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Study and Analysis of the Effect of Chemical Composition of Spring Water of Dhofar Region Against Turbidity

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ABSTRACT

The aim of this study is to calculate the physical properties of eight springs of the water of Dhofar region in Oman using physiochemical parameters like pH, total dissolved solids (TDS), conductivity, turbidity, and dissolved oxygen (DO). The chemical properties estimated the concentrations of the metals in springs of water and specified the best healthy spring of water depending on the percentage difference between the actual and normal range set by the World Health Organization (WHO). Eight samples for each test were collected from eight springs of water, namely, Ain Hamran, Ain Deribat, Ain Tobruk, Ain Al-Nabi Ayoub, Ain Atom, Ain Jarziz, Ain Sahlnot, and Ain Razat using an atomic absorption spectrophotometer (AAS) to study the chemical composition of the samples. Ain Jarziz represented high quality water because the percentage difference between actual and WHO was 78.78% compared to Ain Al-Nabi Ayoub, where the difference percentage was 105.95 %. Quantity of dissolved solid particles has a big effect on TDS and conductivity compared to the turbidity. Identification system was used to evaluate the effect of the quality of the chemical composition on the turbidity for Ions of Cl^{-1}, So_4^{-2}, Ca^{+2}, Na^{+1}, Mg^{+2}, and K^{+1} to be equal to 99.52%, 75.4%, 92.548%, 95.346%, 98.011%, and 97.33 %, respectively. However, more studies are required to conform with the outcomes of this research employing this energetic technique.

Keywords: Springs water; Metals; Physical properties; Drinking water; Turbidity.

INTRODUCTION

Water stands second to the most important factors to keep the lifespan on the earth after air. Water requirements increase with the time due to the world consumption. Water in 2000 was close to 4000 billion cubic meters compared to approximately 4700 billion cubic meters in 2016. Requirement for the water increases with the rise of the populations (WHO, 2017). Springs of water symbolize a very important resource to supply water in Sultanate of Oman; especially, in Dhofar governorate, there are eight springs of water, namely, Ain Hamran, Ain Deribat, Ain Tobruk, Ain Al-Nabi Ayoub, Ain Atom, Ain Jazz, Ain Sahlnot, and Ain Razat. These springs are situated in the south of Sultanate of Oman.

The activity of humans in different fields of life increases the level of pollution of heavy metals that have been associated with increased risks of osteoporosis, high blood pressure, clogged arteries, nephrolithiasis (kidney stones), colorectal cancer, hypertension and stroke, coronary artery disease, insulin resistance, and obesity (WHO, 2017). Three to five million are killed due to waste of water, and more than one billion humans do not have appropriate drinking water (Nathan et al., 2019, Amani et al., 2019 & Kawashima, 2003). Metals like iron, copper, Zink, magnesium, sodium, potassium, lithium, calcium, and boron create toxic effects on mankind, plants, and animals when their levels increase certain limits of safety (Muhammad et al., 2018, Nakahara, 2003; Ene et al., 2009, & CaioVinicius et al., 2018).

Some researchers focus on the springs of water to study and analyze the pollution degree of these leaps of water (Saito, 2003, Nagoshi, 2005, Afzal et al., 2013, Pantelica et al., 2008, Ogoyi et al., 2011& Gebrekidan M. & Samuel Z., 2011). Spatial analysis of rare elements of thermal springs of water is performed, like Na-So4-Cl, Ca-So4-Cl, Arsenic (As), Na-Cl-HCO3, Mercury (Hg), etc. (Gautam P. & Irfan A. , 2011, Popescu et al., 2009, Fujiwara S et al., 2007, Awni T, 2010, Ata S. et al., 2015, Mauricio O. et al., 2015, Eva et al., 2016, Falk et al., 2016, Gill G. & Geesey et al., 2016, Sonia L. et al., 2019 & M. Fernández et al., 2019).

Some researchers perform activities for desalination using advanced technology like polymeric membrane and nuclear desalination with a scope to convert wastewater into fresh water (Muhammad et al., 2018 & Amani et al., 2019). The innovation of this work provides an active technique to merge actual, theoretical, and identification systems to evaluate the healthy level of spring water by comparing it against WHO standards as optimum value. Study and analysis of the effect of quality of chemical composition of springs of water against turbidity using an identification system due to this site has not been a debate, and the effect of quality chemical compositions against turbidity. This study will provide researchers with a reference for study and analysis of the interaction between quality of the chemical composition and turbidity, TDS, electrical conductivity, DO, and pH.

