

## One and a half centuries of physicochemical data of Urmia Lake, Iran: 1852-2008

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Cover of "The Limits of The World from The East to The West"

Urmia Lake, as one of the world's unique ecosystems, has been under consideration for a very long time. The first scientific report of this Lake goes back to 982, more than one thousand years ago, in "The Limits of the World from the East to the West" by unknown Iranian geographer(s):

"And second lake is Kabuzan [Kabudan Lake or Urmia Lake] from the Urmia. Its length is 50 Parasangs [an ancient unit of length] and its width is 30 Parasangs. There is a village in this lake, called Kabuzan [Kabuzan = Kabudan; an island in the Urmia Lake] and this lake is called with this village. There are cities around that and there are no animals because its water is salty, except a worm." (The Limits of the World from the East to the West, pages 5-6).

"In the Urmia Sea [Urmia Lake] lies one island with a village called Kabuzan [Kabudan]. It is a rich place with many inhabitants." (The Limits of the World from the East to the West; page 10).

The Persian word of "ارمينيه" had been translated to the word Armenia by Minorsky but according to the Dekhoda Dictionary, the famous Persian encyclopedia with 16 volumes and more than 23,000 pages, Urmia is the correct meaning. It seems that this confusion arose from a pronunciation

mistake by a re-writer and/or translator between the words Armenia and Urmia (Dekhoda, 1998).

The first extensive hydrochemical study of Urmia Lake was done by "Otto Wilhelm Hermann von Abich" in 1852 (Abich, 1856); after that, several researches have been conducted in different parts of the Lake.

Urmia Lake is drying now and is experiencing a serious ecological crisis (Fig. 1). Historical documents indicate that Urmia Lake experienced a severe drought in 1800, more than 200 years ago (Tamaddon 1971, Asem *et al.*, 2012). In that year, the maximum depth was only 75 cm. The Lake was so shallow that an east-west road was created through the lake bed and oral histories from elders confirm the presence of this road (Tamaddon 1971, Asem *et al.*, 2012). Although several hydrochemical studies had been done previously, unfortunately there is no any comprehensive reference for physicochemical information about Urmia Lake. In this manuscript all official reports of hydrochemical results have been collected. It is hoped that re-analyses of these data will lead to a better understanding of the ecology of the Lake.



Otto Wilhelm Hermann von Abich  
(December 11, 1806 – July 1, 1886)



Figure1. Osman Yumruğu, the smallest island of Urmia Lake in rainy and drought periods

I. Abich, 1856

Table1. The composition of salt in 100 parts with neglect of the bromine  
(Locality: Unknown; Date: 1852)

NaCl	MgCl <sub>2</sub>	CaSO <sub>4</sub>	MgSO <sub>4</sub>	CaCl <sub>2</sub>	Salinity
86.37	6.94	0.34	6.08	0.27	22.28%

II. Hunt, 1868

Table2. Solid content in 100 parts of water  
(Locality: Unknown; Date: Unknown)

NaCl	MgCl <sub>2</sub>	CaSO <sub>4</sub>	MgSO <sub>4</sub>	Solid contents
19.05	0.52	0.18	0.8	20.55

These data were mistakenly attributed to Schlimmer (1861) in Persian citations (see Adarangi, 1941; Djonidi, 1970).

III. Günther and Manely, 1899

Table3. The hypothetical proximate composition of 100 parts of the total salts  
(Locality: Bezaou Daghi [Kaboudan Island]; data: 16- Sept.-1898)

	Sample A	Sample B <sub>i</sub> *	Sample B <sub>ii</sub> *
NaCl	86.332	86.203	86.203
MgCl <sub>2</sub>	6.661	6.816	6.816
MgSO <sub>4</sub>	4.211	4.15	3.915
CaSO <sub>4</sub>	0.988	1.151	1.151
K <sub>2</sub> SO <sub>4</sub>	1.741	1.741	1.741
Density at 15 °C	1.11338		1.11389
Total salts in 100 grams of water	14.814		14.893

\*Result B<sub>i</sub> was obtained by calculating the Magnesium Sulphate from the residual Sulphate (SO<sub>3</sub>). Result B<sub>ii</sub> from the residual Magnesium.

