

Supplementary material

GIS, Multivariate Statistics Analysis and Health Risk Assessment of Water Supply Quality for Human Use in Central Mexico

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Table S1. The geographic location of municipalities in the eastern region of Michoacán-Mexico

Municipality name	Acronym	Geographical coordinates	M.A.S.L.
Zinapécuaro	ZIN	19° 52' 15" N; 100° 50' 06" W	2,463
Ciudad Hidalgo	HID	19° 41' 32" N; 100° 33' 26" W	2,060
San Pedro Jácharo	SPJ	19° 42' 52" N; 100° 38' 41" W	2,160
Maravatío	MAR	19° 53' 36" N; 100° 26' 34" W	2,020
Irimbo	IRI	19° 42' 00" N; 100° 28' 42" W	2,150
Zitácuaro	ZIT	19° 26' 17" N; 100° 21' 32" W	1,942
Tuxpan	TUX	19° 34' 00" N; 100° 27' 46" W	1,726

Table S2. Water quality parameters, methods and equipment used in laboratory determination [18]

Parameter	Analytical Method	Equipment
Turbidity	2130B. Nephelometric	HACH Turbidimeter 2100 ANIS
Color	2120C. Spectrophotometric	HACH Spectrophotometer DR 2800
Acidity	2310B. Titration	NA ^d
Alkalinity	2310B. Titration	NA ^d
Hardness	2340B. Calculated by Ca ⁺² and Mg ⁺²	NA ^d
COD ^a	5220D. Closed-reflux Colorimetric	HACH Digester DR 8200
BOD ^b	5210D. Respirometric	BOD analyzer Trak (HACH) with incubator
Cations/Anions: Li ⁺ , Na ⁺ , NH ₄ ⁺ , K ⁺ , Ca ⁺² , Mg ⁺² , F ⁻ , Cl ⁻ , NO ₂ ⁻ , Br ⁻ , NO ₃ ⁻ , PO ₄ ⁻³ , SO ₄ ⁻²	4110 B. (anions)/ASTM D 6919-03 (cations). Chromatographic: external standard method	Ion chromatograph, Metrohm 861. Advanced Compact Model with a conductivity detector
Metals and toxic elements: Ba, Cr, Fe, Cu, Zn, Cd, Al, Pb, As, Sb, Mn, Co, Ni, Se	3125B. ICP-MS ^c	Perkin Elmer ELAN 9000 ICP-MS ^c

^a COD: Chemical Oxygen Demand; ^b BOD: Biochemical Oxygen Demand; ^c ICP-MS: Inductively Coupled Plasma-Mass Spectrometry; ^d NA: No Applycate

Table S3. Negative effects on human health of parameters employed in the WQI.

Parameter	Effects on human health
pH¹	Below pH 4.0, induce redness and irritation of the eyes. Below pH 2.5, damage in epithelium is irreversible and extensive. Furthermore, pH can affect the degree of corrosion of metals as well as disinfection efficiency; it may have an indirect effect on health.
EC²	Electric conductivity have a relation with Total Dissolved Solids (TDS) or inorganic salts present in water. High levels of TDS may be objectionable to consumers owing to the resulting taste and to excessive scaling in water pipes, heaters, boilers, and household appliances. TDS in low concentrations could be unacceptable to consumers because of its flat, insipid taste; it is also often corrosive to water-supply systems.
Temperature³	Cool water is generally more palatable than warm water, and temperature will impact the acceptability of a number of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems (indirect effect on human health).
Sodium⁴	Acute effects may include nausea, vomiting, convulsions, muscular twitching and rigidity, and cerebral and pulmonary oedema. Aggravates chronic congestive heart failure, and ill effects due to high levels of sodium in drinking water. In infants induce severe gastrointestinal infections from fluid loss, leading to dehydration and raised sodium levels in the plasma (hypernatraemia); permanent neurological damage is common under such conditions.
Calcium^{5,6}	High calcium levels contribute to hard water. Hard water could provide an important supplementary contribution to total calcium intake. Inadequate intakes of calcium have been associated with increased risks of osteoporosis, nephrolithiasis (kidney stones), colorectal cancer, hypertension, etc.
Magnesium^{5,6}	High magnesium levels contribute to hard water. Hard water could provide an important supplementary contribution to total magnesium intake. Magnesium in high concentration (250 mg/L) can have a laxative effect.

