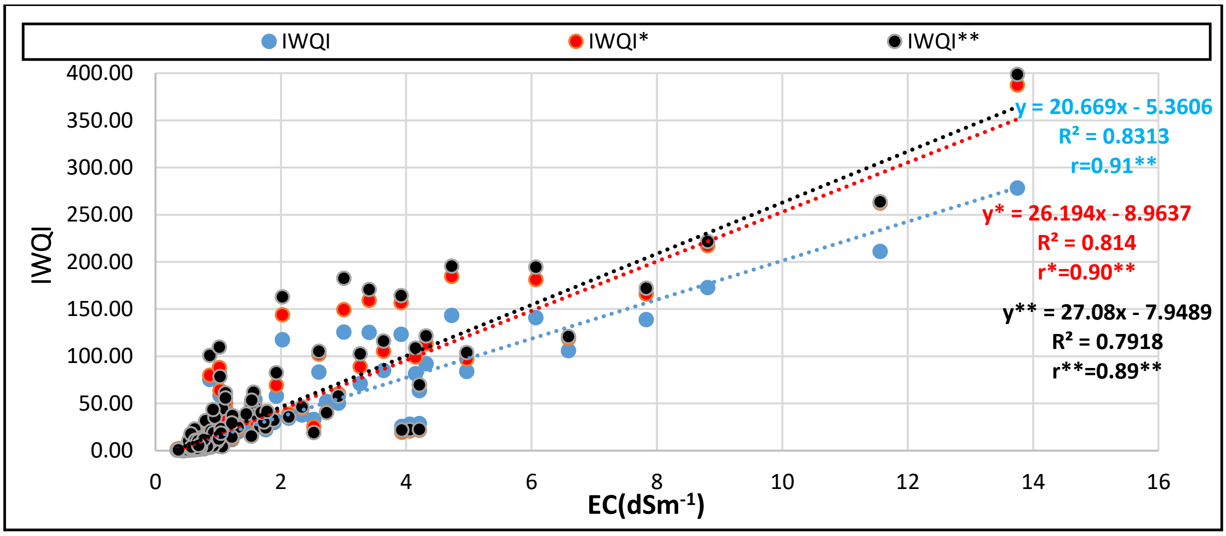

Figure 4. The relation between IWQI before and after correcting ion pairs plus activity in the dry season

Appendix. 1 a. The range and mean of the studied water parameters before correcting ion pairs and ion pairs plus activity for both seasons

W.R	W. P	Wet season		Dry season	
		Range (Max. – Min.)	Mean ±SE	Range (Max. – Min.)	Mean ±SE
River	EC	1.39 - 0.24	0.51 - 0.04	1.67 - 0.35	0.65 - 0.04
	SAR	2.36 -0.02	0.31 - 0.08	2.14 - 0.02	0.26 - 0.07
	$CROSS_o$	3.74 - 0.02	0.45 - 0.12	2.08 - 0.02	0.26 - 0.07
	MCAR	5.07 - 0.02	0.56 - 0.17	4.60 - 0.05	0.52 - 0.16
	SP	4.12 - 0.46	1.24 - 0.14	5.92 - 0.60	1.96 - 0.17
	RSC	0.14 – (-4.47)	-1.37 - 0.16	-0.50 – (-6.19)	-2.56 - 0.22
Spring	EC	3.68 - 0.34	0.94 - 0.16	4.21 - 0.37	1.07 - 0.18
	SAR	4.64 - 0.02	0.52 - 0.19	4.90 - 0.03	0.45 - 0.16
	$CROSS_o$	6.88 - 0.03	0.73 - 0.27	7.55 - 0.04	0.64 - 0.24
	MCAR	11.80 - 0.03	1.13 - 0.41	9.10 - 0.05	1.04 - 0.35
	SP	10.32 - 0.43	2.03 - 0.43	11.11 - 0.80	2.39 - 0.42
	RSC	1.21 - (-15.79)	-2.14 - 0.57	1.64 - (-20.09)	-2.72 - 0.64
Well	EC	14.25 - 0.39	1.71 - 0.22	13.75 - 0.37	1.80 - 0.22
	SAR	12.48 - 0.03	2.63 - 0.30	11.62 - 0.04	2.32 - 0.28
	$CROSS_o$	15.37 - 0.04	3.48 - 0.39	15.79 - 0.05	3.00 - 0.37

	MCAR	43.62 - 0.05	6.65 - 1.00	9.91 - 0.04	2.03 - 0.24
	SP	129.50 - 0.38	7.93 - 1.68	113.18 - 1.86	6.40 - 1.21
	RSC	5.48 - (-94.07)	-5.58 - 1.35	4.17 - (-91.51)	-7.32 - 1.43

W. R= water resources, W. P= water parameters.

SE= Standard Error for the studied parameters.