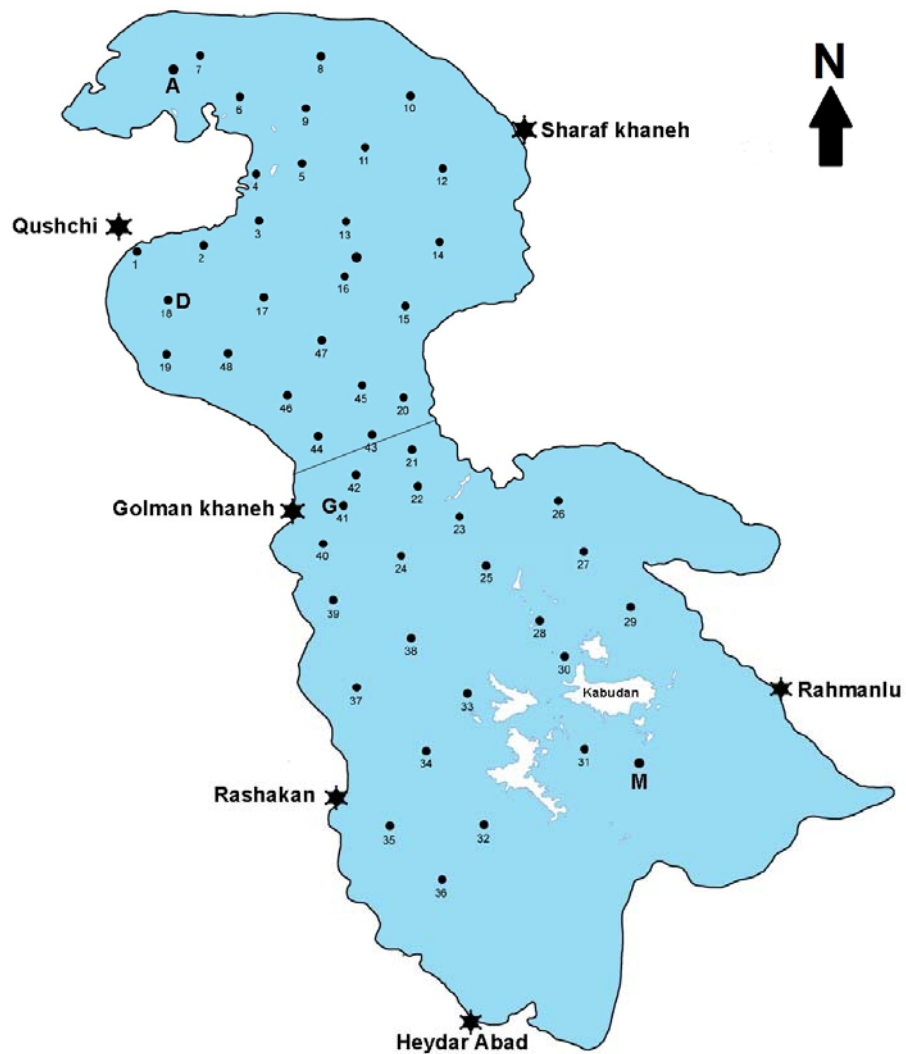


Figure2. Urmia Lake; Geographical locations of the studied area

#### IV. Khlopin, 1923

Table4. Physicochemical quality of Urmia Lake in 1916  
(Locality: Qushchi Coast; Date: 1916)

KCl (g.l <sup>-1</sup> )	NaCl (g.l <sup>-1</sup> )	CaSO <sub>4</sub> (g.l <sup>-1</sup> )	MgCO <sub>3</sub> (g.l <sup>-1</sup> )	MgSO <sub>4</sub> (g.l <sup>-1</sup> )	MgCl <sub>2</sub> (g.l <sup>-1</sup> )	Salinity (g.l <sup>-1</sup> )
2.46	160.03	2.416	0.214	9.231	7.941	188.4

V. Adarangi, 1941

Table5. Physicochemical quality of Urmia Lake in 1941  
(Locality: Sharaf Khaneh region; Date: Spring and Fall 1941)

	Spring	Fall
pH	~ 8	~ 8
PO <sub>4</sub> <sup>-</sup>	+	+
Density (g.cm <sup>-3</sup> )	1.2	1.215
Water Tem. (°C)	16	Not reported
NH <sub>3</sub>	+	+
NO <sub>3</sub> <sup>-</sup>	-	-
NO <sub>2</sub> <sup>-</sup>	-	-
NaCl (g.l <sup>-1</sup> )	222.595	241.7426
MgCl <sub>2</sub> (g.l <sup>-1</sup> )	18.7597	20.5215
MgSO <sub>4</sub> (g.l <sup>-1</sup> )	16.899	18.2614
Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> (g.l <sup>-1</sup> )	0.2969	0.3116
CaSO <sub>4</sub> (g.l <sup>-1</sup> )	1.53	1.7435
FeSO <sub>4</sub> (g.l <sup>-1</sup> )	0.0135	0.0147
Na <sub>2</sub> SiO <sub>3</sub> (g.l <sup>-1</sup> )	0.8037	0.823
KI (g.l <sup>-1</sup> )	0.0125	Not measured
KBr (g.l <sup>-1</sup> )	0.01	Not measured
Organic compounds (as KMnO <sub>4</sub> g.l <sup>-1</sup> )	0.0045	0.0049
Dry residue at more than 100 °C (g.l <sup>-1</sup> )	261.1159	284.7972

