КОРРЕЛЯЦИОННЫЙ АНАЛИЗ СТАБИЛЬНОСТИ КАЧЕСТВА ПОДЗЕМНЫХ ВОД В РЕКЕ ХЭЙХЭ

CORRELATION ANALYSIS OF THE STABILITY OF GROUNDWATER QUALITY IN THE HEIHE RIVER

УДК 550

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Аннотация: Стабильность качества подземных вод - важный показатель для оценки качества подземных вод. В низовьях реки Хэйхэ в Китае экологическая среда является плохой, это засушливая и полузасушливая территория на материке. Местные грунтовые воды являются основным источником воды для дома. Для обеспечения стабильности качества подземных вод путем расчета индекса устойчивости подземных вод делается вывод, что стабильность качества подземных вод в этой области очень низкая. Подземные воды слабощелочные. В этом документе для корреляционного анализа Пирсона будут использоваться уровень грунтовых вод в скважине за 2012 год, содержание воды в почве, гидравлическая проводимость и другие показатели, а также результаты стабильности качества подземных вод, результаты показывают, что стабильность качества подземных вод и корреляция уровня грунтовых вод в скважине GW13 сильная, индикаторы почвы и грунтовые воды. качество корреляции плохое.

Annotation: The stability of groundwater quality is an important index to evaluate the quality of groundwater. In the lower reaches of the Heihe River in China, the ecological environment is poor, which is an arid and semi-arid area on the mainland. Local groundwater is the main source of domestic water for people. to ensure the stability of groundwater quality, through the calculation of groundwater stability index, it is concluded that the stability of groundwater quality in this area is very poor. The groundwater is weakly alkaline. This paper will use the 2012 groundwater borehole water level, soil water content, hydraulic conductivity and other indicators and groundwater quality stability results for Pearson correlation analysis, the results show that groundwater quality stability and GW13 borehole groundwater level

correlation is strong, soil indicators and groundwater quality correlation is poor.

Ключевые слова: низовья реки Хэйхэ, подземные воды, стабильность качества воды, корреляция

Key words: lower reaches of Heihe River, groundwater, water quality stability, correlation

Data source

Using the results of 49 groundwater quality tests in Heihe River Basin in 2012 as research samples,[1] the correlation between the physical properties of soil profile and the depth of groundwater level was analyzed. The main imaging factors of groundwater quality in the lower reaches of Heihe River Basin are discussed.

Table 1 conventional ion content (mg/l) of groundwater in the lower reaches of Heihe River [1]

