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Quality Evaluation of Geothermal Fluid in the Lindian Area of the Songliao Basin

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Abstract: The quality of geothermal fluids determines their direction of use, and in the past, the evaluation of geothermal fluid quality mainly focused on single well evaluation or local area evaluation. This article uses 5 pieces of geothermal water chemistry data to conduct quality evaluation of geothermal fluids in the Lindian area, mainly including medical thermal mineral water quality evaluation, drinking mineral water evaluation, domestic drinking water evaluation, fishery water evaluation, agricultural irrigation water evaluation, and geothermal fluid corrosiveness and scaling tendency evaluation. The evaluation results show that the geothermal wells in the study area are not suitable for developing drinking mineral water; Not suitable as drinking water for daily use; It cannot be directly used as irrigation water evaluation; Suitable for medical hot mineral water development and aquaculture; Geothermal fluids are all non-corrosive water with minimal fouling, and can be used for geothermal heating after treatment.

Keywords: Geothermal Fluid; Water Chemistry; Lindian Area; Quality Evaluation.

1. Introduction

Geothermal fluid is a hot mineral water resource rich in heat, water, and minerals, and its formation is related to factors such as the migration, evolution, and redistribution of chemical elements in the environment. At the same time, geothermal water is also a recognized clean, environmentally friendly, and multifunctional green resource both domestically and internationally. It can not only be used for power generation, heating, fisheries, etc., but also is rich in special chemical components, mineral salts, trace elements, gas components, and radioactive elements that are beneficial to human health, and has certain therapeutic value. The Lindian area is located in the northern part of the Songliao Basin and is a famous "hometown of hot springs" in China. The area has favorable geological conditions for the formation of geothermal resources. The highland temperature field can provide energy security for the Lindian region; There are two deep depressions in the regional structure, Wuyuer and Heiyupao, which are the central areas of groundwater infiltration and convergence on the three sides of the east, west, and north; The high porosity and permeability sand bodies in the northern source provide a good space for hot water storage in this area; The multiple rivers in the Xing'an Mountains on the outer side of the basin provide sufficient water supply for the geothermal field. However, the overall therapeutic efficacy and applicable pathways of geothermal water in the Lindian area are not yet clear, and there is an urgent need to conduct geothermal fluid quality evaluation based on relevant standards. Therefore, this study evaluated the use, corrosiveness, and scaling of geothermal water in multiple locations in the Lindian area through analysis and research, providing strong support for the development and utilization of geothermal water resources in the area.

2. Geological Overview

The Lindian region is located in Lindian County, Daqing City, Heilongjiang Province, belonging to the Paleo Asian tectonic domain. Based on deep structural zoning, it is located in the Songnen upper mantle uplift area, with a Moho depth of 30-32km There is a mirror image relationship between the uplift of the Moho surface and the thickness of the sedimentary cover. Extremely developed faults in the Lindian area There are two main faults in the work area and its vicinity: the Lindian Fault (L1) and the Lindian East Fault (L2). The geothermal field in Lindian Town is a medium to low temperature geothermal field Structurally, it is located in the contact zone between the Keshan Yilong Anticline, Wuyuer Depression, and Heiyupao Depression, as shown in Figure 1. The stratigraphic sequence of the geothermal field in Lindian Town consists of the Carboniferous Permian (basement), Jurassic, Cretaceous Denglouku Formation, Quantou Formation, Qingshankou Formation, Yaojia Formation, Nenjiang Formation, Sifangtai Formation, Mingshui Formation, and Tertiary Yi'an Formation from bottom to top; The Quaternary Taikang Formation, Lindian Formation, and Daxingtun Formation.