Table6. Physicochemical quality of Urmia Lake in 1938  
(Locality: Unknown; Date: 1938; Reporter: Dr. Sadegh Moghadam)

Density (g.cm <sup>-3</sup> )	Cl <sup>-</sup> (as NaCl g.l <sup>-1</sup> )	NH <sub>3</sub>	NO <sub>3</sub> <sup>-</sup>	NO <sub>2</sub> <sup>-</sup>	Dry residue (g.l <sup>-1</sup> )
1.22	310	+	-	-	382.2

VI. Djonidi, 1970

Table7. Physicochemical quality of Urmia Lake in 1967  
(Locality: Golman Khaneh and Heydar Abad regions; Date: July 1967)

Date	Locality	
	Golman Khaneh	Heydar Abad
25-July-1967	24-July-1967	
Total Alkalinity (g.l <sup>-1</sup> )	0.27	0.3
Permanent Alkalinity (g.l <sup>-1</sup> )	0.265	0.295
Na <sup>+</sup> (g.l <sup>-1</sup> )	93.83	100
K <sup>+</sup> (g.l <sup>-1</sup> )	1.8	1.8
Ca <sup>2+</sup> (g.l <sup>-1</sup> )	0.8	0.76
Mg <sup>2+</sup> (g.l <sup>-1</sup> )	7.464	7.56
Fe <sup>2+</sup> (g.l <sup>-1</sup> )	+	+
Cl <sup>-</sup> (g.l <sup>-1</sup> )	160.075	162.915
SO <sub>4</sub> <sup>=</sup> (g.l <sup>-1</sup> )	13.434	14.308
Br <sup>-</sup> (g.l <sup>-1</sup> )	0.06	0.0625
F <sup>-</sup> (g.l <sup>-1</sup> )	0.003	0.003
SiO <sub>2</sub> (g.l <sup>-1</sup> )	0.003	0.004
NH <sub>3</sub>	-	-
NO <sub>3</sub> <sup>-</sup>	-	-
NO <sub>2</sub> <sup>-</sup>	-	-
Dry residue at 180 °C (g.l <sup>-1</sup> )	282.122	288.164

Table8. Physicochemical quality of Urmia Lake  
(Locality: Unknown; Date: Unknown)

Ca <sup>2+</sup>	0.115%
Mg <sup>2+</sup>	0.7295%
K <sup>+</sup>	0.42%
Na <sup>+</sup>	10.093%
Cl <sup>-</sup>	17.08%
Br <sup>-</sup>	0.32%
SO <sub>4</sub> <sup>=</sup>	1.343%
NO <sub>3</sub> <sup>-</sup>	0.14%
Free Oxygen	0.096%
Density	1.211
Dry residue at 180 °C	30.25%

VII. Daneshgar, 1975

Table9. Physicochemical quality of Urmia Lake in 1974  
(Locality: Sharaf Khaneh region; Date: 1-Jun.-1974)

Water Tem. (°C)	22.5
Air Tem. (°C)	23
pH	7.8
EC (µmhos/cm)	280000
Total Hardness (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	24000
Permanent Hardness (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	16800
Total Alkalinity (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	300
Permanent Alkalinity (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	270
HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	8784
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	12250
Cl <sup>-</sup> (mg.l <sup>-1</sup> )	102100
PO <sub>4</sub> <sup>3-</sup> (mg.l <sup>-1</sup> )	1.4
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	480.5
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	5472
Na <sup>+</sup> (mg.l <sup>-1</sup> )	92000
K <sup>+</sup> (mg.l <sup>-1</sup> )	1072.5
Fe <sup>2+</sup> (mg.l <sup>-1</sup> )	2
SiO <sub>2</sub> (mg.l <sup>-1</sup> )	14.7
Br <sup>-</sup> (mg.l <sup>-1</sup> )	1.4
Cu <sup>2+</sup> (mg.l <sup>-1</sup> )	1
NH <sub>4</sub> <sup>+</sup> (mg.l <sup>-1</sup> )	0.25
NO <sub>2</sub> <sup>-</sup>	-
NO <sub>3</sub> <sup>-</sup>	-
Organic compounds (in Alkaline medium mg.l <sup>-1</sup> )	30
Organic compounds (in Acidic medium mg.l <sup>-1</sup> )	24
Dry residue at 180 °C (g.l <sup>-1</sup> )	188.72

VIII. Javanbakht, 1975

Table10. Physicochemical quality of Urmia Lake in 1974  
(Locality: Golman Khaneh region, Date: 10-Oct.-1974)