Образец серийного номера	F	Cl	N	SO	Na	K	Mg	Ca	HCO	CO	pH
1#	/	49.4	3.63	173	53.4	5.75	39	39.3	151	/	8.13
2#	0.31	179	3.58	320	166	9.2	26.5	83.9	119	/	8.14
3#	0.49	1035	62.4	2973	1207	50.5	465	126	643	/	8.01
4#	1.36	138	12.5	1429	174	13.7	96.4	388	196	/	7.77
5#	0.65	170	25.2	695	244	18.6	180	48.8	535	4.51	8.33
6#	/	335	6.4	924	316	28	176	121	387	/	8.15
7#	3.35	4533	241	4009	3480	62	164	845	163	/	8.03
8#	0.68	279	0.79	1268	380	22.6	190	91.6	277	5.08	8.42
9#	/	2619	31.5	2529	1655	39	115	793	118	/	7.96
10#	3.26	1164	1.48	1356	1011	13.2	36.6	282	154	/	8.18
11#	2.25	787	39	1328	820	22.5	49	220	163	/	8.18
12#	/	85.5	4.82	369	138	9.1	69.5	71.1	277	1.69	8.29
13#	/	22099	55	11148	20400	2250	210	285	1574	3293	9.58
14#	6.67	168	0.75	208	179	16.8	39.1	49.3	206	28.8	8.4
15#	1.38	937	/	98.5	843	83.8	51.2	78.6	861	58.7	8.49
16#	4.46	166	0.39	27.2	183	9.1	14.9	65.9	408	/	7.99
17#	1.19	444	36.8	601	466	11.4	21.2	102	139	5.08	8.4
18#	/	427	3.75	593	416	19.5	29.5	119	133	/	8.09
19#	1.56	200	33.3	354	267	7.4	18.8	70.8	202	6.21	8.55
20#	/	1318	1.81	1756	1124	52	102	326	295	/	8.05
21#	/	5848	6.1	4126	4610	140	220	774	539	/	8.08
22#	/	1001	18.3	1144	862	41	59	265	112	/	8.17
23#	43.5	10895	/	6887	8060	105	308	1056	154	/	8.18
24#	1.4	573	3.62	1222	705	13.4	48.6	212	199	4.51	8.36
25#	/	586	5.85	749	618	24.5	38	143	227	6.77	8.56
26#	/	820	6.95	912	779	21	36	142	251	6.77	8.58
27#	/	3309	4.3	2280	2460	/	74	540	135	/	8.23
28#	4.1	3386	7	2849	2586	76	56	598	48	/	7.48
29#	/	672	34.5	2029	1010	/	41	302	108	15.5	8.37
30#	2.95	381	30.9	981	586	/	27.5	125	124	1.13	8.32
31#	2.9	296	4.35	428	396	10	16.6	38.1	239	2.82	8.51
32#	0.2	47.1	2.18	224	62.5	5.4	53.7	48	196	3.39	8.56
33#	/	2049	4	1853	1607	38	88	352	181	1.13	8.29
34#	/	2070	24	1837	1558	27.5	59	486	95	/	8.18
35#	/	666	2.7	1605	906	23.5	62	205	222	21	8.55
36#	/	679	31	1332	814	22.5	46	195	130	/	8.22
37#	/	3954	/	3684	2978	94	200	734	20	/	7.04
38#	7.3	220	26.1	328	487	5	5	12.5	424	28.8	8.82
39#	0.85	207	1.07	180	187	9	18.2	77.5	235	23.4	8.64
40#	3.9	1386	/	1303	1032	53	30	349	42	/	7.52
41#	2.8	2535	61.6	3342	2466	108	162	534	662	/	7.78
42#	0.76	314	/	896	428	15.4	95.6	94.7	301	4.51	8.53
43#	0.64	383	/	545	282	11.6	86.6	94	173	/	8.17
44#	/	671	/	1120	438	24.5	64.5	348	137	/	7.96
45#	/	1191	1.4	746	919	35	171	210	893	/	7.79
46#	/	659	1.3	1175	591	35	132	314	563	1.13	8.3
47#	0.76	328	18.3	614	362	9.4	34.4	130	113	/	7.98
48#	0.36	135	7.86	534	182	12	107	105	319	37.7	8.46
49#	2.31	119	21.5	127	176	15.3	16.7	16.9	187	11.7	8.51

The basic condition of electrolytic solution is electrically neutral, that is, cationic

charge and anionic charge are equal in total, and its mathematical expression is ∑ Zmc= ∑ Zma (Formula 1): Z is the number of ionic charges, mc and ma are the molar concentrations of cations and anions, respectively. The above equation is called the charge balance equation. As a complex electrolytic solution, groundwater also follows the charge balance equation, and its electrical neutrality equation is usually expressed in the form of constant components, that is, $(Na^{+}) + (K^{+}) + 2\,(Ca^{2+}) + 2\,(Mg^{2+}) = (Cl^{-}) + (HCO^{3-}) + (NO^{3-}) + 2\,(SO_4^{2-})$ (formula 2) [2] [3] parentheses represent ion molar concentration. Since the chemical components in groundwater include not only constant components but also trace components, the two sides of the above formula can only be approximately equal. In practical application, the charge balance equation is usually used to check the accuracy of the main ion analysis results, that is, E% = (∑ Zmc, ∑ Zma/ ∑ Zmc+ ∑ Zma) × 100% (formula 3), where E is the charge balance error (%). In general, an absolute value of E less than 5% is allowed, and if the error exceeds 5%, the sampling and analysis process needs to be checked. In this study, the old hot spring data of Eryuan were selected to analyze the ions, including all the constant ions in the charge balance equation, and the results showed that the absolute value of the charge balance error E of all samples was less than 5%. The errors caused by artificial sampling and sample detection are excluded [4] [5].