MATERIALS AND METHODS

Eight water spring samples have been collected and gathered in 350 ml precleaned polyethylene bottles, and we used density meter, viscometer, dissolved oxygen meter, total dissolved solids, electrical conductivity, and pH to recognize physical properties for each sample of spring of water. We used an atomic absorption photometer to measure the chemical composition of Magnesium (Mg^{+2}), Zinc (Zn^{+2}), Calcium (Ca^{+2}), Sodium (Na^{+1}), Potassium (K^{+1}), Cobalt (Co), Molybdenum (Mo), Cupper (Cu^{+2}), Iron (Fe^{+2}), manganese (Mn), sulfate (So_4), and Fluoride (F-) for the eight samples of springs of water, depending on experimental results using identification system to estimate the percentage effect of each metal on turbidity as shown in Figure 1.

RESULTS AND DISCUSSION

CHEMICAL TEST

The allowable limit of elements of drinking water recommended by WHO for solutes is shown in Tables 1a & 1b. The results showed that concentrations of Magnesium (Mg^{+2}), Calcium (Ca^{+2}), Sodium (Na^{+1}), Cobalt (Co), Molbidium (Mo), and Iron (Fe^{+2}) were within the permissible limits set by WHO, while Zinc (Zn^{+2}), Potassium (K^{+1}), Sulfate (So_4^{-2}), Chloride (Cl^{-1}), Florid (F^{-1}), and Copper (Cu^{+2}) were less than the acceptable limits set by the WHO. Concentration of Manganese (Mn) was more than the acceptable limits set by the WHO as shown in Tables 1a and 1b.