Water Tem. (°C)	20
Air Tem. (°C)	25
pH	7.2
EC (µmhos/cm)	340000
Total Hardness (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	24000
Permanent Hardness (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	19650
Total Alkalinity (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	320
Permanent Alkalinity (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	267
HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	5207
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	11500
Cl <sup>-</sup> (mg.l <sup>-1</sup> )	146815
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	752
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	5308
Na <sup>+</sup> (mg.l <sup>-1</sup> )	94560
K <sup>+</sup> (mg.l <sup>-1</sup> )	1750
Fe <sup>2+</sup>	1.2
NO <sub>2</sub> <sup>-</sup>	+
NO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	1
SiO <sub>2</sub> (mg.l <sup>-1</sup> )	7
Br <sup>-</sup> (mg.l <sup>-1</sup> )	54
NH <sub>4</sub> <sup>+</sup> (mg.l <sup>-1</sup> )	1
Organic compounds (in Alkaline medium mg.l <sup>-1</sup> )	27.8
Organic compounds (in Acidic medium mg.l <sup>-1</sup> )	21.6

IX. Azami-Oskoei, 1975

Table11: Physicochemical quality of Urmia Lake in 1974  
(Locality: Heydar Abad and Rahmanlu regions, Date: October of 1974)

Date	Heydar Abad	Rahmanlu
	region	region
Date	10-Oct.-1974	16-Oct.1974
Water Tem. (°C)	20	17
Air Tem. (°C)	18	20
pH	7.2	7.8
EC (µmhos/cm)	540000	370000
Total Hardness (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	28000	23200
Permanent Hardness (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	12500	21600
Total Alkalinity (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	310	380
Permanent Alkalinity (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	260	280
HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	18910	1952
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	10113.6	11712
Cl <sup>-</sup> (mg.l <sup>-1</sup> )	165000	117050
PO <sub>4</sub> <sup>3-</sup> (mg.l <sup>-1</sup> )	2	1.6
Br <sup>-</sup> (mg/l)	1	1
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	1081	600.6
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	6671	51480
Na <sup>+</sup> (mg.l <sup>-1</sup> )	85100	96600
K <sup>+</sup> (mg.l <sup>-1</sup> )	1365	1755
Fe <sup>2+</sup> (mg.l <sup>-1</sup> )	1.3	1
Cu <sup>2+</sup> (mg.l <sup>-1</sup> )	0.96	Not measured
Zn <sup>2+</sup> (mg.l <sup>-1</sup> )	0.04	2
Pb <sup>2+</sup>	+	Not measured
NO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	0.7	0.2
NO <sub>2</sub> <sup>-</sup>	-	+
NH <sub>4</sub> <sup>+</sup> (mg.l <sup>-1</sup> )	-	3
SiO <sub>2</sub> (mg.l <sup>-1</sup> )	10	12
Organic compounds (in Alkaline medium mg.l <sup>-1</sup> )	36	28.4
Organic compounds (in Acidic medium mg.l <sup>-1</sup> )	102.5	23
Dry residue at 180 °C (g.l <sup>-1</sup> )	195	196.4



X. Saberi, 1978

Table12. Physicochemical quality of Urmia Lake in 1977

	Rashakan region	Heydar Abad region	Golman Khaneh region	Qushchi Coast	Rashakan region	Heydar Abad region	Golman Khaneh region	Sharaf Khaneh region
Date	16-Nov.-1976			22-April-1977			23-April-1977	
Water Tem. (°C)	6	5	9	7	10	9	9.5	8
Air Tem. (°C)	11	10.5	15	10	12.5	11.5	10	9.5
pH	7.5	7.5	7	7	7	7	7	7
EC (µmhos/cm)	300000	278000	290000	285000	224000	215500	234000	240000
Total Alkalinity (mg.l <sup>-1</sup> )	206	232	242	312	268	280	296	308
Total Hardness (mg.l <sup>-1</sup> )	28400	25000	25400	24400	23000	25000	23600	23000
Permanent Hardness (mg.l <sup>-1</sup> )	5160	4600	5000	4910	4610	4900	4720	4800
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	840	820	640	440	320	520	600	200
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	1722	2590	2664	2664	2568	2668	2496	2640
Na <sup>+</sup> (mg.l <sup>-1</sup> )	73000	70000	75000	63000	55000	56000	62000	60700
K <sup>+</sup> (mg.l <sup>-1</sup> )	2300	2000	2150	1600	1600	1400	1800	1500
HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	317.2	341.6	451.4	378	244	292.8	305	414
Cl <sup>-</sup> (mg.l <sup>-1</sup> )	124250	117860	125315	106500	93820	95140	105080	102240
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	686	798	882	818	588	884	818	774
NO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	140	163.8	238.5	48	16.5	24.5	13.7	58
NH <sub>4</sub> <sup>+</sup> (mg.l <sup>-1</sup> )	-	11.2	11.5	9.4	6	14.5	12.3	12
NO <sub>2</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	0.94	0.102	0.038	0.55	0.03	0.03	0.7	0.04
SiO <sub>2</sub>	+	+	+	+	+	+	+	+
Fe <sup>2+</sup>	+	+	+	+	+	+	+	+
I <sup>-</sup> (µg.l <sup>-1</sup> )	0.111	0.75	0.5	1.4	1.35	0.98	0.65	0.47
Dry residue at 180 °C (g.l <sup>-1</sup> )	220.413	202.67	223.047	216.148	204.018	200.65	206.348*	206.348*

