Appendix A:Supplemental data

Water Quality Changes in the Xingkai (Khanka) Lake, Northeast China, Driven by Climate Change and Human Activities: Insights from Published Data (1990–2020)

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Table S1. Supplementary measurements of water pollution in Lake Xingkai.

NO.	Period	WT/℃	pH	EC/ μs/cm	NH_3-N/ mg/L	COD/ mg/L	TN/ mg/L	TP/ mg/L	Chl-a/ μg/L	DO/ mg/L	Reference
1	1985-1998				0.04-2.43						[1]
2	1994-1998		7.0-7.53			4.09、4.73	0.09-2.65	0.01-0.07			[2]
3	1998-2007		7.05-7.81							8.89-10.32	[3]
4	May,Jul,Sept 2001	21	7.3-7.8 7.5		0.003-1.79 1.13	4.25-7.31 5.3	0.09-2.65 0.97			7.3-7.8 7.5	[4-6]
5	May,Jul,Sept. 2007	18.7-22.23	7.95-8.89 8.43	0.12-2.15 0.21					1.8-162.2 19.44	8.05-11.61 9.66	[7-9]
6	May-08		8.37-8.89 8.6	0.13-0.16 0.14						8.05-10.75 8.77	[7]
7	Jan-Feb,May-Jun,Aug,Oct 2010		7.42-7.97 7.77	0.185-0.55 307.29						6.6-14.84 10.93	[10]
8	2010						0.5-0.7 0.6	0.07-0.08 0.075			[11]
9	Jan,May-Sept. 2011						0.4-2.45 0.92	0.04-0.22 0.15			[11,12]
10	Sept. 2012		6.9-9.62 7.58		0.14-0.7 0.26	0.16-44.48 7.79	0.49-8.35 2.87	0.01-0.38 0.12	6-117 18.6	8.07-15.57 12.18	[13]
11	2012-2014		5.86–9.62 7.43	33.9-260.1 194.33	0.00–0.9 0.17	0.16–85.60 7.68	0.16–12.29 1.63	0.01–0.97 0.11	1.03–65.13 7.62	0.11–14.21 6.45	[14]
12	May,Jul-Nov 2013		6.19-9.4 8.94	0.02-0.24 0.18	0.001-0.02	2.24-78.5 48.74	0.38-5.55 1.39	0.03-0.18 0.09	1.19-99.98 33.33	1.38-12.29	[15-21]
13	Apr,May,Sept.-Dec 2014		7.85-9.41 8.5	0.25 0.25	0.01-0.87	31.66 31.66	0.76-1.81 1.23	0.07-0.29 0.12	2.7-9.1 5.72	4.05-4.21 4.11	[16,22-24]
14	2013-2014		8.17	0.17		42.2	1.38	0.11			[25,26]
15	Jul-Sept. 2015	15.61-16.63 16.13	7.6-7.94 7.67		0.20-0.46	18.34-20.7 19.59	0.63-2.3 1.5		3.45-5.42 4.46	7.1-9.16 8.47	[27,28]
16	Jul,2016		8.12							7.94	[29]

Table A1 (continued)