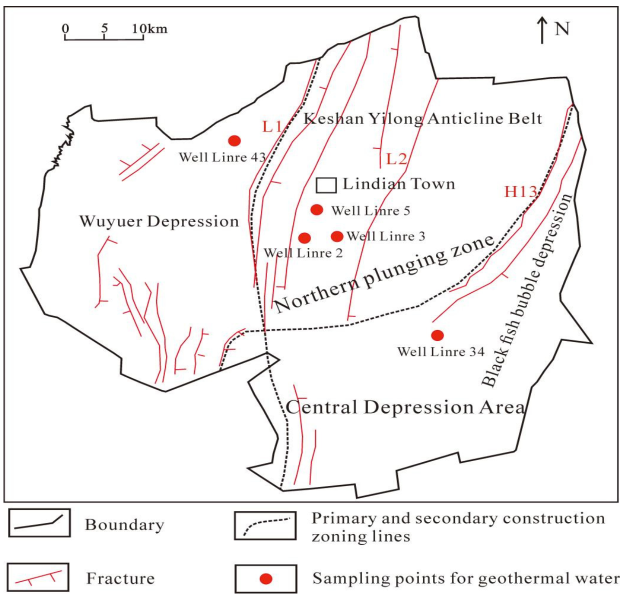

Figure 1. Distribution map of sampling points in the study area

According to the previous exploration data, the main thermal reservoir of the Lindian Town geothermal field is the medium sandstone, fine sandstone and siltstone of the Mesozoic Cretaceous Yaojia Formation, Qingshankou Formation and Quantou Formation III and IV, with the buried depth of the roof of 924~1324m. Among them, the second and third members of Qingshankou Formation and the third and fourth members of Quantou Formation are the main thermal reservoirs of the geothermal field.

3. Materials and Methods

A total of 5 geothermal water samples were collected for this geothermal fluid quality assessment. The samples were evenly distributed in the study area and the sampling time was relatively short, of which well Linre 2 was collected on August 12, 2003 for a long time. The full analysis indicators of water chemistry were tested by the laboratory of geological engineering Survey Institute of Beijing, and the test implementation standard was Drinking Natural Mineral Water Quality Standard (GB/T 8538-1995); The sampling time of Well Linre 3 and Well Linre 5 was on May 23, 2012. The full hydrochemical analysis index was tested by Harbin Mineral Resources Supervision and Testing Center of the Ministry of Land and Resources. In the same year, the full hydrochemical analysis index of Well Linre 34 and Well Linre 43 was tested by the laboratory of Heilongjiang Hydrological geological engineering Geological Survey Institute. The test standard was the Drinking Natural Mineral Water Quality Standard (GB/T 8538-2008). Based on the comprehensive analysis of water quality data, this evaluation of geothermal fluid quality includes evaluation of physical therapy hot mineral water, evaluation of drinking natural mineral water, evaluation of agricultural irrigation water, evaluation of fishery water, and evaluation of corrosiveness and scaling trend.

4. Results and Discussion

4.1. Hydrochemical Characteristics

The main ion results of the full analysis of hydrochemistry are shown in Table 1. The cations are mainly Na^+, with a content of 159.5-896mg/L and an average value of 641.73mg/L; The anions are mainly HCO_3^- and Cl^-, with HCO_3^- content ranging from 134 to 1312.3mg/L, with an average value of 850.7mg/L; The Cl^- content is 96.3-780mg/L, with an average value of 452.1mg/L.

Table 1. Main ion content of water samples in the study area

Well No.	K+	Na^+	Ca^{2+}	Mg^{2+}	HCO_3^-	CO_3^{2-}	Cl^-	SO_4^{2-}	F^-	NO_3^-
	mg/L									
Well Linre 2	9.4	896.0	4.0	1.2	921	54.0	780.0	0.4	1.3	1.5
Well Linre 3	2.9	732.2	4.9	0.8	1312.3	2.7	380.3	7.9	8.0	<0.2
Well Linre 5	3.1	761.9	5.4	1.3	1262.1	0	434.8	3.9	7.0	0.5
Well Linre 34	7.0	159.5	3.0	1.2	134.0	47.9	96.3	49.0	3.5	17.2
Well Linre 43	3.8	659.0	4.0	0	624.2	74.9	569.2	22.5	0.7	6.2