\* It seems, one of values is wrong (authors)

XI. Kelts and Shahrabi (1986)

Table13. Physicochemical quality of Urmia Lake in 1977  
(Locality: C10; Date: Jun 1977)

Na <sup>+</sup> (mg.l <sup>-1</sup> )	K <sup>+</sup> (mg.l <sup>-1</sup> )	Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	Cl <sup>-</sup> (mg.l <sup>-1</sup> )	HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	pH	TDS (mg.l <sup>-1</sup> )
72000	960	4800	470	111000	334	29400	7.6	201700

XII. Kargarnejad, 1986

Table14. Physicochemical quality of Urmia Lake in 1985  
(Locality: Rahmanlu region; Date: 27-July-1985)

Water Tem. (°C)	29
EC (µmhos/cm)	310000
pH	7.9
Alkaline earth bicarbonate (as HCO <sub>3</sub> <sup>-</sup> mg.l <sup>-1</sup> )	3660
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	10750
Cl <sup>-</sup> (mg.l <sup>-1</sup> )	125000
Fe <sup>2+</sup> (mg.l <sup>-1</sup> )	2
NO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	0.165
NO <sub>2</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	-
NH <sub>4</sub> <sup>+</sup> (mg.l <sup>-1</sup> )	2.5
F <sup>-</sup> (mg.l <sup>-1</sup> )	12
I <sup>-</sup> (mg.l <sup>-1</sup> )	0.2
PO <sub>4</sub> <sup>3-</sup> (mg.l <sup>-1</sup> )	1.4
SiO <sub>3</sub> <sup>3-</sup> (mg.l <sup>-1</sup> )	11
Total Hardness (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	23200
Permanent Hardness (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	20200
Total Alkalinity (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	220
Permanent Alkalinity (as CaCO <sub>3</sub> mg.l <sup>-1</sup> )	230
Na <sup>+</sup> (mg.l <sup>-1</sup> )	70000
K <sup>+</sup> (mg.l <sup>-1</sup> )	1400
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	680
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	5160
Cu <sup>2+</sup> (mg.l <sup>-1</sup> )	1.2
Dry residue at 180 °C (g.l <sup>-1</sup> )	215.02

XIII. Daneshvar and Ashasi Sorkhabi (1997)

Table5. Physicochemical quality of Urmia Lake in 1987

	April			Fall (90 stations)
	North (29 stations)	Southwest (23 stations)	Central & Southeast (35 stations)	
pH	7.74±0.03	7.76±0.04	7.79±0.04	7.72±0.07
Dry residue at 180 °C (g.l <sup>-1</sup> )	235±3	225±4	211±16	251±2.5
Density (g.l <sup>-1</sup> )	1.146±0.002	1.140±0.002	1.138±0.004	1.159±0.001
EC (µmhos/cm)	185±1	180±2	174±7	191±2
Na <sup>+</sup> (meq.l <sup>-1</sup> )	3426±25	3442±40	3123±222	3742±40
Mg <sup>2+</sup> (meq.l <sup>-1</sup> )	474±4	4454±6	429±26	511±6
Ca <sup>2+</sup> (meq.l <sup>-1</sup> )	36±2	37±2	34±4	34±4
K <sup>+</sup> (meq.l <sup>-1</sup> )	33±1	32±1	31±3	36±1
Cl <sup>-</sup> (meq.l <sup>-1</sup> )	3690±37	3548±57	3336±223	4048±48
SO <sub>4</sub> <sup>=</sup> (meq.l <sup>-1</sup> )	225±4	216±5	206±13	237±4
HCO <sub>3</sub> <sup>-</sup> (meq.l <sup>-1</sup> )	5±0.2	5±0.1	5±0.2	4.8±0.3
Br <sup>-</sup> (meq.l <sup>-1</sup> )	2.45±0.05	2.35±0.05	2.25±0.15	2.7±0.0
SiO <sub>2</sub> (ppm)	1.7±0.4	1.7±0.6	1.9±0.4	2±0.3