Table 2 groundwater ion balance table

Образец серийного номера	1#	2#	3#	4#	5#	6#	7#
∑ Zmc	215.75	396	2439.5	1156.5	720.2	938	5560
∑ Zma	550.03	941.58	7686.4	3204.5	2120.2	2576.4	12955
E %	-43.65%	-40.79%	-51.82%	-46.96%	-49.29%	-46.62%	-39.94%
Образец серийного номера	8#	9#	10#	11#	12#	13#	14#
∑ Zmc	965.8	3510	1661.4	1380.5	428.3	23640	372.6
∑ Zma	3092.79	7826.5	4031.48	3645	1105.32	46024	790.75
E %	-52.41%	-38.08%	-41.63%	-45.06%	-44.15%	-32.13%	-35.94%
Образец серийного номера	15#	16#	17#	18#	19#	20#	21#
∑ Zmc	1186.4	353.7	723.8	732.5	453.6	2032	6738
∑ Zma	1995	628.79	1821.8	1749.75	1143.3	5126.81	14645.1
E %	-25.42%	-28.00%	-43.13%	-40.98%	-43.19%	-43.23%	-36.98%
Образец серийного номера	22#	23#	24#	25#	26#	27#	28#
∑ Zmc	1551	10893	1239.6	1004.5	1156	3688	3970
∑ Zma	3419.3	24823	3219.62	2316.85	2901.95	8008.3	9139
E %	-37.59%	-39.00%	-44.40%	-39.51%	-43.03%	-36.94%	-39.43%
Образец серийного номера	29#	30#	31#	32#	33#	34#	35#
∑ Zmc	1696	891	515.4	271.3	2525	2675.5	1463.5
∑ Zma	4872.5	2497.9	1395.35	693.28	5940	5863	4100.7
E %	-48.36%	-47.42%	-46.05%	-43.75%	-40.34%	-37.33%	-47.40%
Образец серийного номера	36#	37#	38#	39#	40#	41#	42#
∑ Zmc	1318.5	4940	527	387.4	1843	3966	824
∑ Zma	3504	11342	1326.1	803.07	4034	9942.6	2407
E %	-45.32%	-39.32%	-43.12%	-34.92%	-37.28%	-42.97%	-48.99%
Образец серийного номера	43#	44#	45#	46#	47#	48#	49#
∑ Zmc	654.8	1287.5	1716	1518	700.2	618	258.5
∑ Zma	1646	3048	3577.4	3573.3	1687.3	1529.86	581.5
E %	-43.08%	-40.61%	-35.16%	-40.37%	-41.34%	-42.45%	-38.45%

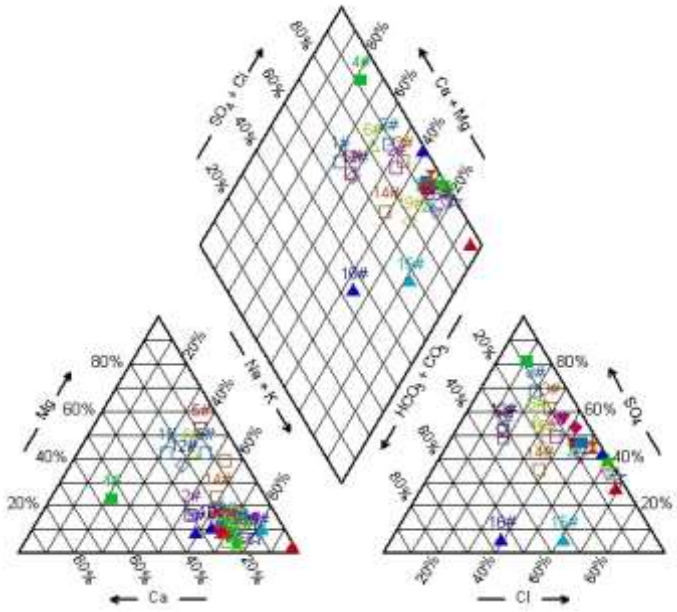


Fig. 1 piper diagram of groundwater chemistry

Research methods

In this paper, Langlier saturation index and Reizner stability index are used to predict the stability of calcium carbonate in groundwater solution.

LSI=pH-pHs (Formula 4).

The pH value is the pH value of the measured water sample, and pHs is the pH, when the water sample solution is in equilibrium, which is calculated according to temperature, alkalinity, hardness, and total solubility value.

