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Short Communication

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Hydrogeological characterization of the perennial spring "El Pozito" Northeast of the Juárez city mountain, Chihuahua, México

Abstract

"El Pozito" spring has been the source of consumption during 50 years by nearby communities of Juárez city, so it can be said that it is perennial. Therefore, two main aims justify the present research. Firstly; Its Physical-Chemical Characterization and Secondly, their hydrological behavior. First, two water samples were obtained, transported and analyzed in the Environmental Laboratory of the UACJ. One of them, was analyzed on April (P18-073) and the other on July of 2018 (P18-145). The results were;

a. According to Piper, the two samples were of the Sulphated-Calcic type.
b. In relation to dissolved solids both samples, were fresh water,
c. Hardness, both were very hard water.
d. According to Salinity Index, it is observed that the sample P18-073 belongs to the group C3-S2.

Which indicates that it is water with a high risk of salinization and a medium adsorption ratio, on the other hand, the sample P18-145 corresponds to the group C2-S2, showing a high risk of salinization and a medium adsorption ratio? Second, regarded to hydrological behavior, it can be seen that: evapotranspiration were higher than rainfall, so evapotranspiration influenced the discharge of the spring during the period from April to September. The discharge observed and the rainfall and temperatures were recorded (Table 1). Summarizing, the physical and chemical water characterization is associated with the rocks predominately limestone while the hydrological behavior is a consequence of arid climate.

Keywords: Spring, Perennial, Hydrogeological, Characterization, discharge, precipitation

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Introduction and research aims

The research aims are to assess water quality as well hydrogeological behavior of "El Pozito" spring. Therefore, Geological settings and quality water characterization models were performed. Geological settings were a key to understand the water origin as well its flow path: Traditional model such as: Physical-Chemical models of Piper; Total Solids Dissolved to assess; Hardness, Salinity and (SAR) Index for Agricultural purposes. Also, the hydrogeological behavior was assessed using the hydric balance between water discharge and hydrological cycle parameters such as: Rainfall, Temperature, True Evapotranspiration and discharge.

Study area location and main features

Ciudad Juárez, Chihuahua, northern México, is the southern continuation of New México and El Paso Texas. Its landscape is permeated by late Tertiary-Quaternary soils from southern USA to northern México (Figure 1A) Moreover, in a desert climate, there are few rainfall events mostly of high intensity and short duration, in average rainfall in the city is nearly 254 mm by year. Finally, El Pozito spring is located Northeast of Juárez Mountains (Figure 1).

Methods and results

Geological map, structural sections and climatic settings of the study area

The Pre-Neogene landscape in the region began from Laramide Orogeny occurring during Paleocene to Eocene time. Then, a synclinorium emerged. After that, four thrust sheets oriented slightly towards NW were developed in the study area (Figure 2A). Later, during the Eocene to Oligocene time, intrusive rocks, extrusive lavas, reverse, normal and oblique faults of the Basin and Range physiographic province were developed. Finally, these previous events were associated with block rotation throughout Chihuahua State, Juárez city, New México and El Paso Texas,[1] (Figure 2). Furthermore, during Miocene to Pleistocene time volcanism produced volcanic-ashes and mudflows**.** The geological map (Figure 2) was derived from Drewes & Dryer[1] and adapted with fieldwork to verify contacts between formations as; lithologies, structures, intrusive and extrusive rocks. Rock formations were grouped from older to younger as: (Kc=cuchillo, Kbe=Benigno, Kl=Lagrima, Kf=Finlay, Ksf=Supra Finlay and Tra=tertiary rhyolite and andesitic dikes. However, for simplicity's sake, a subgroup (Kdn=Del norte, Ka=Anapra, Kmv=Mesilla valley, Ksm=Smeltertown, Kmu=Muleros, Kdr=Del rio, Kbo=Boquillas and Tf=Tertiary felsite named Supra-Finlay (Ksf) was added. Also, Oligocene to Miocene (30-12 ma) and Miocene to Pliocene (12-5 ma) as well as the Upper Santa Fe Group from Pleistocene to Holocene time. In order to illustrate water source of el "Pozito spring" a sequence of figures are presented (Figure 3D & Figure 3E). Located on the Basin and Range geological province (Figure 2A), The Panteón stream normal fault (Figure 3C) is a key to understand the water source of el Pozito perennial spring. Moreover, there are an upper outcropping springs near a volcanic andesite dike with carbonaceous shale of Mesilla Valley formation (Kmv) in contact with Limestones of Benigno Formation (Kb).Therefore, a normal fault is located in these two locations (Figure 3D & Figure 3E). Summarizing, a future research related to the present is to assess the origin of "Ël Pozito Perennial spring". Then, models to find the trajectory of the underground water flow lines will be needed.