XIV. Toulouie et al, 1997

Table16. Physicochemical quality of Urmia Lake in different years

	Na <sup>+</sup> (g.l <sup>-1</sup> )	K <sup>+</sup> (g.l <sup>-1</sup> )	Mg <sup>+2</sup> (g.l <sup>-1</sup> )	Ca <sup>+2</sup> (g.l <sup>-1</sup> )	Cl <sup>-</sup> (g.l <sup>-1</sup> )	SO <sub>4</sub> <sup>=</sup> (g.l <sup>-1</sup> )	Br <sup>-</sup> (g.l <sup>-1</sup> )	TDS (g.l <sup>-1</sup> )
Northeast, 1973		1.6	8.19	0.48	167.81	14.54		318.2
North, Spring 1987	80.04	1.4	5.86	0.82	134.19	11.04	0.199	242
North, Fall 1987	87.16	1.46	6.35	0.92	150.87	11.76	0.223	246
South, Fall 1987	84.18	1.36	6.07	0.6	140.22	10.99	0.207	255.5
Northeast, Summer 1994	54.28	1.2	4.2	0.4	90.88	9.6		160.58
Northeast, 1994	45.7	0.73	3.5	0.4	76.7	6.92	0.08	

XV. Emamali-Sabzi, 1993

Table17. Physicochemical quality of Urmia Lake in 1991 and 1992  
(Locality: Golman Khaneh region)

	07-June-1991	30-Nov.-1991	03-April-1992	30-April-1992
Na <sup>+</sup> (ppm)	82354.3	94300	75900	71345
K <sup>+</sup> (ppm)	1742	1955.1	1720.5	1642.3
Mg <sup>2+</sup> (ppm)	6515.1	7095.6	5924.2	5105.6
Ca <sup>2+</sup> (ppm)	491.5	703.2	555.6	534.4
Cl <sup>-</sup> (ppm)	122768.7	154516.4	128096.2	144856.8
SO <sub>4</sub> <sup>=</sup> (ppm)	13124.4	13709.1	10336.2	11173.8
Density (g.cm <sup>-3</sup> )	1.138	1.144	1.132	1.128

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Table18. Physicochemical quality of Urmia Lake in 2002  
(Locality: Rashakan region, Date: Spring 2002)

	g.l <sup>-1</sup>	Percentage	meq.l <sup>-1</sup>
Na <sup>+</sup>	72.35	34.13	3145.7
Mg <sup>2+</sup>	5.01	2.36	414
Ca <sup>2+</sup>	0.74	0.35	37
K <sup>+</sup>	1.35	0.46	34.6
Cl <sup>-</sup>	122.18	57.63	3441.7
SO <sub>4</sub> <sup>=</sup>	10.02	4.73	217.8
HCO <sub>3</sub> <sup>-</sup>	0.35	0.16	5.7
pH		7.72	

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Table19. Urmia Lake water salinity (g.l<sup>-1</sup>) fluctuation in sampling sites during the study period  
(Locality: see Fig. 2; Date: Jul 2005- Feb. 2006)

	Station A	Station D	Station G	Station M
Jul. 2005	299	303	297	291
Aug. 2005	301	303	306	306
Sep. 2005	311	308	309	310
Oct. 2005	318	326	313	315
Nov. 2005	318	311	310	313
Dec. 2005	323	315	314	316
Jan. 2006	319	309	324	325
Feb. 2006	306	292	326	319

Table20 (a). Physicochemical quality in Urmia Lake in sampling site (A) during the study period  
(Locality: see Fig. 2; Date: Jul 2005- Feb. 2006)

	Jul. 2005	Aug. 2005	Sept. 2005	Oct. 2005	Nov. 2005	Dec. 2005	Jan. 2006	Feb. 2006
Cl <sup>-</sup> (g.l <sup>-1</sup> )	193.6	199.4	200.2	190.9	179.7	181.9	180.5	
CO <sub>2</sub> (mg.l <sup>-1</sup> )	125	120	110	135	152	128	165	
HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	158	230	280	320	320	370	460	
DO (mg.l <sup>-1</sup> )	0.6	0.4	0.9	0.1	0.8	2.4	2.6	1.7
PO <sub>4</sub> <sup>3-</sup> (mg.l <sup>-1</sup> )	185	340	476	390	104	371	201	612.4
NO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	512	330	1014	3121	723	5104	2310	750
NO <sub>2</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	7.8	7.6	21.5	17.3	10	15.5	14.2	15.5
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	20120	29150	18680	18040	15890	11430	18370	
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	952	1002	1202	1202	801	1603	762	
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	5705	4862	4376	9482	11913	11184	12642	
Hardness (mg.l <sup>-1</sup> )	24000	22500	21000	42000	44200	50000	53000	