Rizner stability index = 2pHs-pH (Formula 5) [6]

Table 3 Stability table of groundwater quality in the lower reaches of Heihe River

Образец серийного номера	pH	pHS	Индекс Ланжере	Индекс Ризнера	SI-кальцит	Образец серийного номера	pH	pHS	Индекс Ланжере	Индекс Ризнера	SI-кальцит
1#	8.13	7.92	0.21	0.33	7.71	25#	8.56	7.23	1.33	1.94	5.9
2#	8.14	7.31	0.83	1.09	6.48	26#	8.58	7.31	1.27	1.85	6.04
3#	8.01	7.49	0.52	1.59	6.97	27#	8.23	6.76	1.47	1.74	5.29
4#	7.77	6.67	1.1	1.49	5.57	28#	7.48	7.01	0.47	0.55	6.54
5#	8.33	8.04	0.29	1.45	7.75	29#	8.37	6.99	1.38	1.59	5.61
6#	8.15	7.37	0.78	1.56	6.59	30#	8.32	7.27	1.05	1.29	6.22
7#	8.03	6.61	1.42	1.72	5.19	31#	8.51	7.96	0.55	0.62	7.41
8#	8.42	7.57	0.85	1.66	6.72	32#	8.56	7.81	0.75	1.44	7.06
9#	7.96	6.64	1.32	1.58	5.32	33#	8.29	6.83	1.46	1.8	5.37
10#	8.18	6.88	1.3	1.61	5.58	34#	8.18	6.85	1.33	1.54	5.52
11#	8.18	6.96	1.22	1.54	5.74	35#	8.55	7.08	1.47	1.95	5.61
12#	8.29	7.55	0.74	1.44	6.81	36#	8.22	7.06	1.16	1.42	5.9
13#	9.58	9.56	0.02	2.91	9.54	37#	7.04	7.27	-0.23	-0.27	7.5
14#	8.4	7.68	0.72	1.32	6.96	38#	8.82	8.77	0.05	1.23	8.72
15#	8.49	8.32	0.27	1.94	8.15	39#	8.64	7.63	1.01	1.77	6.62
16#	7.99	7.53	0.46	1.31	7.07	40#	7.52	7.14	0.38	0.45	6.76
17#	8.4	7.26	1.14	1.5	6.12	41#	7.78	6.7	1.08	1.94	5.62
18#	8.09	7.15	0.94	1.24	6.21	42#	8.53	7.61	0.92	1.71	6.69
19#	8.55	7.57	0.98	1.57	6.59	43#	8.17	7.31	0.86	1.24	6.45
20#	8.05	6.79	1.26	1.79	5.53	44#	7.96	6.77	1.19	1.48	5.58
21#	8.08	6.51	1.57	2.21	4.94	45#	7.79	7.26	0.53	1.7	6.73
22#	8.17	6.99	1.18	1.4	5.81	46#	8.3	7.07	1.23	2.19	5.84
23#	8.18	6.61	1.57	1.82	5.04	47#	7.98	7.13	0.85	1.09	6.28
24#	8.36	6.99	1.37	1.8	5.62	48#	8.46	7.52	0.94	1.77	6.58
						49#	8.51	8.21	0.3	0.96	7.91

The results show that according to Langerre index 37#, the groundwater reaches equilibrium with calcite, and the groundwater in other places is prone to scaling and the stability of water quality is poor. According to the Reizner stability index, it is calculated that the corrosive water quality is easy to be corroded, while the other areas are easy to form fouling, while according to the stability index of Reizner, it is easy to corrode water quality, such as 1#、2#、3#、5#、6#、8#、12#、13#、14#、15#、16#、17#、18#、19#、26#、28#、30#、31#、32#、37#、38#、39#、40#、42#、43#、45#、47#、48#、49#. The spatial distribution is shown in the picture.

[6]