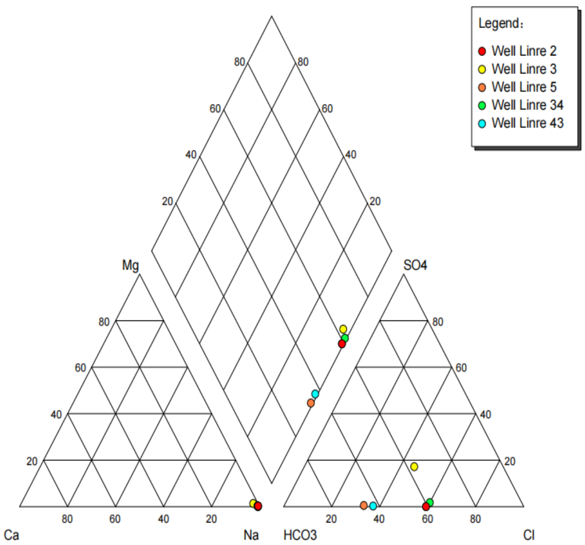

Figure 2. Piper three-line diagram of geothermal chemistry in the study area

The Na^+, K^+, Mg^{2+}, Ca^{2+}, HCO_3^-, CO_3^{2-}, Cl^-, and SO_4^{2-} milligram equivalent percentages of the hydrochemical data in the study area were projected onto the Piper triline map (Figure 2), and the water samples in the study area were classified and named using the Schukalev classification method (Table 2). The results show that the hydrochemical types of geothermal water in the study area are mainly $Cl·HCO_3$-Na type and $HCO_3·Cl$-Na type. Among them, the hydrochemical types of Well Linre 3 and Well Linre 5 are $HCO_3·Cl$-Na, mainly affected by the mixing of shallow cold water. Well Linre 34 and Well Linre 43 are oxidized by H_2S during migration, resulting in an increase in the concentration of SO_4^{2-} in geothermal water.

4.2. Evaluation of Geothermal Water Usage

4.2.1. Medical Thermal Mineral Water Evaluation

According to Appendix C of the "Code for Geological Exploration of Geothermal Resources" (GB/T 11615-2010), the water quality standards for medical mineral water were used to evaluate the hot water of five geothermal wells in the research area. The results are shown in Table 2. The fluorine concentration of geothermal water in the Lindian area has reached the standard for naming mineral water concentration, which can be classified as fluorine water. Except for the Linre 34 well, both boric acid and silicic acid in the area have reached the standard for mineral water concentration.

4.2.2. Evaluation of Drinking Natural Mineral Water

According to the "Water Quality Standard for Drinking Natural Mineral Water" (GB8537-2008), the water quality of hot mineral water in this area is evaluated. The evaluation results of boundary indicators are detailed in Table 3. The comprehensive evaluation results indicate that among the boundary indicators of the five geothermal wells in the study area, except for zinc element and free carbon dioxide, which did not meet the standards, all other projects belong to individual standards.

Table 2. Evaluation table of medical thermal mineral water in lindian region

Evaluating indicator	Well Linre 2		Well Linre 3		Well Linre 5		Well Linre 34		Well Linre 43	
	concentration	evaluation	concentration	evaluation	concentration	evaluation	concentration	evaluation	concentration	evaluation
fluorine	1.25	fluorine water	8.00	fluorine water	7.00	fluorine water	3.48	fluorine water	1.69	fluorine water
bromine	2.20		1.243		1.59		0.106		1.71	
iodine	0.45		0.487		0.667		0.050		0.50	
strontium	0.28		0.818		0.951		0.058		0.095	
lithium	0.21		0.147		0.149		0.019		0.436	
iron	3.20		<0.03		<0.03		1.377		38.63	molten iron
barium	0.248		0.391		0.397		0.189		0.495	
manganese	0.163		0.009		0.010		0.157		<0.01	
metaborate	10.6	conforming	4.227	conforming	4.159	conforming	4.348	conforming	17.734	conforming
metasilicate	31.4	conforming	33.04	conforming	30.24	conforming	39.63	conforming	11.35	conforming

4.2.3. Evaluation of Domestic Drinking Water

Evaluate drinking water according to the "Hygienic Standards for Drinking Water" (GB5749-2006). The results are shown in Table 5**.**

(1) Sensory traits

The chromaticity, turbidity, odor, and visible substances of the Linre 2, Linre 3, and Linre 5 wells in the research area meet the standards, while the Linre 34 and Linre 43 wells do not meet the standards.