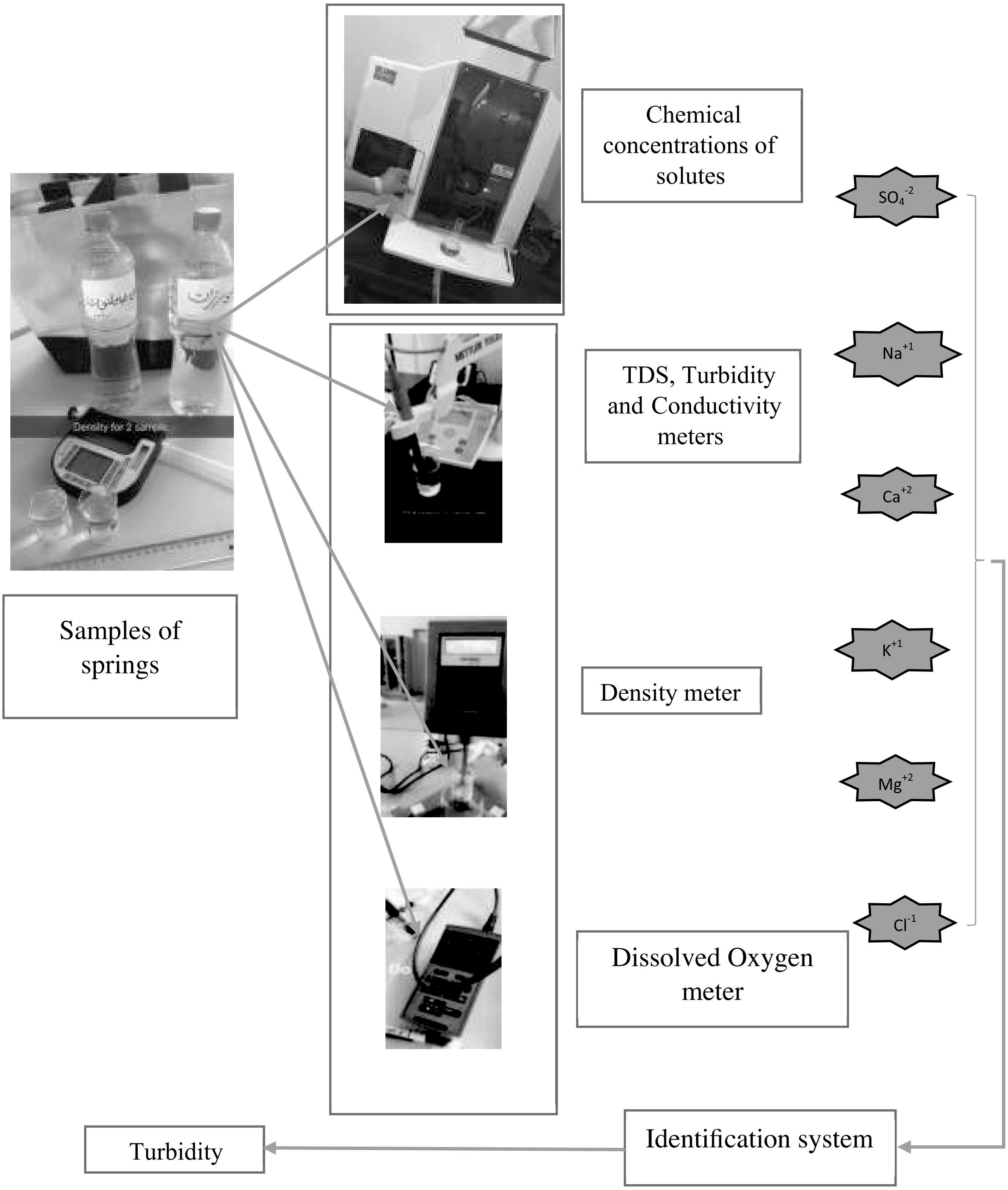

Figure 1. Physical and chemical equipment.

All springs of water are polluted by Mn, and springs of Himran, Derpat, Sahalnoot, and Razat are polluted by Mn and Ca as shown in Table 1a. The clear divergence in the distribution of concentrations is represented in standard deviation for Ca^{+2}, Na^{+1}, Cl^{-1} and So_4^{-2} as shown in Tables 1a & 1b, depending on the analysis of standard deviation to be more appropriate with the outcomes of identification system because the concentrations of Cl^{-1}, Ca^{+2} and Na^{+1} have a high effect on the turbidity as shown in Tables 4, 6, & 7, and concentration of So4-2 has a lower effect on turbidity as shown in Table 5.

Table 1a. Chemical concentration of different samples of spring water.

Springs of water	Mg^{++} (mg/L)	Zn^{++} (mg/L)	Ca^{++} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Co (µg/L)	Mo (µg/L)	Cu^{+2} (mg/L)	Fe^{+2} (mg/L)	Mn (mg/L)
Springs of water of Himran	11	0.328	93	14	1.83	0.235	0.190	0	0.002	0.094
Springs of water of Deribat	21	0.329	99	19	2.15	0.227	0.493	0	0.005	0.094
Springs of water of Tobruk	13	0.328	62	44	1.91	0.235	0.522	0	0.003	0.094
Springs of water of Auyb	20	0.328	86	8	4.85	0.244	0.582	0	0.003	0.096
Springs of water of Athom	25	0.337	38	59	1.49	0.247	0.695	0	0.003	0.099
Sprins of water of Jarziz	21	0.329	87	22	1.73	0.238	0.903	0	0.001	0.098
Springs of water of Sahalnoot	17	0.331	98	9	1.9	0.232	0.896	0	0.002	0.097
Springs of water of Razat	19	0.328	101	11	1.99	0.217	0.966	0	0.003	0.098
WHO	2.1-53	5	40 – 90	≤ 200	5.2	≤1	≤10	2	≤ 0.3	0.001-0.05
Standard deviation	4.56	0.003	22.026	18.514	1.075	0.009	0262.	0	0.001	0.002

Table 1b. Chemical concentration of different samples of spring water.

Springs of water	F^- (mg/L)	Cl^- (mg/L)	So_4^{-2} (mg/L)
Springs of water of Himran	0.01	86	9
Springs of water of Deribat	0.27	94	22
Springs of water of Tobruk	0.2	75	7
Springs of water of Auyb	0.74	67	42
Springs of water of Athom	0.17	66	14
Sprins of water of Jarziz	0.87	85	30
Springs of water of Sahalnoot	0.36	81	12
Springs of water of Razat	0.6	84	9
WHO	0.6-1.4	200-600	250-500
Standard deviation	0.302	9.735	12.418

PHYSICAL TEST

The acceptance ranges of physical properties of drinking water were specified by WHO for pH, TDS, conductivity, turbidity, and DO as shown in Table 2. In all samples, the properties of physical test were through an acceptable range except the value of conductivity that was more than the acceptable range and springs of Ain Hamran that were through acceptable range as shown in Table 2. Table 2 presents the results of evaluation parameters of spring water showing that TDS and electrical conductivity had higher values in the spring of Deribat compared to the turbidity value that had a lower value compared to the other springs of water. Also, TDS and electrical conductivity had lower values in spring of Himran compared to the turbidity value that had a higher value compared to the other springs of water. So, from the outcomes above, it appears that TDS is proportional with the electrical conductivity compared to the turbidity depending on the quality of chemical composition of solutes as shown in Table 2.