	Low magnesium levels are associated with endothelial dysfunction, increased vascular reactions, decreased insulin sensitivity, hypertension, coronary heart disease, type 2 diabetes mellitus and metabolic syndrome.
Chloride⁷	Chloride toxicity has not been observed in humans except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure. Little is known about the effect of prolonged intake of large amounts of chloride in the diet. Hypertension associated with sodium chloride intake appears to be related to the sodium rather than the chloride ion.
Nitrate⁸	The exposure risk to nitrate is by their reduction in nitrite. Nitrate could induce methaemoglobinaemia, carcinogenicity, congenital malformations in some case, cardiovascular effects, and effect on thyroid function and goiter incidence.
Sulfate⁹	Cathartic effects in people consuming drinking water containing sulfate, dehydration are a common side-effect following the ingestion of large amounts of magnesium or sodium sulfate. Children, transients and the elderly are sensitive populations because of the potentially high risk of dehydration from diarrhea by high levels of sulfate in drinking water.
Chromium¹⁰	Acute tubular necrosis, <u>asthma</u> —allergen, sensitizer, bronchitis—acute, contact dermatitis—irritant, lung <u>cancer</u> , nasal polyps, nasal septal perforation, pneumonitis (hypersensitivity), rhinitis—allergic, skin ulceration, brain <u>cancer</u> —adult, chronic renal disease, etc.
Lead¹⁰	<u>Abnormal sperm (morphology, motility, and sperm count)</u> , acute tubular necrosis, hyperactivity, anemia (including hemolytic), behavioral problems, cataracts, chronic renal disease, <u>cognitive impairment (includes impaired learning, impaired memory, and decreased attention span/mental retardation/developmental delay)</u> , etc.
Arsenic¹⁰	<u>Angiosarcoma</u> (hepatic), arrhythmias, bladder <u>cancer</u> , contact dermatitis—irritant, <u>diabetes—Type II</u> , hearing loss, hyperkeratosis/hyperpigmentation, lung <u>cancer</u> , peripheral neuropathy, skin <u>cancer</u> (non-melanoma), skin ulceration, adult-onset <u>leukemias</u> , anemia (including hemolytic), aplastic anemia. Bronchitis—chronic, <u>cardiomyopathy</u> , cirrhosis, <u>congenital malformations—general</u> , <u>coronary artery disease (peripheral vascular disease, atherosclerosis)</u> , <u>fetotoxicity (miscarriage/spontaneous abortion, stillbirth)</u> , hepatocellular <u>cancer</u> (liver cancer), etc.
Manganese¹¹	The progressive increases in the manganese concentration in drinking water are associated with a progressively higher prevalence of neurological signs of chronic manganese poisoning and higher manganese concentrations in the hair of older persons.

¹WHO, 2003. *pH in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality*. World Health Organization (WHO). Originally published in *Guidelines for drinking-water quality*, 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva, 1996.

²WHO, 2003. *Total dissolved solids in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality*. World Health Organization (WHO). Originally published in *Guidelines for drinking-water quality*, 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva, 1996.

³WHO, 2011. *Guidelines for Drinking-water Quality*. World Health Organization (WHO). 4^a edition. ISBN 978 92 4 154815 1.

⁴WHO, 2003. *Sodium in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality*. World Health Organization (WHO). Originally published in *Guidelines for drinking-water quality*, 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva, 1996.

⁵WHO, 2009. *Calcium and Magnesium in Drinking-water: Public health significance*. World Health Organization (WHO). 1a edition. ISBN 978 92 4 156355 0.

⁶Sengupta, P. (2013). Potential health impacts of hard water. *International Journal of Preventive Medicine*. 4(8): 866-875.

⁷WHO, 2003. *Chloride in Drinking-water Background document for development WHO Guidelines for Drinking-water Quality*. World Health Organization (WHO). Originally published in *Guidelines for drinking-water quality*, 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva, 1996.

⁸WHO, 2011. *Nitrate and Nitrite in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality*. World Health Organization (WHO).

⁹WHO, 2004. *Sulfate in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality*. World Health Organization (WHO).

¹⁰<https://www.healthandenvironment.org/environmental-health/environmental-risks/global-environment/water-quality>

¹¹WHO, 2010. *Aluminium in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality*. World Health Organization (WHO).