(2) General chemical indicators

The pH, aluminum, iron, manganese, TDS, and oxygen consumption of geothermal water in the research area are all individually up to standard, with Fe^{2+}only below 0.3mg/L in the Linre 3 and Linre 5 wells, and others exceeding the standard.

Table 3. Evaluation table of boundary indicators for drinking natural mineral water in the lindian area

Testing items	Index	Well Linre 2	Well Linre 3	Well Linre 5	Well Linre 34	Well Linre 43	Evaluation
strontium	≥0.2	0.28	0.818	0.951	0.058	0.095	Individual compliance
lithium	≥0.2	0.21	0.147	0.149	0.019	0.436	Individual compliance
zinc	≥0.2	<0.001	0.00689	0.00375	0.0078	0.0258	Not meeting standards
bromide	≥1.0	2.20	1.243	1.59	0.106	1.71	Individual compliance
iodide	≥0.2	0.45	0.487	0.667	0.050	0.50	Individual compliance
metasilicate	≥25.0	31.4	33.04	30.24	39.63	11.35	Individual compliance
selenium	<0.05	0.0012	0.00205	0.00278	0.00048	0.00022	All meet the standards
free carbon dioxide	≥250	0.00	0.00	0.00	0.00	0.00	Not meeting standards
Total Dissolved Solids	≥1000	2680	2478.24	2504.02	553.32	2013.64	Individual compliance

Table 4. Comprehensive evaluation of domestic drinking water

Classification	Testing items	Index	Well Linre 2	Well Linre 3	Well Linre 5	Well Linre 34	Well Linre 43	Evaluation
organoleptic	chrominance	15	<2	<5	<5	370	450	Individual compliance
	turbidity	1	<1	<0.5	<0.5	50	150	
	smell and taste	No odor or odor	not have	not have	not have	Odor	not have	
	visible to the naked eye	not have	not have	not have	not have	Massive precipitation	Massive precipitation	
general chemical indicators	pH	6.5-8.5	8.38	8.40	8.30	8.62	8.79	Individual compliance
	aluminium	0.2	1.94	<0.01	<0.01	0.403	0.158	
	iron	0.3	3.2	<0.03	<0.03	1.377	38.63	
	manganese	0.1	0.163	0.009	0.010	0.157	<0.01	
	copper	1.0	<0.0008	0.0016	0.0014	<0.008	0.0136	Compliance
	zinc	1.0	<0.001	0.0069	0.0038	0.0078	0.0258	
	TDS	1000	2680	2478.24	2504.02	553.32	2013.64	Individual compliance
	total hardness	450	15	15.46	18.55	12.51	12.51	Compliance
	oxygen consumption	3	2.46	1.51	1.61	36.54	20.04	Individual compliance
	volatile phenol	0.002	<0.001	<0.002	<0.002	<0.002	<0.002	Compliance
toxicological indicators	arsenic	0.01	<0.002	0.0056	0.0018	0.00454	0.0029	
	cadmium	0.005	0.00125	0.00032	0.00035	0.0026	0.0043	
	chromium (hexavalent)	0.05	<0.001	<0.004	<0.004	<0.004	<0.004	
	lead	0.01	0.0083	0.00014	0.00013	<0.001	0.0016	
	mercury	0.001	0.00005	<0.0004	<0.0004	0.000122	0.00091	
	selenium	0.01	0.0012	0.0021	0.0028	0.00048	0.0002	
	cyanide	0.05	<0.001	<0.002	<0.002	<0.002	<0.002	
	Nitrate	10	<0.001	0.04	<0.002	—	—	

(3) Toxicological indicators

The detection items of geothermal water in the research area all meet the standards.