Table 2. Physiochemical parameters of water samples.

Springs of water	Density (gm/cm^3)	TDS (mg/L)	DO (mg/L)	Turbidity NTU	Conductivity µS/cm	pH
Ain Humran	0.999	391	8.09	1.94	791	8.08
Ain Deribat	0.944	523	7.086	0.16	1047	7.67
Ain Tobruk	1.0000	429	6.903	0.33	848	7.82
Ain Alnabi Ayoub	0.999	481	7.216	1.14	953	8.17
Ain Athom	0.9997	407	6.856	0.45	808	7.8
Ain Jrziz	0.999	463	7.68	1.13	931	7.69
Ain Sahlnot	0.999	427	7.736	0.34	879	7.42
Ain Razat	1.000	491	7.56	0.18	1015	7.49
WHO	1.000	300-800	7-10	≤ 5	200-800	6.5-8.5
Standard deviation	0.0196	45.39	0.442	0.633	93.691	0.261

OPTIMIZATION STUDY

Depending on World Health Organization (WHO) that represents the optimum chemical composition for healthy water to represent the objective function and trying to calculate the difference percentage between actual and optimum of WHO results as shown in Table 3 and Figure 2, springs of water of Ain Jarziz, Ain Deribat, Ain Razat, Ain Sahlnot, Ain Humran, Ain Tobruk, Ain Athom, and Ain Alnabi Ayoub represent first, second, third, fourth, fifth, sixth, seventh, and eighth optimum healthy springs of water, respectively.

Table 3. Average percentage difference between experimental results and optimum value of WHO.

	Springs of water								
Concentration of metals	**Ain Humran**	**Ain Deribat**	**Ain Tobruk**	**Ain Alnabi Ayoub**	**Ain Athom**	**Ain Jarziz**	**Ain Sahlnot**	**Ain Razat**	**WHO**
Mg^{+2}(mg/L)	0.5677	0.1748	0.4891	0.2141	0.0176	0.1748	0.332	0.2534	25.45
Zn^{+2}(mg/L)	0.9344	0.9342	0.9344	0.9344	0.9326	0.9342	0.9338	0.9344	5
Ca^{+2}(mg/L)	0.55	0.571	0.033	0.4333	0.3666	0.45	0.6346	0.6833	5
Na^{+1}(mg/L)	0.3	0.05	1.2	3.3	1.95	0.1	0.55	0.45	20
K^{+1}(mg/L)	0.648	0.5865	0.6326	0.6	0.7134	0.6673	0.6346	0.6173	5.2
Co(μg/L)	0.235	0.227	0.235	0.244	0.247	0.238	0.232	0.217	1
Mo(μg/L)	0.019	0.0493	0.0522	0.0582	0.0695	0.0903	0.0896	0.0966	10
Fe^{+2}(mg/L)	0.0066	0.0166	0.01	0.01	0.01	0.0033	0.0066	0.01	0.3
Mn(mg/L)	5.266	5.266	5.266	5.4	5.6	5.53	5.46	5.53	0.015
F^1(mg/L)	0.99	0.73	0.8	0.26	0.83	0.13	0.64	0.4	1
Cl^1(mg/L)	0.785	0.765	0.8125	0.8325	0.835	0.7875	0.7975	0.79	400
So_4^2(mg/L)	0.3866	0.2373	0.376	0.4266	0.2906	0.3493	0.328	0.3226	375
$Average\% \ difference = \frac{(Actual - WHO)}{WHO} 100$	0.88	0.8006	0.9034	1.0594	0.988	0.7878	0.886	0.858	0