Table S4. Descriptive statistics for water quality parameters during dry season

		ZIN			HID			SPJ			MAR			IRI			ZIT			TUX	
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
pH	8	7.23	0.24	17	7.25	0.34	13	5.35	0.90	5	6.71	0.21	6	6.60	0.12	9	6.59	0.11	10	6.69	0.21
EC	8	286.75	179.62	17	216.06	108.71	13	272.45	110.25	5	255.60	13.01	6	198.33	33.57	9	211.89	64.22	10	265.70	157.96
Temperature	8	26.69	5.18	17	19.14	2.15	13	18.04	3.05	5	23.56	2.14	6	20.45	2.06	9	19.96	1.00	10	19.57	1.51
TDS	8	142.50	88.68	17	108.06	54.23	13	137.08	54.40	5	127.60	6.47	6	99.17	16.75	9	105.89	32.00	10	146.80	87.88
DO	8	4.46	1.28	17	5.41	1.16	13	ND	--	5	4.88	0.75	6	4.16	0.45	9	5.75	1.82	10	5.90	2.00
Turbidity	8	0.33	0.26	17	0.65	0.61	13	0.64	0.68	5	0.29	0.32	6	3.17	2.91	9	1.61	1.02	10	6.87	15.47
Color	8	16.75	17.21	15	7.87	5.57	13	9.00	10.74	4	2.50	1.73	6	24.50	20.75	9	10.00	4.03	10	29.70	37.15
Acidity	8	9.42	3.99	17	8.13	5.83	13	27.31	19.22	5	5.06	1.77	6	3.24	1.26	9	3.62	1.32	10	4.26	1.69
Alkalinity	8	102.18	36.35	17	110.88	55.05	13	128.46	48.28	5	125.50	8.02	6	79.67	27.59	9	91.72	27.86	10	132.26	95.29
Hardness	8	66.41	45.46	17	91.57	51.70	13	ND	--	5	81.55	2.54	6	65.04	10.53	9	84.08	22.84	10	121.87	74.11
COD	8	3.96	3.20	2	2.85	3.18	8	33.40	85.85	5	B.D.L.	--	3	1.27	1.42	9	3.18	1.49	10	3.32	2.52
BOD ₅	8	ND	--	17	ND	--	1	5.20	--	5	B.D.L.	--	6	B.D.L.	--	0	B.D.L.	--	1	2.20	--
Li ⁺	8	B.D.L.	--	17	B.D.L.	--	13	B.D.L.	--	5	B.D.L.	--	6	B.D.L.	--	9	B.D.L.	--	10	B.D.L.	--
Na ⁺	8	27.22	13.68	17	14.47	5.22	13	21.20	9.02	5	19.02	1.95	6	12.14	3.14	9	11.86	4.93	10	15.36	12.72
NH ₄ ⁺	8	B.D.L.		17	B.D.L.	--	13	ND	--	5	B.D.L.	--	6	B.D.L.	--	9	B.D.L.	--	10	B.D.L.	
K ⁺	8	10.38	11.80	17	4.19	2.42	13	9.55	3.88	5	4.41	1.05	6	3.65	1.07	9	3.43	1.16	10	3.26	1.33
Ca ⁺²	8	13.97	13.28	17	15.92	9.64	13	15.34	8.58	5	10.93	1.43	6	11.94	1.80	9	17.19	5.15	10	26.39	13.87
Mg ⁺²	8	7.65	3.11	17	12.59	7.46	13	12.09	8.24	5	13.18	0.65	6	8.56	1.70	9	9.99	2.49	10	13.59	11.89
F ⁻	1	0.35	--	17	B.D.L.		13	ND	--	5	B.D.L.	--	6	B.D.L.	--	9	B.D.L.	--	10	B.D.L.	--
Cl ⁻	8	7.87	12.10	17	3.45	4.11	13	3.60	4.64	5	2.37	0.48	6	1.40	0.62	9	4.83	4.55	10	2.37	1.34
NO ₂ ⁻	8	B.D.L.	--	17	B.D.L.	--	13	ND	--	5	B.D.L.	--	6	B.D.L.	--	9	B.D.L.	--	10	B.D.L.	--
Br ⁻	8	B.D.L.	--	17	B.D.L.	--	13	ND	--	5	B.D.L.	--	6	B.D.L.	--	9	B.D.L.	--	10	B.D.L.	--
NO ₃ ⁻	8	19.67	36.82	17	9.63	12.59	13	ND	--	5	4.96	2.03	6	6.28	5.55	9	11.05	9.84	10	6.30	8.18
PO ₄ ⁻	2	1.06	0.55	2	0.45	0.01	13	ND	--	5	B.D.L.	--	6	B.D.L.	--	9	B.L.D.	--	10	B.D.L.	--
SO ₄ ⁺²	7	16.05	12.43	17	8.44	9.45	12	27.12	15.88	5	5.04	1.39	6	16.24	14.75	9	8.75	6.06	7	35.54	33.09
Ba	8	17.43	28.00	17	18.61	28.69	4	0.02	0.01	5	18.89	6.53	6	19.40	11.75	9	23.61	38.72	10	31.99	52.02
Cr	8	0.29	0.16	17	0.30	0.12	13	B.D.L.	--	5	0.82	0.08	6	1.35	1.94	9	1.59	0.61	10	2.39	1.32
Fe	1	0.10	--	3	0.08	0.04	13	0.12	0.21	5	ND	--	6	ND	--	9	64.38	21.22	10	223.39	373.70
Cu	8	0.93	1.14	17	0.43	0.33	13	B.D.L.	--	4	0.25	0.18	6	0.33	0.30	9	1.37	1.11	10	1.76	1.49
Zn	6	7.04	10.70	9	31.93	76.44	2	0.02	0.01	1	0.69	--	3	0.82	0.79	9	2.29	1.30	10	26.46	73.77
Cd	7	0.01	0.01	16	0.01	0.01	13	B.D.L.	--	5	0.003	0.002	5	0.002	0.001	8	0.004	0.002	9	0.19	0.55
Al	8	B.D.L.	--	1	1.10	--	3	1.07	0.85	5	B.D.L.	--	6	B.D.L.	--	8	1.01	1.47	10	165.87	515.21
Pb	7	0.02	0.01	17	0.02	0.02	13	B.D.L.	--	5	0.02	0.004	6	0.03	0.02	2	0.02	0.01	1	15.31	--
As	8	19.68	17.04	16	2.60	1.88	13	B.D.L.	--	5	1.08	0.27	4	0.68	0.90	9	0.85	0.65	10	1.40	1.96
Sb	8	0.12	0.14	13	0.02	0.02	14	B.D.L.	--	5	0.01	0.002	4	0.02	0.02	8	0.07	0.04	9	0.11	0.21
Mn	8	0.12	0.14	13	0.02	0.02	2	0.14	0.00	5	0.01	0.002	4	0.02	0.02	9	1.99	2.79	10	110.85	325.62
Co	4	1.19	2.25	14	8.76	28.74	13	B.D.L.	--	2	0.47	0.33	5	0.39	0.70	9	0.05	0.05	10	0.11	0.20
Ni	5	0.09	0.13	17	0.06	0.05	13	B.D.L.	--	5	0.01	0.005	6	0.04	0.03	9	0.78	0.33	10	1.26	0.65
Se	8	0.55	0.63	17	0.59	0.67	13	B.D.L.	--	5	0.42	0.22	6	0.40	0.29	8	0.33	0.21	8	0.29	0.18

Table S5. Descriptive statistics for water quality parameters during rainy season