Table20 (b). Physicochemical quality in Urmia Lake in sampling site (D) during the study period  
(Locality: see Fig. 2; Date: Jul 2005- Feb. 2006)

	Jul. 2005	Aug. 2005	Sept. 2005	Oct. 2005	Nov. 2005	Dec. 2005	Jan. 2006	Feb. 2006
Cl <sup>-</sup> (g.l <sup>-1</sup> )	195.1	201.3	196.6	193	179.7	184.1	182	
CO <sub>2</sub> (mg.l <sup>-1</sup> )	150	130	95	135	152	105	135	
HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	150	241	240	321	320	380	444	
DO (mg.l <sup>-1</sup> )	0.7	0.6	0.8	0.2	0.8	0.9	2.8	1.2
PO <sub>4</sub> <sup>3-</sup> (mg.l <sup>-1</sup> )	184	679	544	173	104	205	221	129.2
NO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	422	891	842	3125	723	3611	1105	376
NO <sub>2</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	8.8	10.1	14.5	18.2	10	14.9	13	4
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	14010	24900	18190	22500	15890	18795	18300	
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	1202	801	561	1603	801	1606	801	
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	6078	4376	5105	9481	11913	12642	13128	
Hardness (mg.l <sup>-1</sup> )	26000	20000	21000	41000	44200	59000	56000	

Table20 (c). Physicochemical quality in Urmia Lake in sampling site (G) during the study period (Locality: see Fig. 2; Date: Jul 2005- Feb. 2006)

	Jul. 2005	Aug. 2005	Sept. 2005	Oct. 2005	Nov. 2005	Dec. 2005	Jan. 2006	Feb. 2006
Cl <sup>-</sup> (g.l <sup>-1</sup> )	185.1	197.7	198	198.4	183.3	183.3	179.8	176.2
CO <sub>2</sub> (mg.l <sup>-1</sup> )	152	125	130	110	175	173	160	170
HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	144	180	220	330	340	370	430	490
DO (mg.l <sup>-1</sup> )	0.6	0.2	0.9	0.3	1.4	0.4	2.5	1.9
PO <sub>4</sub> <sup>3-</sup> (mg.l <sup>-1</sup> )	131	774	330	611	562.7	196	875	363
NO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	871	481	1142	1005	1205	1454	660	1815
NO <sub>2</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	11.5	6.1	14.8	13.4	10.5	14.5	6	19.5
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	18050	22320	29840	15530	10490	23030	15050	17910
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	801	1202	902	1402	1683	1202	962	721
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	5634.9	5592	6321	5228	13031	13858	12156	13177
Hardness (mg.l <sup>-1</sup> )	26000	26000	28000	35000	44200	60000	55000	56000

Table20 (d). Physicochemical quality in Urmia Lake in sampling site (M) during the study period (Locality: see Fig. 2; Date: Jul 2005- Feb. 2006)

	Jul. 2005	Aug. 2005	Sept. 2005	Oct. 2005	Nov. 2005	Dec. 2005	Jan. 2006	Feb. 2006
Cl <sup>-</sup> (g.l <sup>-1</sup> )	190.1	194.1	199.2	195.6	195.6	183.3	179.8	180.5
CO <sub>2</sub> (mg.l <sup>-1</sup> )	105	100	125	105	105	120	160	155
HCO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	160	210	240	320	320	365	400	496
DO (mg.l <sup>-1</sup> )	0.1	0.7	0.9	0.3	0.3	2.8	1.5	1.8
PO <sub>4</sub> <sup>3-</sup> (mg.l <sup>-1</sup> )	191	408	408	272	272	354	354	375
NO <sub>3</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	752	921	1252	1003	1003	4012	1105	1720
NO <sub>2</sub> <sup>-</sup> (mg.l <sup>-1</sup> )	10.1	19.5	14.1	18.2	18.2	9.5	9.1	15.5
SO <sub>4</sub> <sup>=</sup> (mg.l <sup>-1</sup> )	13200	27900	12620	18440	18440	18430	18750	18260
Ca <sup>2+</sup> (mg.l <sup>-1</sup> )	801	1202	801	1202	1202	1603	962	801
Mg <sup>2+</sup> (mg.l <sup>-1</sup> )	7293.6	3649	5106	4984	4984	12642	12545	14587
Hardness (mg.l <sup>-1</sup> )	25000	28100	23000	32000	32000	5600	54000	62000

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Table21. Physicochemical quality of Urmia Lake from 48 sampling stations in 2008  
(Locality: see Fig. 2; Date; June 2008)