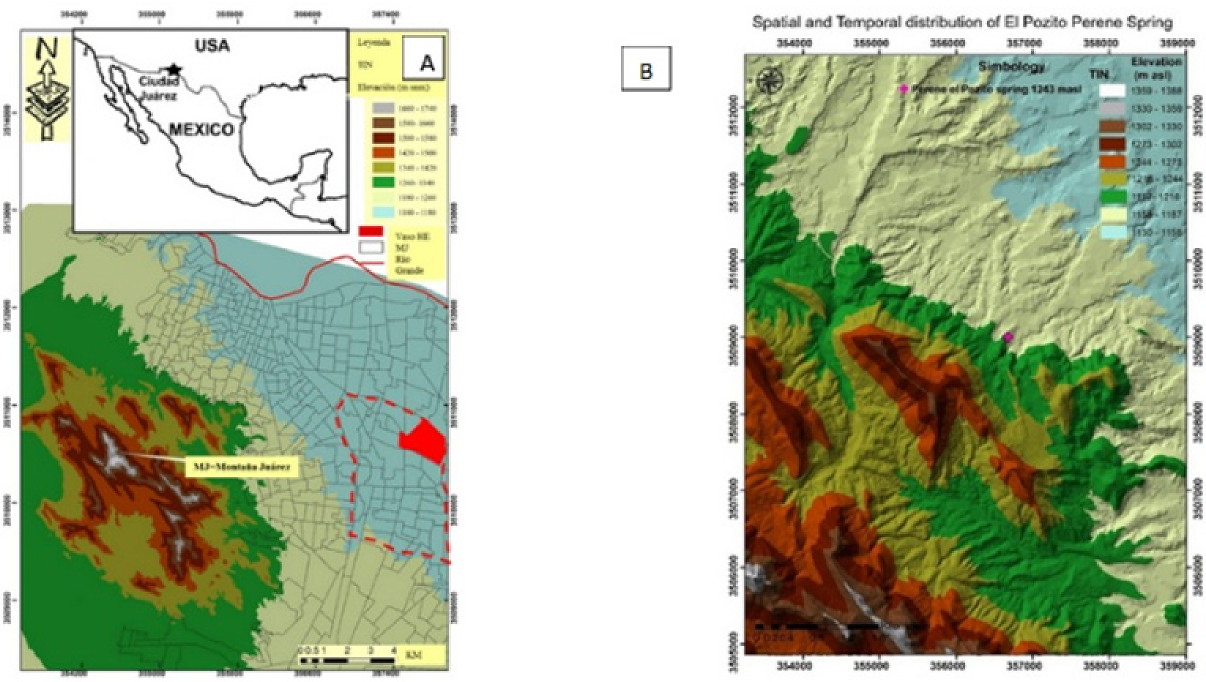

Figure 1 (A) Location of the study area: Digital elevation model (see legend on the upper right map); Streets network (gray lines) Bravo River also named (Rio Grande) red color line. UTM datum WGS 1984; (B) El Pozito Perennial spring (Magenta cross elevation 1243 masl (simbology masl) red line El Panteón perennial stream.