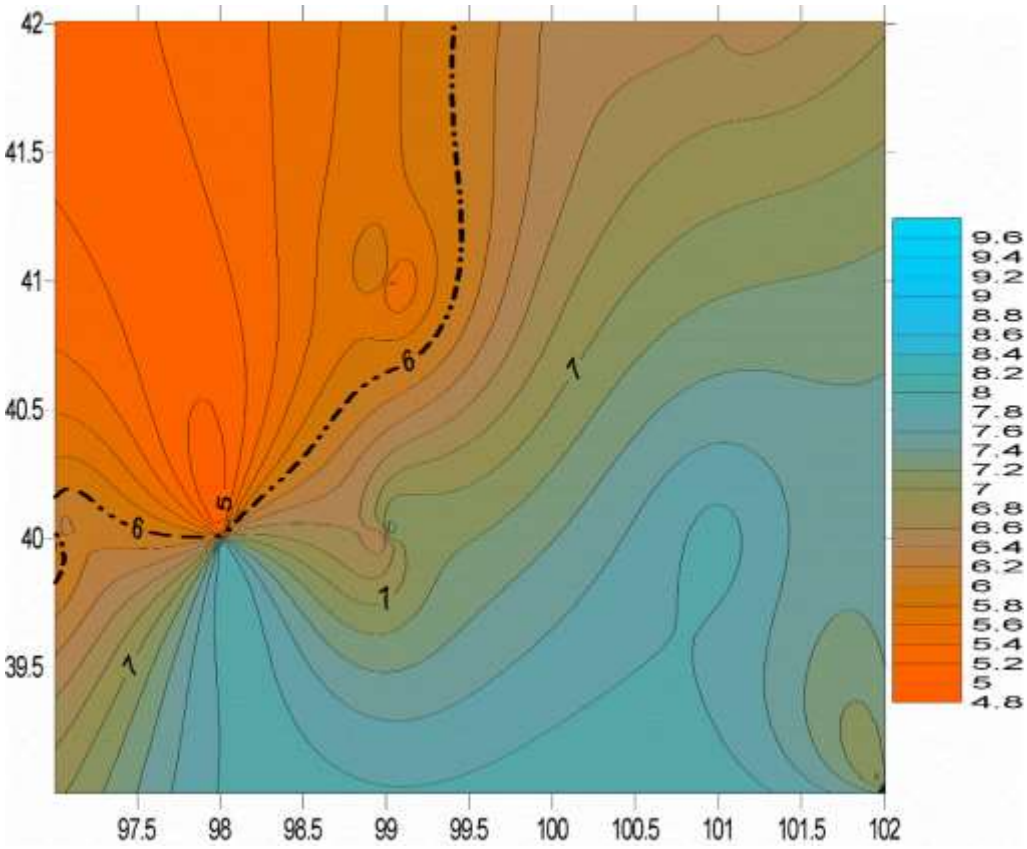
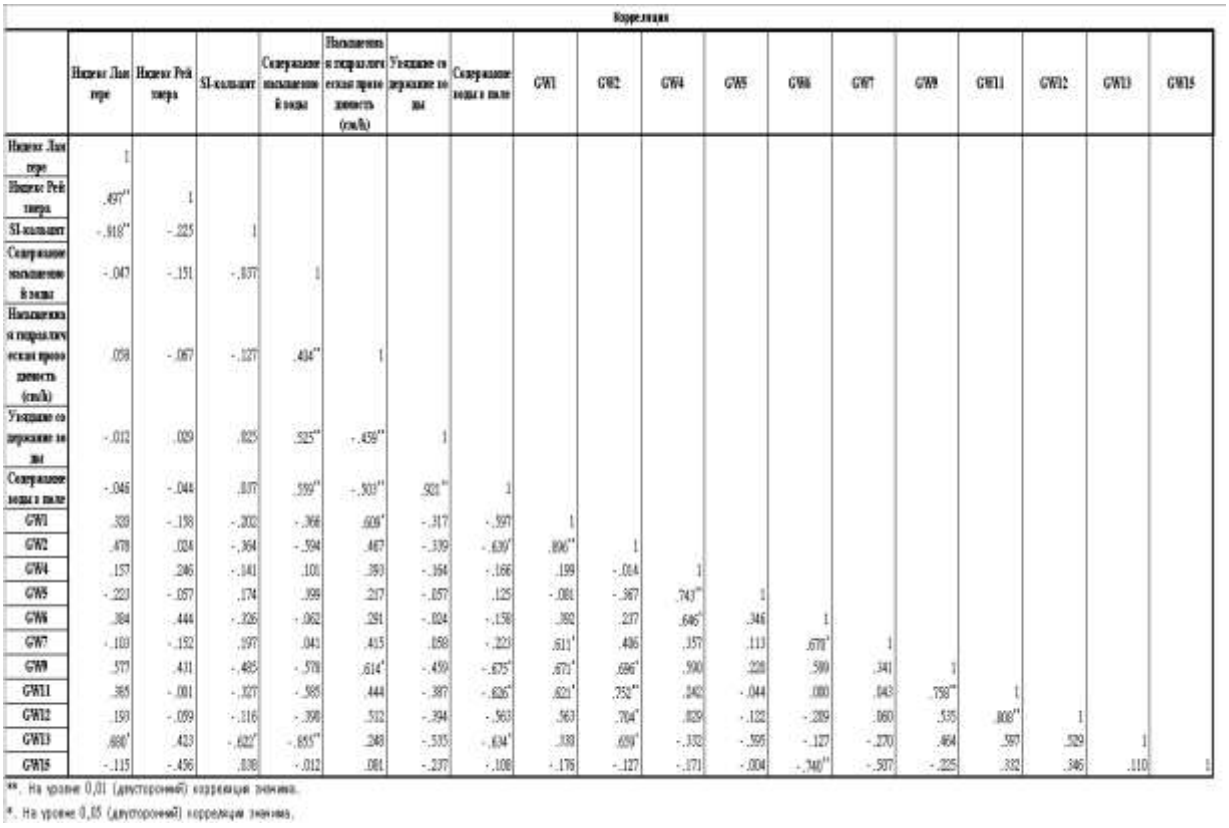