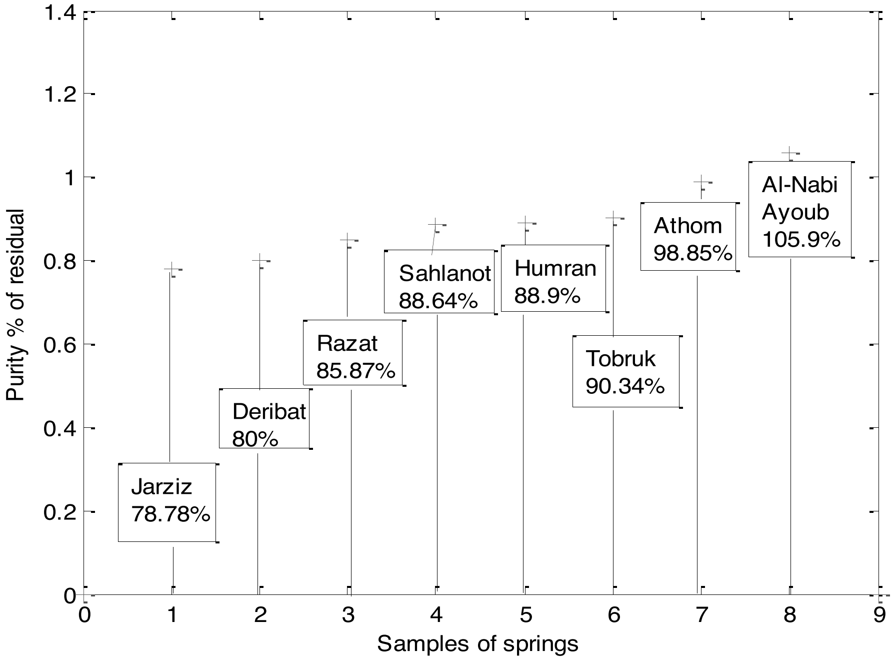

Figure 2. Comparison between purity % of springs of water and WHO to specify the optimization springs of water.

IDENTIFICATION SYSTEM FOR ACTUAL DATA

Depending on the outcomes of physical and chemical properties of spring water the quantity of total dissolved solids of organic and inorganic compounds has big effects on TDS, DO, and conductivity compared to turbidity. Turbidity depends on the quality of chemical composition of water. So, an identification system was employed to specify the effects of these six input elements on the turbidity as output for Cl^{-1}, So_4^{-2}, Ca^{+2}, Na^{+1}, Mg^{+2}, and K^{+1} to be equal to 99.52%, 75.4%, 92.548%, 95.346%, 98.011%, and 97.33 %, respectively, as shown in Figure 3 (Ahmmed et al., 2009). Tables 4 to 9 represent the details of identification system for Cl^{-1}, $So4^{-2}$, Ca^{+2}, Na^{+1}, Mg^{+2}, and K^{+1}, respectively. The final results of identification system are in good agreement with the results of higher value of turbidity due to the high concentrations of Cl^{-2} and Ca^{+2} of spring of Himran, which are 86 (mg/L) and 93 (mg/L), respectively. Ions of Cl^{-1} and Ca^{+2} have a big effect on turbidity, about 99.52% and 92.548%, respectively, to increase the turbidity. Turbidity value was lower for the spring of Deribat because the high concentration of So_4^{-2}, about 22 (mg/L), has lower effects on the turbidity of about 75.4%.