		ZIN			HID			SPJ			MAR			IRI			ZIT			TUX	
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
pH	8	6.72	0.16	14	6.91	0.33	7	6.31	1.12	5	7.03	0.29	6	7.14	0.34	9	7.23	0.52	10	7.11	0.42
EC	8	268.38	160.53	14	238.29	109.98	7	186.86	126.42	5	245.40	11.97	6	211.83	56.08	9	208.67	62.70	10	291.40	151.17
Temperature	8	26.15	5.27	14	20.28	2.11	7	19.85	3.68	5	23.40	2.49	6	20.63	1.42	9	18.71	1.28	10	19.56	1.42
TDS	8	134.25	80.35	14	119.29	54.93	7	93.57	63.18	5	122.80	6.18	6	87.50	45.91	9	104.11	31.25	10	145.70	75.64
DO	8	2.96	0.81	14	3.27	1.06	7	5.20	1.11	5	3.34	0.45	6	4.31	0.39	9	5.80	1.20	10	3.22	1.03
Turbidity	8	1.18	1.52	14	0.74	0.97	7	22.07	35.67	5	0.44	0.65	6	11.42	16.94	9	0.44	0.41	10	0.64	0.85
Color	7	11.29	9.98	8	5.25	6.10	5	40.40	47.60	3	5.83	6.66	5	104.80	103.53	9	11.83	19.07	9	4.61	5.34
Acidity	8	31.09	16.45	14	14.81	4.20	7	20.43	25.50	5	33.85	7.66	6	7.95	2.89	9	14.96	2.80	10	17.64	5.70
Alkalinity	8	84.12	46.05	14	121.17	65.21	6	89.87	72.29	5	130.94	8.04	6	88.60	34.71	9	107.00	24.91	10	150.02	93.48
Hardness	8	65.08	46.17	14	93.62	53.04	5	108.89	74.44	5	94.63	7.30	5	54.48	44.43	9	88.30	23.49	10	128.74	72.19
COD	7	13.20	17.08	14	2.73	1.63	7	7.79	5.15	4	1.93	1.51	6	3.63	2.61	9	3.72	1.48	10	2.87	1.00
BOD ₅	3	10.85	11.84	14	B.D.L.	--	3	0.67	0.47	5	ND	--	6	B.D.L.	--	9	B.D.L.	--	10	N.D.	--
Li ⁺	8	B.D.L.	--	14	B.D.L.	--	1	0.16	--	5	B.D.L.	--	6	B.D.L.	--	9	B.D.L.	--	10	B.D.L.	--
Na ⁺	8	28.33	13.27	14	15.55	6.60	6	22.59	12.88	5	20.36	1.84	4	13.60	6.48	9	12.27	4.54	10	16.86	12.16
NH ₄ ⁺	8	ND	--	14	ND	--	7	B.D.L.	--	5	ND	--	1	6.02	--	1	0.18	--	2	0.17	0.19
K ⁺	5	12.34	10.13	14	3.18	1.53	6	10.83	5.40	3	3.90	0.85	5	6.08	6.39	9	2.25	0.97	10	2.06	1.07
Ca ⁺²	8	13.96	13.48	14	15.21	8.81	6	16.47	11.59	5	12.89	2.38	5	12.00	5.35	9	16.85	5.19	10	26.01	12.53
Mg ⁺²	8	7.34	3.17	14	13.51	8.12	5	15.03	11.26	5	15.16	1.05	5	10.01	5.09	9	10.57	2.73	10	15.49	11.66
F ⁻	8	0.30	0.11	12	0.12	0.03	1	0.22	--	5	0.26	0.02	6	B.D.L.	--	9	B.D.L.	--	6	0.13	0.04
Cl ⁻	8	9.81	15.02	14	2.91	3.62	7	4.44	8.69	5	2.96	0.79	3	2.90	3.47	9	4.68	4.61	10	1.96	1.37
NO ₂ ⁻	8	B.D.L.	--	14	ND	--	7	ND	--	5	B.L.D.	--	6	B.D.L.	--	9	B.D.L.	--	10	B.D.L.	--
Br ⁻	8	B.D.L.	--	14	ND	--	7	ND	--	5	B.L.D.	--	6	B.L.D.	--	90	B.D.L.	--	10	N.D.	--
NO ₃ ⁻	8	23.12	47.53	14	8.30	11.88	5	0.61	0.36	5	6.30	3.03	5	7.21	6.00	9	12.50	12.46	10	9.63	10.38
PO ₄ ⁻	2	3.66	2.91	14	B.D.L.	--	7	B.D.L.	--	5	B.L.D.	--	6	B.D.L.	--	9	B.D.L.	--	10	B.D.L.	--
SO ₄ ⁺²	8	22.86	19.97	12	8.69	9.50	7	21.91	19.45	5	7.22	1.47	6	17.52	23.35	9	10.04	7.85	10	20.59	26.62
Ba	8	34.99	77.30	14	33.73	64.71	7	10.89	7.94	5	18.88	6.16	6	25.14	11.84	9	28.33	47.85	10	39.38	60.60
Cr	8	2.95	2.37	14	7.15	6.34	7	13.52	16.48	5	6.57	2.23	6	10.08	3.42	9	9.05	2.58	10	11.27	6.29
Fe	8	231.46	273.26	14	143.55	79.64	7	356.48	452.90	5	67.11	23.60	6	2131.08	3695.47	9	142.40	161.25	10	203.06	177.10
Cu	8	2.78	2.49	14	5.20	8.92	7	1.53	1.56	5	1.64	0.42	6	2.02	0.86	9	2.00	1.10	10	2.00	1.08
Zn	8	5.72	4.78	14	8.84	17.37	7	3.95	3.91	5	1.90	0.37	6	3.34	2.35	9	2.66	1.85	10	8.32	19.65
Cd	8	0.03	0.03	13	0.005	0.003	6	0.01	0.005	5	0.004	0.002	6	0.004	0.004	8	0.005	0.002	8	0.005	0.005
Al	8	290.24	360.99	14	214.31	385.26	7	2386.59	2989.09	5	23.67	27.12	5	3163.04	5436.37	9	60.24	95.34	10	152.55	294.87
Pb	8	0.28	0.18	14	0.46	0.67	6	0.29	0.26	3	0.17	0.16	6	0.40	0.55	9	0.13	0.10	8	0.15	0.19
As	8	17.75	15.76	14	2.94	1.79	7	8.67	7.57	5	1.35	0.30	6	0.81	0.84	9	0.96	0.75	10	1.05	1.27
Sb	8	0.19	0.19	14	0.03	0.01	7	0.16	0.35	5	0.03	0.004	6	0.04	0.02	9	0.07	0.04	10	0.03	0.02
Mn	8	7.02	17.44	14	24.18	84.43	7	43.15	99.77	5	0.84	0.77	6	6.20	9.76	9	4.78	6.65	10	2.44	5.31
Co	8	0.10	0.15	14	0.06	0.04	7	0.13	0.16	5	0.03	0.01	6	0.23	0.28	9	0.07	0.06	10	0.06	0.02
Ni	8	2.22	2.82	14	1.05	0.50	7	0.95	0.64	5	0.69	0.15	6	1.13	0.70	9	0.83	0.39	10	1.26	0.51
Se	8	0.17	0.14	14	0.22	0.22	5	0.15	0.07	5	0.17	0.03	4	0.26	0.09	9	0.52	0.62	7	0.32	0.14