NO.	Period	WT/℃	pH	EC/ μs/cm	NH_3-N/ mg/L	COD/ mg/L	TN/ mg/L	TP/ mg/L	Chl-a/ μg/L	DO/ mg/L	Reference
17	May,Jul,Sept. ,Oct 2018					37.22-111.9	1.28-1.79	0.07-0.12			[30,31]
						49.93	1.49	0.1			
18	2011-2018	15.66-19.67	5.86-8.71	315.34-763.2	0.01-2.64	1.6-93.35	0.26-4.47	0.01-1.07			[32]
	2011	15.8-16.4	6.52-8.21	490.3-610.1	0.05-2.64	1.6-41.7	0.6-4.47	0.01-1.07			
		16.3	7.37	562.51	0.8	14.84	2.01	0.29			
	2012	16.4-18.6	6.34-7.37	624.8-763.2	0.01-0.5	7.57-49.57	0.35-2.41	0.04-0.15			
		17.16	6.89	715.09	0.14	24.13	1.1534	0.102			
	2013	15.66-17.43	6.01-7.71	428.9-532.3	0.03-0.45	7.38-32.45	0.58-3.53	0.03-0.14			
		16.47	6.83	480.83	0.14	15.76	1.29	0.07			
	2014	15.73-17.83	5.88-7.67	419.9-490.8	0.01-0.34	8.86-93.35	0.39-2.71	0.01-0.19			
		17.02	6.82	443.24	0.13	25.96	1.31	0.09			
	2015	17.2-18.07	6.52-8.33	447.9-494.4	0.08-0.32	3.7-19.6	0.33-1.53	0.02-0.13			
		17.61	7.43	468.78	0.14	12.45	0.76	0.06			
	2016	17.19-19.37	5.86-8.71	394.96-500.66	0.03-0.26	3.7-42.5	0.37-1.55	0.04-0.13			
		18.17	7.15	450.11	0.11	14.73	0.78	0.08			
	2017	17.47-19.17	6.35-8.53	315.34-643.5	0.05-0.26	3.7-21.4	0.26-1.11	0.03-0.13			
		18.26	7.14	522.4	0.13	13.12	0.61	0.07			
	2018	16.63-19.67	6.36-8.41	458.4-573.8	0.05-0.76	10.7-22.1	0.3-1.41	0.02-0.14			
		18.28	7.39	522.86	0.21	15.65	0.8	0.06			
19	Oct 2020						0.85-1.37	0.12-0.2	1.46-4.51		[33]
							1.11	0.17	2.56		
20	Aug-Nov 2021	16.75-19.33	9.93-11.4	136.1-257.2	0.05-0.19	3.47-5.72	0.34-9.66	0.04-0.36	0.81-346.44	8.79-10.99	[34,35]
		17.88	10.65	176.26	0.07	4.36	1.15	0.15	57.92	9.65	
21	Jan,May 2022			61.31-270.29	0.001-0.24	2.94-5.75	0.18-3.46	0.03-0.2	3.28-380.4	12.81-18.35	[35,36]
				127.99	0.07	4.12	1.08	0.14	72.18	12.37	

Table S2. Supplementary measurements of sediment pollution measurements for Xingkai Lake.

NO.	period	TN/ mg/kg	TP/ mg/kg	Mn/ mg/kg	Cr/ mg/kg	Ni/ mg/kg	Cu/ mg/kg	Zn/ mg/kg	As/ mg/kg	Cd/ mg/kg	Pb/ mg/kg	Hg/ mg/kg	Reference
1	2011			650	75.95	23.35	19.65	60.35		0.14	21.63		[37]
2	Jul 2013	188.73-3224.79	181.02-805.73										[19,20]
		1676.54	478.64										
3	Sept. 2016		84.76-1421.79	330									[38]
			655.71										
4	Sept. 2018		84.76-1305										[30]
			495.85										
5	Jul 2021	210.30-4718.41	14.41-1272.23		28.6-73.8	11.6-32.9	9-29.1	17-59.7	2.9-13.2	0.08-0.2	14.2-22.8	0.01-0.13	[39,40]
		1053.34	229.47		55.3	24.1	16.7	42.9	6.7	0.13	18.65	0.05	
6	Jan,May,Jul,Sept. 2021	256.5-12361	142.9-1989		28.58-262.3		3.12-28.05	18.21-90.73	2.58-14.35	0.05-0.21	10.87-58.85	0.003-0.14	[34]
		1474	563.3		60.31		11.8	47.17	9.21	0.13	19.09	0.04	

This additional information includes the range and average

Table S3. Relative weights and standard values for each water quality factor

Parameter	**Relative weight** P_i	**Environmental quality standards for surface water**				
		$I_{i,1}$ = 20	$I_{i,2}$ = 40	$I_{i,3}$ = 60	$I_{i,4}$ = 80	$I_{i,5}$ = 100
pH	1	6~9				
Water temperature/（℃）	1	12 ~22	10 ~28	0~32	-4~36	-6~45
EC(us/cm)	1	≤75	75~150	150~200	200~500	>500
TN（mg/L）	4	≤0.2	≤0.5	≤1	≤1.5	≤2
TP（mg/L）	3	≤0.01	≤0.025	≤0.05	≤0.1	≤0.2
NH_3-N（mg/L）	3	≤0.15	≤0.5	≤1	≤1.5	≤2
COD（mg/L）	2	≤15	≤15	≤20	≤30	≤40

For pH, when pH ∈ [6,9],I_i= 0, and vice versa, I_i= 1

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