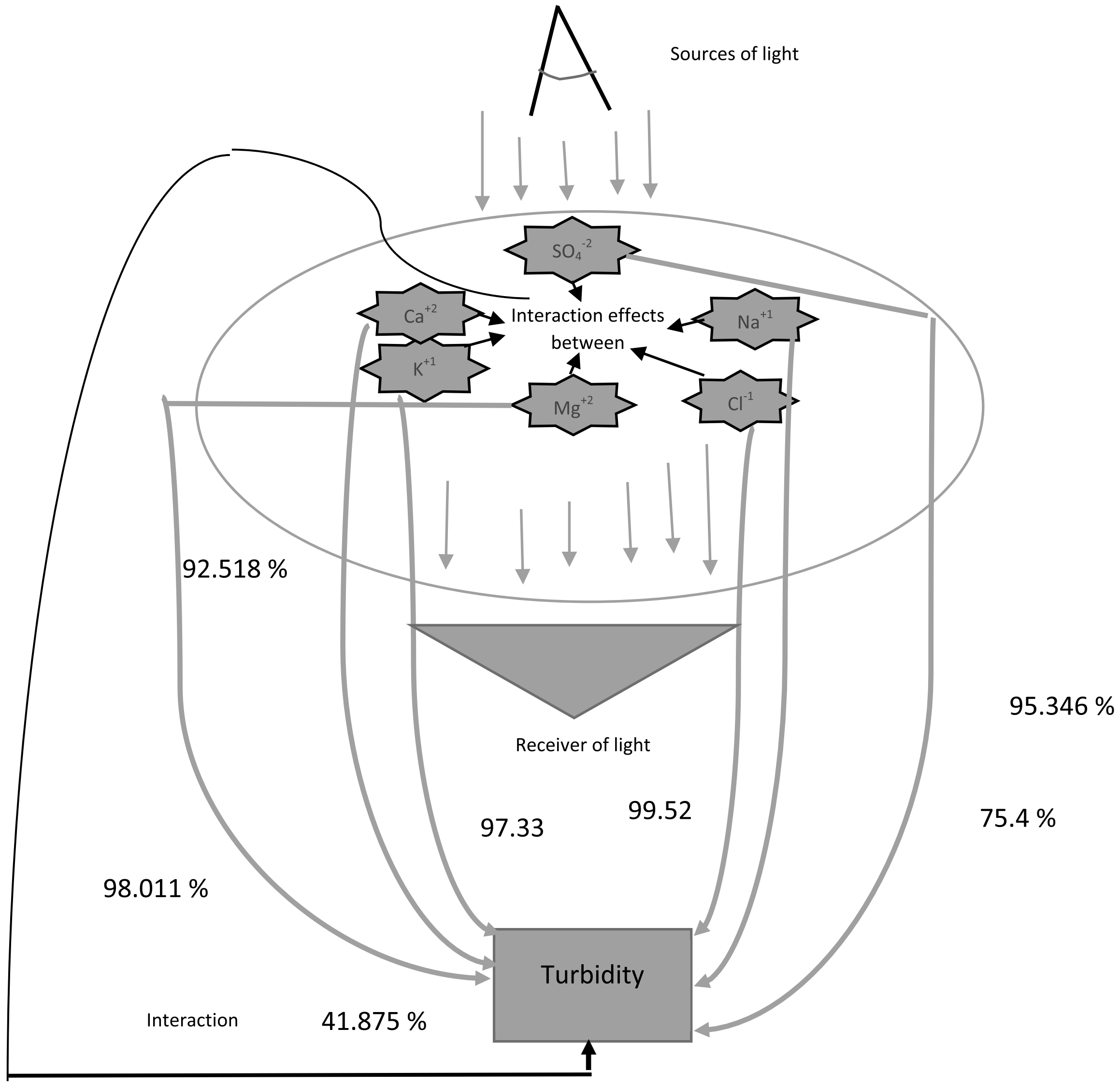

Figure 3. Identification system of water springs.

Table 4. Identification system of Cl^{-1} effects.

X_i,(Cl^{-1}) mg/l	$\|(X_i-X_n) / X_n\|$	Y_i (Turbidity)	$\|(Y_i-Y_n) / Y_n\|$	Slope
66	0.214	0.45	1.5	7.01
67	0.202	1.14	5.333	26.401
75	0.107	0.33	0.833	7.785
81	0.035	0.314	0.888	25.371
84	0	0.18	0	0
85	0.012	1.13	5.277	439.75
86	0.023	1.94	9.777	425.087
94	0.12	0.16	0.111	0.925
				Average slope=133.19

$$\theta = tan^{-1} Average\ slope = tan^{-1} 133.19 = \theta = 89.52^{o} \quad (1)$$

$$\%\ effect = \frac{\theta}{90^{o}} = \frac{89.52}{90} \times 100 = 99.52\%$$

Table 5. Identification system of SO_4^{-2} effects.

X_i,(SO_4) mg/l	$\|(X_i-X_n) / X_n\|$	Y_i (Turbidity)	$\|(Y_i-Y_n) / Y_n\|$	Slope
7	0.5	0.33	0.266	0.532
9	0.357	1.94	3.311	9.274
12	0.142	0.34	0.244	1.718
14	0	0.45	0	0
22	0.571	0.16	0.644	1.127
30	1.142	1.13	1.511	1.323
42	2	1.14	1.533	0.766
				Average slope=2.405

$$\theta = tan^{-1} Average\ slope = tan^{-1} 2.405 = \theta = 67.85^{o} \quad (2)$$

$$\%\ effect = \frac{\theta}{90^{o}} = \frac{67.85}{90} \times 100 = 75.4\%$$

Table 6. Identification system of Ca^{+2} effects.