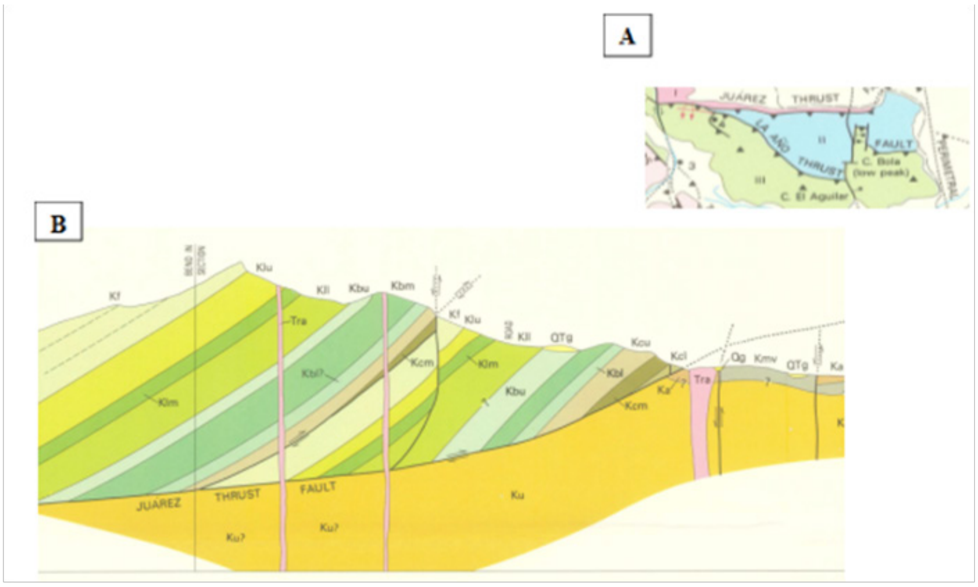

Figure 2 (A) Plant view of the northeast Juárez Mountain were two geological provinces were presented. Two nappes from older to younger: Juárez thrust (Kmv) in contact with (Kcu) and the año thrust fault (Kf) in contact with (Kcu) oriented nearly NW. (B) Sequence of normal faults of Basin and Range geological province nearly orthogonal to the napples. Geological cross section on the Panteon Stream indicated in Figure 2C. Source: Drewes & Dryer (1993).

Citation: león DZ, Zubia GAP, Reyes LCA, et al. Hydrogeological characterization of the perennial spring "El Pozito" Northeast of the Juárez city mountain, Chihuahua, México. *Int J Hydro.* 2018;2(6):737–742. DOI: 10.15406/ijh.2018.02.00151

Figure 3 Chronological sequences of pictures related to El Pozito perennial spring. (A) nappes inverse low angle thrust oriented NW. and normal faults of the Basin and Range geological province; (B) Upper intermittent spring, (E) Lower El Pozito perennial sping.

Hidrogeological results

Firstly, Turc model[5,6] were used to assess Evapotranspiration. Then, annual rainfall (104.85mm) and average temperature (25°C) were obtained (Table 1) from historical dates of regional meteorological stations from 10/2017 to 10/2018. Therefore using Turc model; True Evapotranspiration were (109.21 mm).

Table 1 Monthly rainfall and temperatures

Temperature (°C)			Rainfall (mm)	Date
max	mean	min.	monthly	
32	27	22	0	10/2017
26	20	13	11.43	11/2017
21	15	10	31.75	12/2017
20	15	10	0	01/2018
31	26	21	0	02/2018
30	22	15	6.35	03/2018
32	25	20	0	04/2018
36	31	26	0	05/2018
40	33	27	13.46	06/2018
40	32	27	16.56	07/2018
36	31	26	14.97	08/2018
35	30	22	10.33	09/2018

Spring discharge results

Result was measured from (12/04/2018 to 28/09/2018).Then, the behavior response is shown (Table 2).

