



Supplement of

Assessment of the evolution of groundwater quality for the state of California, United States using weighted index overlay analysis

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S1. Weightages for WQI and WIOA

In this study WHO (2011) drinking standards has been used because our data ranges 2009- 2023. In this paper we've shown the comparison between the results obtained by WIOA and WQI for the year 2022 because of space constraints.

The choice to reference the 2011 standards has been driven by a desire to maintain consistency with earlier studies conducted around that period. Using the same standards ensures comparability of results over time and allows for a direct comparison with previous data, facilitating trend analysis and evaluating changes or improvements in water quality management.

PARAMETERS	WEIGHTAGE (W1)	RELATIVE WEIGHTAGE	WHO (2011) STANDARDS
TDC	5	(W_i)	(11g/1)
105	5	0.122	1300
TH	5	0.122	500
Ca ²⁺	4	0.098	200
Mg^{2+}	3	0.073	150
Na+	4	0.098	200
K +	2	0.048	12
HÇ0-	5	0.122	500
Cl-	5	0.122	600
SQ ^{2–}	3	0.073	400
Ng-	4	0.098	100
∑Wa	41	1	

Table S1: Relative weight (W_i) values for groundwater quality parameters

Table S2: Shows the weightage & ranking for the water quality parameters.

PARAMETERS	UNIT	PARAMETER	RANKINGS	WEIGHTAGE	
		RANGE		(%)	
		(mg/l)			
	mg/l	<500	1		
TDS		500-1500	2	13	
		>1500	3		
	mg/l	<100	1		
TH		100-500	2	12	
		>500	3		
	mg/l	<50	1		
Na^+		50-200	2	9	
		>200	3		
	mg/l	< 75	1		
Ca ²⁺		75-200	2	9	
		>200	3		
	mg/l	1-10	1		
K^+		10-12	2	6	
		>12	3		

	mg/l	< 30	1	
Mg^{2+}		31-100	2	11
		>100	3	
	mg/l	<250	1	
Cl-		250-600	2	12
		>600	3	
	mg/l	<200	1	
HCO-3		200-500	2	12
		>500	3	
	mg/l	<45	1	
N0-3		45-100	2	13
		>100	3	
	mg/l	<50	1	
SO^{2-4}		50-100	2	8
		>100	3	

S2. WIOA Workflow



Figure S1. Flowchart showcasing WIOA working procedure for groundwater quality assessment for drinking purpose.

S3. General Hydro-Chemistry

Total dissolved solids (TDS) in the research region varied from 115 to 2515 mg/l, much over the allowed limit of 1500 mg/L (WHO, 2011). Fourteen of the 201 samples that had TDS testsexceeded the permissible amount suggested by the WHO. There were 22 samples that had totalhardness (TH) over the WHO's 2011 tolerable level, ranging from 3.13 to 1150 mg/l. Despite the relatively low values of the physical and chemical characteristics, the parameters under analysis were compared to the WHO (2011) drinking standard, as given in Table C2.

While NO⁻ is noted above the permissible limit, the comparison reveals that most other physical and chemical parameters are within the acceptable range. Concentrations of K⁺, Na⁺, Cl⁻, & SO²⁻ were found to be above the desirable range, and in many locations, the level of NO⁻ was above the permissible limit with much higher levels.

PARAMETERS	MINIMUM	MAXIMUM	MEAN
TDS	115.00	2515.00	452.98
TH	3.13	1150.00	140.895
Ca ²⁺	1.03	315.00	48.34
Mg^{2+}	0.10	100.00	11.26
Na+	6.55	348.57	31.26
K +	1.00	15.74	3.38
HCO ⁻ ₃	19.00	496.00	152.34
Cl-	1.52	1266.00	107.73
SO ₄ ²⁻	3.40	1200.00	49.37
NO ⁻ 3	0.10	21.71	6.64

Table S3: Statistical summary of the groundwater quality parameters (2022)

Table S4: Comparison with WHO drinking standards (2022)

PARAMETERS	ST	UDY	WHO VA	LUES	NUMBER C	OF SAMPLES
	AREA					
	VALUES					
	MIN	MAX	DESIRABLE	PERMISSIBLE	BELOW	ABOVE
	(mg/l)	(mg/l)	LIMIT	LIMIT	PERMISSIBLE	PERMISSIBLE
	× 0 /		(mg/l)	(mg/l)	LIMIT	LIMIT
TDS	115.00	2515.00	500	1500	113	14
ТН	3.13	1150.00	100	500	43	22
Ca ²⁺	1.03	315.00	75	200	138	10
Mg ²⁺	0.10	100.00	30	150	158	Nil
Na ⁺	6.55	348.57	50	200	115	07
K ⁺	1.00	15.74	10	12	199	01
HCO ⁻ ₃	19.00	496.00	200	500	106	Nil
Cl-	1.52	1266.00	250	600	173	06
S04 ²⁻	3.40	1200.00	250	400	183	04
NO ⁻ ₃	0.10	121.71	45	100	201	14

S4. Spatial distribution maps for physiochemical parameters

The creation of spatial distribution maps for physiochemical parameters involved theintegration of the geospatial and characteristic datasets produced by Arc Map.

The Inverse Distance Weighted (IDW) method interpolation technique produced the spatialmaps, allowing us to examine the cause-and-effect relationship through visual representation.













Figure S2: Spatial distribution of different parameters (a) Potassium (K), (b) BicarbonateAlkalinity (BCA), (c) Calcium (Ca), (d) Magnesium (Mg), (e) Nitrate (NO⁻), (f) Sodium (Ŋa), (g) Sulfate (SO²⁻), (h) Total Dissolved Solids (TDS), (i) Total Hardness (TH) and (j) Chloride (Cl)

S5. WQI (2009-2023)









Figure S3. Groundwater quality using WQI for the years 2009-2023