Table S6. Factor loadings of the study parameters in dry season with PCA

Parameter	Principal Component							
	1	2	3	4	5	6	7	8
pH	-0.186	-0.028	0.059	0.103	0.063	-0.904*	0.076	-0.094
EC	0.929*	0.027	-0.132	0.166	0.134	0.067	0.121	-0.000
Temperature	0.200	-0.077	-0.019	0.837*	-0.047	-0.166	0.177	-0.148
TDS	0.948*	0.050	-0.089	0.174	0.129	0.073	0.110	0.017
Turbidity	-0.038	0.188	0.177	-0.308	-0.088	0.022	0.098	0.788*
Color	-0.158	0.328	0.102	-0.011	0.049	0.074	-0.051	0.724*
Acidity	0.203	0.227	-0.658**	0.061	0.060	0.428	0.093	-0.212
Alkalinity	0.792*	-0.011	-0.008	0.291	-0.139	0.173	0.031	-0.310
Hardness	0.964*	0.038	0.101	-0.077	-0.079	0.022	-0.012	-0.087
COD	-0.049	0.656**	0.123	0.196	0.217	0.332	0.149	0.353
Na ⁺	0.697**	-0.032	-0.350	0.387	0.215	0.051	0.203	-0.096
K ⁺	0.628**	0.032	-0.493	0.028	0.424	0.219	0.086	-0.015
Ca ²⁺	0.903*	0.192	0.189	-0.141	0.011	0.035	0.047	0.028
Mg ²⁺	0.907*	-0.107	-0.001	-0.008	-0.147	0.009	-0.082	-0.199
Cl ⁻	0.537**	0.203	-0.018	-0.067	0.622**	-0.275	0.131	0.202
SO ₄ ²⁻	0.631**	-0.124	-0.191	-0.306	0.291	0.040	0.186	0.262
Ba	0.542**	0.239	-0.012	0.022	0.255	-0.078	-0.151	0.456
Cr	0.113	0.015	0.852*	0.101	-0.142	-0.034	0.056	0.169
Fe	0.087	0.432	0.801*	-0.159	-0.061	0.034	0.145	0.164
Cu	0.201	0.727**	0.012	-0.342	0.090	-0.018	0.175	0.054
Zn	-0.045	0.793*	0.112	0.011	0.005	-0.030	-0.020	0.186
Cd	0.361	0.422	-0.231	0.113	-0.382	0.147	0.378	0.316
Al	-0.049	0.452	0.514**	-0.213	-0.212	0.136	0.295	0.326
Pb	0.065	-0.180	-0.789*	0.023	-0.346	-0.051	0.050	0.219
As	0.296	0.015	-0.217	0.168	-0.135	0.079	0.681**	-0.414
Sb	0.001	0.124	0.251	0.132	0.204	-0.154	0.777*	0.153
Mn	0.277	0.596**	0.188	-0.002	-0.477	-0.154	-0.169	0.108
Co	0.543**	0.1827	0.143	-0.543**	-0.039	-0.356	-0.103	0.233
Ni	0.766*	0.275	0.186	-0.157	-0.171	0.052	0.166	0.079
Se	0.307	0.431	0.389	-0.138	0.000	0.321	0.393	0.118
Eigenvalues ^a	8.889	5.772	2.574	2.226	1.689	1.289	1.091	1.024
Total variance (%)	29.630	19.240	8.582	7.420	5.632	4.297	3.638	3.416
Accumulated variance (%)	29.630	48.871	57.452	64.872	70.504	74.800	78.439	81.855