Table 2 Spring Discharge filling time of a10 liters deposit

Day	Hour	Time (10 L)	Filled (10L/min)	Volume (10L/min)
12/04/18	16:15	2.0066	12.0396	4.98
16/04/18	12:49	2.0144	12.0864	4.96
24/04/18	12:32	2.0504	12.3024	4.88
06/05/18	12:36	2.0679	12.4074	4.84
14/05/18	15:24	2.1072	12.6432	4.75
22/05/18	19:24	2.1091	12.6546	4.74
28/05/18	19:33	2.1052	12.6312	4.75
04/06/18	17:33	2.2144	13.2864	4.52
19/06/18	12:45	2.3622	14.1732	4.23
24/06/18	19:19	2.3346	14.0076	4.28
30/06/18	14:35	2.4135	14.481	4.14
15/07/18	15:44	2.1389	12.8334	4.68
21/07/18	18:05	2.0348	12.2088	4.91
05/08/18	12:48	2.1309	12.7854	4.69
11/08/18	08:24	2.0899	12.5394	4.78
18/08/18	16:26	2.0563	12.3378	4.86
25/08/18	19:07	2.0828	12.4968	4.80
03/08/18	17:03	2.0732	12.4392	4.82
08/09/18	13:40	2.0687	12.4122	4.83
16/09/18	12:02	2.0009	12.0054	5.00
22/09/18	13:25	2.0103	12.0618	4.97
28/09/18	17:21	2.0002	12.0012	5.00
28/10/18	18:18	0.5744	5.744	10.45
11/11/18	12:31	0.5082	5.082	11.81

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Water quality results

Water samples were carried out in the Environmental Engineering Laboratory UACJ to obtain the values of Physical and Chemical parameters. The results obtained are shown in Table 3. Corresponding to the month of April and July consecutively. Then in order to asses Piper water Characteization translate to Meq/l was required (Table 3 & Table 4).

Table 3 Shown results of analyzes performed on water samples source: (UACJ)

Sample P18-073							
	Analyzed ions	**Concentration Mg/L**	**Molecular weight**	**Equivalent number**	**Concentration (meq/l)**	**Concentration**	
						%	**max**
Cations	Calcium (Ca^{2+})	194	40	2	9.70	73.37	
	Magnesium (Mg^{2+})	14.9	24.31	2	1.23	9.27	
	Sodium (Na^{+})	49.96	23	1	2.17	16.43	200
	Potassium (K^{+})	4.8	39	1	0.12	0.93	
				Total	13.22	100	
Aniones	Sulfhates (SO_4^{-2})	90	48	1	1.88	27.00	400
	Chlorides (Cl^{-1})	46	35.5	1	1.30	18.66	250
	Nitrates	2.23	62	1	0.04	0.52	
	Alcalinity (HCO3-)	228	61	1	3.74	53.82	
				Total	6.94	100.00	
Muestra P18-145							
	Analyzed ions	**Concentration Mg/L**	**Molecular *weight***	**Equivalent *number***	**Concentration (meq/l)**	**Concentration**	
						%	***max***
Cations	Calcium (Ca^{2+})	206	40	2	10.30	76.34	
	Magnesium (Mg^{2+})	14.9	24.31	2	1.23	9.09	
	Sodium (Na^{+})	42.4	23	1	1.84	13.66	200
	Potassium (K^{+})	4.8	39	1	0.12	0.91	
				Total	13.49	100.00	
Anions	Sulfates (SO_4^{-2})	85.4	48	1	1.78	21.34	400
	Chlorides (Cl^{-})	95	35.5	1	2.68	32.09	250
	Nitrates	1.92	62	1	0.03	0.37	
	Alcalinity (HCO_3^{-})	235	61	1	3.85	46.20	
				Total	8.34	100.00	

Table 4 Laboratory parameters of two samples

Parameter	**ID P18-073**	**ID P18045**	**Max. value**
Alcalinity (mg/L $CaCO_3$)	228	235	
Electric conductivity (μs/cm)	830	461	
Total hardness (mg/L $CaCO_3$)	288	298	500
Solids dissolved (mg/L)	459	460	1000
Chlorides (mg/L)	46	95	250
Nitrates (mg/L)	2,23	1,92	10
pH	7,75	8,06	6.5-8.5
Sulphates (mg/L)	90	85,4	400
Magnesium (mg/L)	<0,05	<0,05	
Calcium (mg/L)	194	206	
Potassium (mg/L)	<4,80	<4,80	
Sodium (mg/L)	49,96	42.4	200