Appendix. 1 b. The range and mean of the studied water parameters after correcting ion pairs for both seasons

W.R	W. P	Wet season		Dry season	
		Range (Max. – Min.)	Mean ±SE	Range (Max. – Min.)	Mean ±SE
River	EC	1.39 - 0.24	0.51-0.04	1.67 - 0.35	0.65 - 0.04
	SAR*	2.50 - 0.02	0.32 - 0.08	2.29 - 0.02	0.28 - 0.08
	$CROSS_o$*	3.99 - 0.02	0.47 - 0.13	3.06 - 0.03	0.38 - 0.11
	MCAR*	5.05 - 0.03	0.56 - 0.17	4.56 - 0.05	0.52 - 0.16
	SP*	3.67 - 0.44	1.13 - 0.13	5.09 - 0.57	1.73 - 0.15
	RSC*	0.85 - (-3.44)	-1.07 - 0.13	-0.40 - (-4.80)	-2.05 - 0.16
Spring	EC	3.68 - 0.34	0.94 - 0.16	4.21 - 0.37	1.07 - 0.18
	SAR*	5.21 - 0.02	0.55 - 0.20	5.21 - 0.03	0.48 - 0.17
	$CROSS_o$*	7.33 - 0.03	0.78 - 0.29	8.05 - 0.04	0.69 - 0.26
	MCAR*	11.68 - 0.04	1.13 - 0.41	4.32 - 0.03	0.47 - 0.14
	SP*	9.04 - 0.41	1.73 - 0.35	8.81 - 0.72	2.03 - 0.32
	RSC*	1.47 - (-11.12)	-1.31 - 0.34	2.25 - (-14.02)	-1.63 - 0.39
Well	EC	14.25 - 0.39	1.71 - 0.22	13.75 - 0.37	1.80 - 0.22
	SAR*	14.70 - 0.02	2.94 - 0.35	13.99 - 0.04	2.63 - 0.33
	$CROSS_o$*	18.17 - 0.04	3.90 - 0.46	19.05 - 0.05	3.40 - 0.43
	MCAR*	43.46 - 0.05	6.53 - 0.98	11.80 - 0.04	2.28 - 0.28
	SP*	125.92 - 0.36	6.97 - 1.54	116.32 - 0.77	7.51 - 1.46
	RSC*	5.75 - (-86.80)	-3.67 - 1.07	4.34 – (-82.25)	-4.97 - 1.08

W. R= water resources, W. P= water parameters.

SE= Standard Error of the studied parameters.

Appendix. 1 c. The range and mean of the studied water parameters after correcting ion pairs and ion pairs plus activity for both seasons

W.R	W. P	Wet season		Dry season	
		Range (Max. – Min.)	Mean ±SE	Range (Max. – Min.)	Mean ±SE
River	EC	1.39 - 0.24	0.51 - 0.04	1.67 - 0.35	0.65 - 0.04
	SAR**	2.78 - 0.02	0.36 - 0.09	2.54 - 0.02	0.31 - 0.09
	$CROSS_o$**	4.46 - 0.03	0.52 - 0.14	3.42 - 0.03	0.42 - 0.12
	MCAR**	4.47 - 0.02	0.51 - 0.15	3.97 - 0.05	0.46 - 0.14
	SP**	3.00 - 0.39	0.95 - 0.10	3.87 - 0.54	1.42 - 0.11
	RSC**	2.68 - (-1.39)	-0.14 - 0.11	0.46 - (-2.10)	-0.67 - 0.10
Spring	EC	3.68 - 0.34	0.94 - 0.16	4.21 - 0.37	1.07 - 0.18
	SAR**	5.93 - 0.02	0.61 - 0.23	5.80 - 0.03	0.53 - 0.19
	$CROSS_o$**	8.41 - 0.03	0.88 - 0.33	6.62 - 0.05	0.70 - 0.22
	MCAR**	9.95 - 0.04	0.99 - 0.35	4.73 - 0.03	0.50 - 0.16
	SP**	7.60 - 0.38	1.37 - 0.28	6.93 - 0.61	1.60 - 0.22
	RSC**	6.67 - (-4.92)	0.61 - 0.32	7.94 – (-6.54)	0.67 - 0.43
Well	EC	14.25 - 0.39	1.71 - 0.22	13.75 - 0.37	1.80 - 0.22
	SAR**	16.98 - 0.02	3.35 - 0.41	16.33 - 0.04	3.00 - 0.39
	$CROSS_o$**	21.17 - 0.04	4.47 - 0.54	22.58 - 0.06	3.92 - 0.51

	MCAR**	34.04 - 0.05	5.44 - 0.77	13.60 - 0.04	2.56 - 0.33
	SP**	122.46 - 0.33	5.36 - 1.37	112.47 - 0.68	5.69 - 1.27
	RSC**	5.67 - (-35.84)	-0.61 - 0.46	5.46 - (-28.35)	-1.31 - 0.42

W. R= water resources, W. P= water parameters.

SE= Standard Error for the studied parameters.

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