* Loadings with p<0.05, **No significant but moderate loadings. ^a>1

Table S7. Factor loadings of the study parameters in rainy season with PCA

Parameter	Principal Component							
	1	2	3	4	5	6	7	8
pH	-0.109	-0.055	-0.633**	-0.155	-0.208	0.106	-0.008	0.366
EC	0.292	0.142	0.340	-0.037	0.803*	0.134	0.062	0.134
Temperature	0.002	-0.136	0.840*	-0.120	0.042	0.175	0.165	0.041
TDS	0.228	0.042	0.246	0.002	0.753*	0.162	0.027	-0.074
DO	-0.173	-0.009	-0.734**	0.156	-0.207	0.028	0.053	-0.014
Turbidity	-0.160	0.671**	0.004	0.467	-0.362	-0.069	-0.001	0.031
Color	-0.176	0.554**	-0.318	0.106	-0.159	0.161	-0.019	-0.191
Acidity	0.303	-0.275	0.269	-0.331	0.441	0.097	-0.073	-0.442
Alkalinity	0.337	-0.077	0.052	-0.065	0.643**	-0.297	0.147	-0.017
Hardness	0.937*	-0.075	0.090	-0.056	0.259	-0.017	-0.005	0.085
COD	0.096	0.238	-0.031	0.703**	0.013	0.199	0.025	0.265
Na ⁺	0.823*	-0.064	0.294	-0.145	-0.023	0.247	0.098	-0.178
K ⁺	0.456	0.245	-0.073	0.549**	0.241	0.066	-0.057	0.038
Ca ²⁺	0.934*	-0.059	0.004	-0.023	0.249	0.059	-0.045	0.057
Mg ²⁺	0.919*	-0.113	0.154	-0.056	0.210	-0.088	0.035	0.074
Cl ⁻	0.312	-0.296	-0.079	0.170	0.528**	0.504	-0.113	-0.261
NO ₃ ⁻	0.298	0.029	-0.164	-0.612**	0.270	0.295	-0.090	0.016
SO ₄ ²⁻	0.447	0.445	0.079	0.034	0.188	0.370	-0.222	-0.009
Ba	0.170	0.431	-0.333	-0.055	0.619**	0.093	0.250	0.080
Cr	0.164	0.029	-0.108	0.071	0.102	-0.096	-0.240	0.667**
Fe	-0.147	0.857*	0.118	0.136	-0.138	0.010	0.190	0.204
Cu	0.090	-0.069	0.101	-0.146	0.280	-0.005	0.700**	0.160
Zn	0.044	0.118	0.121	0.004	0.154	-0.108	0.799*	-0.269
Cd	0.066	0.359	0.410	0.013	0.318	0.468	0.221	-0.191
Al	-0.420	0.070	-0.029	0.654**	-0.075	0.087	-0.090	-0.158
Pb	-0.133	0.196	0.035	0.080	-0.282	0.148	0.651**	-0.119
As	0.180	-0.061	0.784*	0.359	-0.035	0.312	0.135	-0.115
Sb	0.046	0.205	0.143	0.077	0.015	0.850*	0.036	-0.052
Mn	0.024	0.549**	-0.129	0.248	0.073	0.016	0.498	-0.140
Co	-0.055	0.877*	-0.098	0.058	0.240	0.146	0.066	0.102
Ni	0.172	0.547**	0.182	-0.160	0.441	-0.130	0.019	-0.320
Se	-0.048	-0.235	0.183	-0.111	0.581**	0.495	-0.022	0.232
Eigenvalues ^a	7.623	4.786	3.091	2.347	2.056	1.482	1.421	1.192
Total variance (%)	23.82	14.955	9.660	7.333	6.425	4.630	4.440	3.726
Accumulated variance (%)	23.82	38.778	48.437	55.771	62.196	66.826	71.265	74.991

* Loadings with p<0.05, **No significant but moderate loadings. ^a>1

Table S8. Correlation matrix (rs) between the physicochemical characterization variables of drinking water supply in the dry season considering total sampling sites