Stations	Na <sup>+</sup> (g.l <sup>-1</sup> )	Mg <sup>2+</sup> (g.l <sup>-1</sup> )	K <sup>+</sup> (g.l <sup>-1</sup> )	Ca <sup>2+</sup> (g.l <sup>-1</sup> )	Cl <sup>-</sup> (g.l <sup>-1</sup> )	SO <sub>4</sub> <sup>=</sup> (g.l <sup>-1</sup> )	HCO <sub>3</sub> <sup>-</sup> (g.l <sup>-1</sup> )	TDS (g.l <sup>-1</sup> )	pH	Density (g.cm <sup>-3</sup> )
1	124	10.8	2.66	0.565	222	23.1	1.64	382	7.7	1.25
2	127	11.3	2.61	0.562	223	21.7	1.37	386	7.72	1.25
3	120	11.5	2.72	0.545	213	22.8	1.38	374	7.72	1.24
4	117	11.3	2.75	0.54	209	22.4	1.38	369	7.69	1.24
5	121	11.3	2.69	0.564	213	22.7	1.37	372	7.69	1.24
6	128	11.1	2.66	0.556	220	21.9	1.36	387	7.78	1.25
7	118	10.7	2.37	0.549	211	22.9	1.34	375	7.71	1.24
8	122	11.7	2.72	0.554	217	22.1	1.35	384	7.72	1.25
9	127	11.7	2.69	0.542	219	21.6	1.35	382	7.7	1.25
10	128	11.8	2.78	0.528	221	23.2	1.37	383	7.72	1.25
11	131	12.2	2.76	0.542	224	23.2	1.38	388	7.71	1.25
12	130	11.9	2.91	0.55	222	22.9	1.37	387	7.74	1.25
13	126	11.5	2.7	0.555	214	22.9	1.54	390	7.8	1.25
14	132	11.8	2.62	0.559	224	22.5	1.38	398	7.79	1.26
15	125	11.4	2.59	0.542	222	22.6	1.38	386	7.8	1.25
16	120	10.9	2.68	0.551	211	22.1	1.37	379	7.87	1.25
17	129	10.9	2.73	0.562	221	23.5	1.35	382	7.87	1.25
18	124	11.3	2.61	0.547	219	22.1	1.38	384	7.79	1.25
19	121	10.4	2.46	0.532	216	23.0	1.38	378	7.77	1.25
20	126	10.9	2.53	0.564	218	23.1	1.37	381	7.76	1.25
21	123	11.1	2.67	0.547	215	22.9	1.37	378	7.75	1.24
22	119	10.9	2.66	0.53	209	22.7	1.39	374	7.77	1.24
23	122	11.3	2.55	0.583	211	23.1	1.36	374	7.72	1.24
24	124	11.6	2.64	0.56	213	22.6	1.39	376	7.78	1.25
25	127	11.5	2.56	0.542	222	21.7	1.35	380	7.80	1.25
26	125	11.2	2.64	0.557	217	22.4	1.56	365	7.76	1.24
27	127	11.8	2.52	0.547	224	22.2	1.35	383	7.78	1.25
28	119	11.0	2.59	0.55	213	21.4	1.37	376	7.72	1.25
29	123	10.7	2.62	0.563	215	21.8	1.38	382	7.75	1.25
30	125	11.4	2.47	0.542	213	21.9	1.38	377	7.78	1.25
31	130	11.2	2.59	0.548	224	22.6	1.36	389	7.75	1.25
32	129	11.3	2.69	0.559	220	21.4	1.35	381	7.72	1.25
33	129	10.7	2.68	0.552	220	22.0	1.36	386	7.72	1.25
34	124	11.1	2.78	0.561	215	21.5	1.37	378	7.73	1.25
35	121	11.3	2.71	0.56	213	21.9	1.38	364	7.72	1.25
36	125	11.2	2.62	0.559	216	21.7	1.38	372	7.76	1.24
37	118	11.6	2.55	0.571	206	22.4	1.38	374	7.74	1.24
38	125	11.3	2.63	0.559	210	22.9	1.39	383	7.75	1.25
39	121	11.4	2.49	0.561	213	22.1	1.39	379	7.74	1.25
40	131	11.8	2.78	0.543	222	22.7	1.37	392	7.76	1.25
41	119	10.9	2.41	0.569	206	22.1	1.38	373	7.79	1.25
42	123	10.0	2.63	0.56	213	21.8	1.37	376	7.77	1.25
43	120	11.3	2.57	0.559	211	22.8	1.38	368	7.77	1.25
44	121	11.4	2.48	0.567	207	22.6	1.36	370	7.76	1.25
45	119	11.8	2.58	0.549	211	21.8	1.38	376	7.76	1.25
46	133	11.9	2.66	0.561	225	22.7	1.38	398	7.74	1.25
47	129	11.6	2.70	0.568	218	22.8	1.38	390	7.76	1.25
48	130	11.6	2.64	0.549	220	22.0	1.36	385	7.79	1.25

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