X_i,(Ca^{+2}) mg/l	$\lvert(X_i-X_n) / X_n\rvert$	Y_i (Turbidity)	$\lvert(Y_i-Y_n) / Y_n\rvert$	Slope
38	0.59	0.48	0.75	1.271
62	0.33	0.33	0.83	2.515
86	0.07	1.14	0.41	2.857
87	0.06	1.13	0.41	6.833
93	0	1.94	0	0
98	0.05	0.34	0.82	16.4
99	0.06	0.16	0.91	15.166
101	0.08	0.18	0.9	11.25
				Average slope=8.47

$$\theta = tan^{-1}Average\ slope = tan^{-1}8.47 = \theta = 83.26^o \qquad (3)$$

$$\%\ effect = \frac{\theta}{90^o} = \frac{83.26}{90} \times 100 = 92.518\%$$

Table 7. Identification system of Na^{+1} effects.

X_i,(Na^{+1}) mg/l	$\lvert(X_i-X_n) / X_n\rvert$	Y_i (Turbidity)	$\lvert(Y_i-Y_n) / Y_n\rvert$	Slope
8	0.579	1.14	6.125	10.578
9	0.526	0.34	1.126	2.138
11	0.421	0.18	0.125	0.296
14	0.263	1.94	11.125	42.3
19	0	0.16	0	0
22	0.157	1.13	6.062	38.611
44	1.315	0.33	1.062	0.807
59	2.105	0.45	1.812	0.86
				Average slope=13.656

$$\theta = tan^{-1}Average\ slope = tan^{-1}13.656 = \theta = 85.812^o \qquad (4)$$

$$\%\ effect = \frac{\theta}{90^o} = \frac{85.812}{90} \times 100 = 95.346\%$$

Table 8. Identification system of Mg^{+2} effects.

X_i,(Mg^{+2}) mg/l	$\|(X_i-X_n) / X_n\|$	Y_i (Turbidity)	$\|(Y_i-Y_n) / Y_n\|$	Slope
11	0.421	1.94	9.777	23.223
13	0.315	0.33	0.833	2.644
17	0.105	0.34	0.888	8.457
19	0	0.18	0	0
20	0.052	1.14	5.333	102.557
21	0.105	1.13	5.277	50.257
25	0.315	0.45	1.5	4.762
				Average slope=32

$$\theta = tan^{-1} Average\ slope = tan^{-1} 32 = \theta = 88.21^{o} \quad (5)$$

$$\%\ effect = \frac{\theta}{90^{o}} = \frac{88.12}{90} \times 100 = 98.011\%$$

Table 9. Identification system of K^{+1} effects.

X_i,(K^{+1}) mg/l	$\|(X_i-X_n) / X_n\|$	Y_i (Turbidity)	$\|(Y_i-Y_n) / Y_n\|$	Slope
1.49	0.22	0.45	0.363	1.65
1.73	0.09	1.14	2.424	26.93
1.83	0.041	1.94	4.878	110
1.9	0.011	0.34	0.03	2.727
1.91	0	0.33	0	0
1.99	0.041	0.18	0.454	11.073
2.15	0.125	0.16	0.515	4.12
4.85	1.54	1.14	2.454	1.59
				Average slope=23.864

$$\theta = tan^{-1} Average\ slope = tan^{-1} 23.864 = \theta = 87.6^{o} \quad (6)$$

$$\%\ effect = \frac{\theta}{90^{o}} = \frac{87.6}{90} \times 100 = 97.33\%$$

CONCLUSION

1. The comparison between actual and WHO outcomes of physical and chemical properties leads to specifying the best healthy spring water as Ain Jarziz compared to Ain Al-Nabi Ayoub that represents the lowest healthy spring water.
2. Quality of chemical composition of organic and inorganic has big effects on turbidity.
3. Quantity of the chemical composition has active effects on TDS, DO, and electrical conductivity compared to turbidity.
4. The outcomes of this study using an identification system help researchers recognize and evaluate the relation between the quality of the chemical composition towards turbidity, TDS, DO, and electrical conductivity and create the mathematical relation between these parameters.

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