	pH	Cond	Temp	TDS	DO	Turb	Color	Acid	Alkal	Hardness	C.O.D.	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	NO ₃ ⁻	SO ₄ ²⁻	Ba	Cr	Fe	Cu	Zn	Cd	Al	Pb	As	Sb	Mn	Co	Ni	Se
pH																																
Cond	-0.08																															
Temp	-0.16	0.60																														
TDS	-0.08	1.00	0.61																													
DO	0.24	-0.42	-0.53	-0.41																												
Turb	-0.10	-0.17	-0.37	-0.19	-0.04																											
Color	-0.08	-0.24	-0.28	-0.24	-0.04	0.51																										
Acid	0.28	0.44	0.25	0.43	-0.11	-0.20	-0.05																									
Alkal	0.01	0.79	0.62	0.78	-0.31	-0.45	-0.52	0.36																								
Hardness	-0.12	0.74	0.26	0.74	-0.21	-0.18	-0.48	0.28	0.79																							
COD	0.01	0.29	0.34	0.31	-0.42	0.05	0.38	0.26	-0.02	-0.18																						
Na ⁺	0.15	0.87	0.70	0.86	-0.42	-0.23	-0.21	0.53	0.70	0.47	0.41																					
K ⁺	-0.09	0.83	0.37	0.84	-0.28	-0.04	-0.06	0.42	0.61	0.58	0.29	0.70																				
Ca ²⁺	-0.11	0.72	0.24	0.73	-0.31	-0.10	-0.28	0.29	0.68	0.87	0.02	0.47	0.64																			
Mg ²⁺	-0.09	0.70	0.26	0.70	-0.11	-0.21	-0.53	0.24	0.79	0.97	-0.24	0.45	0.52	0.78																		
Cl ⁻	0.08	0.60	0.19	0.61	-0.11	0.10	-0.04	0.25	0.28	0.43	0.21	0.54	0.60	0.35	0.41																	
NO ₃ ⁻	-0.21	0.24	-0.21	0.24	0.07	0.20	0.09	0.03	-0.02	0.29	-0.03	0.08	0.39	0.27	0.25	0.59																
SO ₄ ²⁻	-0.02	0.45	-0.04	0.46	-0.15	0.38	0.32	0.23	0.01	0.22	0.31	0.40	0.63	0.32	0.19	0.65	0.48															
Ba	-0.27	0.58	0.09	0.57	-0.33	0.23	0.09	0.00	0.26	0.49	-0.04	0.32	0.55	0.45	0.43	0.62	0.61	0.42														
Cr	-0.39	-0.10	0.25	-0.10	-0.19	-0.23	-0.29	-0.35	0.11	-0.01	-0.41	-0.08	-0.09	-0.12	0.00	-0.10	0.08	-0.27	0.13													
Fe	0.17	-0.12	0.01	-0.12	0.11	-0.37	-0.25	0.30	-0.05	0.01	-0.10	0.01	-0.24	0.02	-0.01	-0.12	-0.22	-0.14	-0.25	-0.13												
Cu	0.17	0.39	-0.01	0.38	-0.27	0.09	0.02	0.27	0.13	0.26	0.39	0.38	0.23	0.37	0.20	0.42	0.29	0.27	0.28	-0.43	0.03											
Zn	0.15	-0.12	-0.10	-0.12	-0.01	0.10	0.26	-0.01	-0.19	-0.29	0.35	-0.05	-0.16	-0.26	-0.26	-0.03	-0.13	-0.14	-0.04	-0.37	-0.10	0.35										
Cd	-0.16	0.40	0.33	0.39	-0.31	0.13	-0.04	0.13	0.23	0.23	0.29	0.33	0.17	0.16	0.21	0.10	0.04	-0.05	0.23	-0.25	-0.32	0.37	0.23									
Al	0.24	-0.22	-0.27	-0.24	0.12	0.19	0.04	-0.09	-0.19	-0.19	-0.12	-0.19	-0.25	-0.22	-0.15	-0.20	-0.09	-0.14	-0.09	-0.02	-0.06	0.09	0.30	0.18								
Pb	0.01	0.17	0.00	0.14	-0.10	0.16	-0.05	-0.13	0.01	0.17	-0.07	0.05	-0.01	0.13	0.20	0.01	0.14	0.02	0.24	0.01	-0.29	0.43	0.12	0.37	0.29							
As	0.43	0.17	0.37	0.15	-0.11	-0.29	-0.27	0.51	0.32	0.02	0.22	0.50	-0.02	0.05	0.03	-0.14	-0.47	-0.19	-0.48	-0.21	0.36	0.24	0.10	0.20	0.09	-0.11						
Sb	0.38	0.11	0.19	0.09	-0.30	0.04	0.01	0.11	0.06	-0.26	0.32	0.41	0.17	-0.13	-0.31	0.11	-0.04	0.07	-0.02	0.01	-0.07	0.19	0.11	0.13	0.10	-0.13	0.50					
Mn	-0.05	0.07	-0.06	0.06	-0.25	-0.09	-0.03	0.14	0.14	0.21	0.01	-0.11	-0.10	0.20	0.15	-0.17	-0.06	-0.22	0.18	-0.25	0.13	0.20	0.26	0.41	0.16	0.11	0.00	-0.11				
Co	0.06	0.24	-0.41	0.22	0.10	0.28	0.08	0.30	-0.01	0.40	-0.02	0.01	0.25	0.49	0.33	0.27	0.48	0.38	0.36	-0.50	0.03	0.53	0.09	0.13	0.09	0.30	-0.15	-0.20	0.32			
Ni	0.01	0.59	0.27	0.58	-0.29	-0.03	-0.28	0.16	0.45	0.64	-0.02	0.45	0.43	0.60	0.60	0.35	0.38	0.14	0.56	-0.02	-0.13	0.46	-0.14	0.49	0.02	0.52	0.03	-0.07	0.22	0.42		
Se	0.17	0.00	0.07	0.00	0.13	-0.03	0.06	-0.02	-0.22	-0.30	0.23	0.19	-0.10	-0.21	-0.30	0.06	-0.07	-0.07	-0.09	-0.15	-0.11	0.24	0.11	0.30	-0.05	0.11	0.24	0.26	-0.14	0.04	0.20	

Table S9. Correlation matrix (rs) between the physicochemical characterization variables of drinking water supply in the rainy season considering total sampling sites