Fig. 2 Distribution map of groundwater quality stability in the lower reaches of Heihe River

The following results are obtained by Spss Pearson correlation analysis.

Table 4 Pearson correlation table



Корреляции

	Индекс Ланжелье	Индекс Рейзнера	SI-кальцит	Содержание насыщенной воды	Насыщенная гидравлическая проводимость (cm/h)	Увядание содержание воды	Содержание воды в поле	GW1	GW2	GW4	GW5	GW6	GW7	GW9	GW11	GW12	GW13	GW15
Индекс Ланжелье	1																	
Индекс Рейзнера	,497**	1																
SI-кальцит	-,918**	-,225	1															
Содержание насыщенной воды	-,047	-,151	-,037	1														
Насыщенная гидравлическая проводимость (cm/h)	,058	-,067	-,127	,404**	1													
Увядание содержание воды	-,012	,029	,025	,525**	-,459**	1												
Содержание воды в поле	-,046	-,044	,037	,599**	-,503**	,921**	1											
GW1	,320	-,138	-,202	-,366	,609*	-,317	-,397	1										
GW2	,478	,024	-,364	-,594	,467	-,379	-,639*	,896**	1									
GW4	,157	,246	-,141	,101	,393	-,364	-,166	,199	-,014	1								
GW5	-,220	-,057	,174	,399	,217	-,057	,125	-,081	-,367	,743**	1							
GW6	,384	,444	-,326	-,062	,281	-,024	-,158	,392	,237	,646*	,346	1						
GW7	-,103	-,152	,197	,041	,415	,058	-,223	,611*	,486	,357	,113	,678*	1					
GW9	,577	,431	-,485	-,578	,614*	-,459	-,675*	,671*	,696*	,500	,228	,589	,341	1				
GW11	,365	-,001	-,327	-,585	,444	-,397	-,626*	,621*	,752**	,242	-,044	,080	,043	,758**	1			
GW12	,193	-,059	-,116	-,398	,512	-,394	-,563	,563	,704*	,829	-,122	-,289	,060	,535	,808**	1		
GW13	,668*	,423	-,622*	-,655**	,248	-,535	-,634*	,388	,659*	-,332	-,595	-,127	-,270	,464	,597	,529	1	
GW15	-,115	-,456	,398	-,012	,081	-,237	-,108	-,176	-,127	-,171	-,004	-,740**	-,597	-,225	,332	,346	,110	1

**. На уровне 0,01 (двусторонний) корреляция значима.

*. На уровне 0,05 (двусторонний) корреляция значима.

From the correlation results, it can be seen that Langerre index has strong correlation with Reizner stability index and SI- calcite and has correlation with GW13 groundwater level; SI- calcite has correlation with GW13 groundwater level; saturated water content has correlation with saturated hydraulic conductivity (cm/h), withering water content, field water content and GW13 groundwater level. Saturated hydraulic conductivity (cm/h) was correlated with withered water content, field water content and GW1; litter water content was correlated with field water content, and field water content was correlated with GW2, GW9, GW11 and GW13.

Conclusion

The groundwater in the lower reaches of Heihe River is mostly alkaline water (Ph > 7) with strong scaling ability. The stability of its water quality is poor. Through Pearson correlation analysis. The groundwater level of boreholes in the lower reaches of Heihe River has a strong correlation, and the groundwater of GW13 borehole is highly sensitive, which is strongly correlated with Langlier index,

Reizner stability index and SI- calcite, and the saturated water content is correlated with saturated hydraulic conductivity (cm/h), withering water content, field water content and GW13 groundwater level.

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