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Discussion

Chemical quality for human use is good according to results given by Piper model.[2] However**,** According, with the comments in previous paragraphs, it is possible to typify the water taking into account the given on Table 5 & Table 6. Summarizing, we have that the sample P18-073 is classified in the (group 6e c2) and sample P18-145 was classified as (group 5e c2) Sulphated water (Figure 4). In addition, In order to express salinity, it will be measured through the Electrical Conductivity test, which according to Table 6 shows four degrees of salinity risk with the different types of water according to the electrical conductivity at 25ºC. In report shown in Table 4, it is observed that the variation of the total dissolved solids (TSD) in both samples is only 1 mg/l. This means that the presence of these concentrations of solids, whether they are suspended or dissolved in the water, cause physiological reactions harmful to humans. In this aspect, Davis & De Wiest,[2] and Wergner.[3] Classify water based on the distribution of dissolved solids. (Table 7) Classification according to the total dissolved solids. Summarizing, the type of water was classified according to the ranges in Table 7. In the case of this project, both samples are included in the Sweet water group Custodio & Llamas.[4] Classify water according to its hardness range, that is, the content of calcium carbonates ($CaCO_3$). Therefore, in this research only the degree of hardness in the samples was made. It was determined that in both cases the water is classified in the very hard group since it exceeds 180 mg/l of $CaCO_3$ (Table 8). Water interacts with minerals from rocks and soils. Then, salt dissolution is acquired as: Na; Ca and Mg. This, it is the case, of the area of the spring. (SAR index) that takes into account the concentration of soluble salts and is expressed by means of electrical conductivity and sodium concentration with respect to the concentration of calcium and magnesium (See equation 6). Results of electrical conductivity and concentrations are expressed in meq/L, which are indicated in Table 9. Finally, (Figure 5) shows irrigation water according to the Salinity Laboratory Staff[7] and SAR index for spring water. Concentrations are expressed in meq/L.

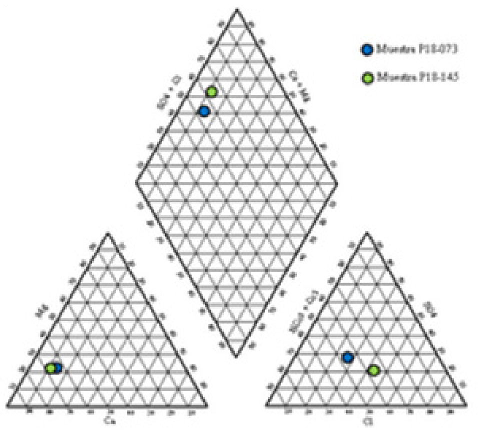

Figure 4 Piper Characterization of two samples.

Table 5 Results of types of water

Type	Anions		Cations
1	$rCl^->rSO_4^{-2}>rHCO_3^-$	a	$rNa^+>rMg^{+2}>rCa^{+2}$
2	$rCl^->rHCO_3^-> rSO_4^{-2}$	b	$rNa^+> rCa^{+2} >rMg^{+2}$
3	$rSO_4^{-2}>rCl^-> rHCO_3^-$	c	$rMg^{+2} >rNa^+> rCa^{+2}$
4	$rSO_4^{-2}> rHCO_3^->rCl^-$	d	$rMg^{+2}>rCa^{+2}>rNa^+$
5	$rHCO_3^->rCl^- >rSO_4^{-2}$	e	$rCa^{+2}>rNa^+ >rMg^{+2}$
6	$rHCO_3^->rSO_4^2>rCl^-$	f	$rCa^{+2}> rMg^{+2}>rNa^+$