	pH	Cond	Temp	TDS	DO	Turb	Color	Acid	Alkal	Hardness	COD	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	NO ₃ ⁻	SO ₄ ²⁻	Ba	Cr	Fe	Cu	Zn	Cd	Al	Pb	As	Sb	Mn	Co	Ni	Se
pH																																
Cond	-0.16																															
Temp	-0.35	0.46																														
TDS	-0.14	0.97																														
DO	0.38	-0.46	-0.49	-0.47																												
Turb	0.01	-0.09	-0.07	-0.13	0.15																											
Color	0.07	-0.08	-0.27	-0.04	0.14	0.43																										
Acid	-0.34	0.46	0.30	0.49	-0.51	-0.27	-0.09																									
Alkal	-0.18	0.81	0.41	0.80	-0.45	-0.25	-0.14	0.50																								
Hardness	-0.03	0.67	0.24	0.66	-0.29	-0.19	-0.14	0.28	0.72																							
COD	-0.01	0.17	-0.07	0.16	0.15	0.47	0.39	-0.21	0.01	0.05																						
Na ⁺	-0.29	0.63	0.61	0.63	-0.49	-0.05	-0.06	0.41	0.48	0.58	0.18																					
K ⁺	-0.11	0.35	0.24	0.33	0.03	0.36	-0.07	-0.05	0.13	0.27	0.44	0.47																				
Ca ²⁺	-0.02	0.64	0.11	0.65	-0.19	-0.16	-0.05	0.22	0.70	0.94	0.13	0.53	0.28																			
Mg ²⁺	-0.01	0.62	0.35	0.59	-0.33	-0.18	-0.21	0.28	0.66	0.93	-0.02	0.57	0.28	0.79																		
Cl ⁻	-0.14	0.60	0.11	0.63	-0.15	-0.12	0.02	0.37	0.43	0.28	0.20	0.42	0.33	0.33	0.17																	
NO ₃ ⁻	0.11	0.31	-0.17	0.27	-0.10	-0.25	0.01	0.27	0.17	0.40	-0.17	0.17	0.04	0.35	0.36	0.33																
SO ₄ ²⁻	-0.07	0.40	0.10	0.34	-0.10	0.26	-0.03	0.19	0.13	0.39	0.32	0.48	0.60	0.39	0.35	0.44	0.42															
Ba	0.03	0.61	-0.03	0.56	-0.13	0.09	0.20	0.26	0.48	0.42	0.05	0.28	0.27	0.42	0.36	0.43	0.41	0.40														
Cr	0.09	0.33	-0.10	0.30	-0.04	0.01	0.01	-0.07	0.44	0.49	0.09	0.12	0.12	0.56	0.37	0.17	0.13	0.18	0.30													
Fe	-0.10	0.25	0.02	0.21	-0.28	0.52	0.41	0.00	0.15	0.15	0.30	0.19	0.17	0.14	0.11	-0.01	-0.01	0.24	0.39	0.16												
Cu	-0.15	0.42	0.22	0.38	-0.27	-0.01	0.02	0.27	0.41	0.33	0.02	0.26	0.03	0.25	0.31	0.14	0.30	0.08	0.28	0.09	0.24											
Zn	-0.32	0.18	0.10	0.19	-0.32	0.06	0.19	0.33	0.16	0.03	-0.09	0.25	0.01	0.00	0.09	-0.05	0.04	-0.09	0.31	-0.13	0.29	0.44										
Cd	-0.38	0.49	0.31	0.51	-0.41	0.17	0.25	0.46	0.28	0.26	0.13	0.49	0.15	0.20	0.27	0.30	0.09	0.31	0.37	-0.08	0.44	0.42	0.57									
Al	-0.09	-0.03	-0.22	-0.07	0.02	0.64	0.43	-0.08	-0.18	-0.24	0.40	-0.12	0.11	-0.17	-0.28	0.02	-0.07	0.14	0.11	0.06	0.54	0.03	0.18	0.18								
Pb	-0.15	0.16	0.07	0.15	-0.30	0.16	0.20	0.18	0.08	0.02	-0.07	0.21	-0.04	-0.01	0.05	-0.05	-0.01	0.02	0.22	-0.10	0.54	0.40	0.62	0.60	0.28							
As	-0.43	0.40	0.54	0.42	-0.53	0.10	0.02	0.36	0.36	0.20	0.28	0.58	0.28	0.18	0.23	0.20	-0.28	0.04	-0.09	0.07	0.23	0.25	0.30	0.52	0.17	0.35						
Sb	-0.01	0.20	0.07	0.21	0.03	0.08	0.28	-0.01	0.04	0.02	0.34	0.28	0.20	0.13	-0.13	0.47	-0.03	0.21	0.07	-0.01	0.16	-0.06	-0.08	0.29	0.08	0.11	0.35					
Mn	-0.10	0.12	-0.05	0.11	-0.08	0.37	0.38	0.05	0.15	0.10	0.20	0.17	0.21	0.12	0.07	0.08	-0.09	0.10	0.46	0.08	0.64	0.12	0.51	0.40	0.49	0.48	0.24	0.13				
Co	-0.05	0.46	-0.11	0.42	-0.21	0.46	0.42	0.12	0.27	0.31	0.34	0.22	0.30	0.33	0.22	0.28	0.30	0.47	0.66	0.18	0.80	0.35	0.29	0.46	0.49	0.42	0.11	0.22	0.57			
Ni	-0.32	0.59	0.06	0.57	-0.38	0.12	0.21	0.37	0.52	0.52	0.13	0.31	0.23	0.54	0.46	0.23	0.25	0.39	0.55	0.25	0.52	0.38	0.42	0.54	0.22	0.40	0.26	0.02	0.46	0.68		
Se	-0.09	0.55	0.13	0.51	-0.24	-0.19	0.03	0.24	0.49	0.37	0.28	0.22	-0.02	0.36	0.26	0.53	0.30	0.17	0.34	0.38	0.14	0.31	-0.02	0.24	0.03	0.00	0.26	0.31	0.08	0.27	0.28	

Cond: Conductivity; Temp: Temperature; TDS: Total Dissolved Solids; DO: Dissolved Oxygen; Turb: Turbidity; Acid: Acidity; Alkal: Alkalinity; COD: Chemical Oxygen Demand. Bold values indicate p<0.05

Figure S1. Quality parameters of drinking water supply sources for humans in the regions of study and the permissible limits defined by WHO, NOM-040 and NOM-127. Green dots (•): rainy season, yellow dots (•): dry season. Vertical lines on the secondary x-axis represent the distribution of each municipality.