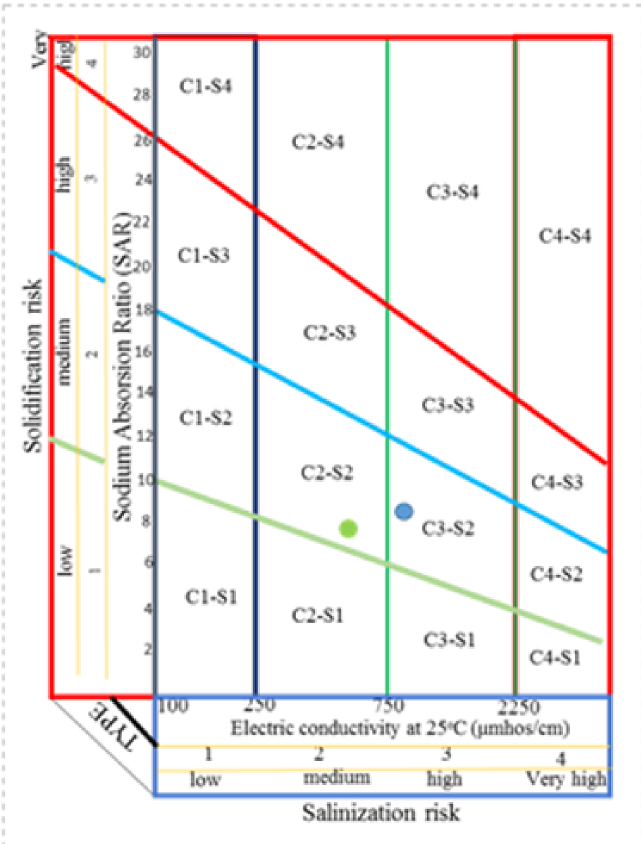

Figure 5 Type of water for Irrigation.

Table 6 Salinity in terms of electrical conductivity

Type	C.E. a 25ºC en (μ mhos/cm)
C1	0-250
C2	250-750
C3	750-2250
C4	>2250

Table 7 Water characterization of TSD

Classification	TSD in parts per milion
Sweet water	0-1000
Brackish water	1000-10000
Saltwater	10000-100000

Table 8 Classification in agree with hardness

Description	Hardness
Soft	0 a 60 mg/l de $CaCO_3$
Moderately hard	61 a 120 mg/l de $CaCO_3$
hard	121 a 180 mg/lt de $CaCO_3$
Very hard	Más de 180 mg/l de $CaCO_3$

Table 9 SAR index and C.E

Sample	C.E. (μ mhos/cm)	SAR (meq/l)
P18-073	830	0.929
P18-145	461	0.768

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Acknowledgments

None.

Conflicts of interest

The author declares that there is no conflict of interest.

References

1. Dyer J, Drewes H. Geologic map and structure sections of the Sierra de Juarez, Chihuahua, Mexico. *Ciudad Juarez: US Geological Survey*. 1993.
2. Davis SN, De Wiest R. *Hydrogeology*. Barcelona. 1971.
3. Wergner J. *Introduction to hydrogeology*. In: UANL. Linares: Faculty of Earth Sciences. 1996;1–101.
4. Custodio E, Llamas R. *Underground hydrology*. Barcelona: Editorial Omega. 2001.
5. Leon DZd. *Hydrogeology of the Huizachal Valley, Ciudad Victoria*. Tamaulipas: Master Degree Thesis. 2005.
6. Turc L. Formula for calculating the actual evaporation. *Materials*. 1954;1–15.
7. DOF. Standard that establishes water analysis - ph determination - test method. *NMX-AA-008-SCFI-2000*. 2000;1–36.
8. DOF. Standard that establishes water analysis - measurement of solids and dissolved salts in natural, residual and treated waste waters - test method. *NMX-AA-034-SCFI-2015*. 2015.
9. DOF. Standard that establishes water analysis - determination of acidity and alkalinity in natural, residual and treated waste waters - test method. *NMX-AA-036-SCFI-2001*. 2001;1–22.
10. DOF. Standard that establishes water analysis - determination of total chlorides in natural, residual and treated waste waters - test method. *NMX-AA-073-SCFI-2001*. 2001;1–18.
11. DOF. Standard that establishes water analysis - measurement of the sulphate ion in natural, residual and treated waste waters - test method. *NMX-AA-074-SCFI-2014*. 2014;1–13.
12. DOF. Standard that establishes water analysis - determination of electrolytic conductivity - test method. *NMX-AA-093-SCFI-2000*. 2000;1–27.