In summary, the sensory indicators and general chemical indicators of hot mineral water in the Lindian area do not meet the hygiene standards for drinking water and are not suitable for use as drinking water.

4.2.4. Evaluation of Agricultural Irrigation Water

According to the "Water Quality Standard for Agricultural Irrigation" (GB5084-2005), evaluate the agricultural irrigation water for geothermal water.

(1) Water temperature

The irrigation water temperature standard in the Northeast region ranges from 10 to 15 ℃, while the geothermal water temperature in the research area is generally around 50 ℃, which is not suitable for farmland irrigation and must be reduced through cascade utilization.

(2) Irrigation coefficient and salinity, alkalinity

Based on the irrigation coefficient Ka evaluation method and combined with domestic salinity and alkalinity evaluation methods, a comprehensive evaluation of geothermal water irrigation agriculture is conducted. Due to the calculation of NaCl, Na_2SO_4, and Na_2CO_3 in geothermal water, the following formula is used:

$$Ka = \frac{288}{10\gamma Na^{+} - 5\gamma Cl^{-} - 9\gamma SO_4^{\ 2-}} \quad (1)$$

$$Salinity = \gamma Cl^{-} + \gamma SO_4^{\ 2-} \quad (2)$$

$$Alkalinity = (\gamma HCO_3^{-} + \gamma CO_3^{\ 2-}) - (\gamma Mg^{2+} + \gamma Ca^{2+}) \quad (3)$$

In the formula, Ka is the irrigation coefficient; γ Is the milligram equivalent per liter of ion content, in mEq/L.

Table 5. Comprehensive evaluation of irrigation water Ka, Salinity, and Alkalinity

Well No.	*Ka*(L·(mmol)$^{-1}$)	*Ka* evaluation	Salinity, (mmol·L^{-1})	Alkalinity(mmol·L^{-1})	Salinity evaluation
Well Linre 2	1.03	1.2	22.01	14.80	Heavy salt alkaline water
Well Linre 3	1.09		11.89	21.29	
Well Linre 5	1.07		12.35	20.31	
Well Linre 34	6.18		3.74	3.54	Saline alkali water
Well Linre 43	1.42		16.52	12.53	Heavy salt alkaline water

The calculation results are shown in Table 5. The table shows that the Ka of four geothermal wells is less than 1.2, and only the forest heat 34 is greater than 1.2. It can be treated as an irrigation water source, and the water quality is saline alkali water - heavy salt alkali water. After irrigation, the soil quickly becomes saline alkali, which has a significant impact on the soil.

4.2.5. Assessment of Fishery Water Quality

According to the grading table for fish farming water quality evaluation and the fishery water quality standard (GB11607-89), a comprehensive evaluation of geothermal water in this area is conducted. The evaluation results are shown in Table 6, which shows that all 5 geothermal wells in the geothermal field of Lindian Town are of Class III and can be used for fishing water.

Table 6. Comprehensive evaluation of fishery water quality

Well No.	Fluoride(F)	Phenol	Arsenic (As)	Mercury (Hg)	Evaluate Results
Well Linre 2	1.25	<0.001	<0.002	<0.00005	III
Well Linre 3	8.00	<0.002	0.00554	<0.0004	III
Well Linre 5	7.00	<0.002	0.00179	<0.0004	III
Well Linre 34	3.48	<0.002	0.00454	0.000122	III
Well Linre 43	0.69	<0.002	0.00292	0.00091	III

4.2.6. Evaluation of the Corrosiveness of Geothermal Fluids

High temperature of geothermal water Contains multiple corrosive chemical components It often causes varying degrees of corrosion and damage to geothermal utilization equipment and pipes. The corrosive effect poses great harm to the boiler It not only shortens the service life of the boiler There is also a possibility of explosion accidents. Therefore, the corrosiveness of underground hot water in thermal reservoirs in the Lindian area is evaluated through the corrosivity coefficient in industry, providing a basis for the subsequent development and utilization of geothermal energy. The calculation steps for the corrosivity coefficient are as follows:

(1) Sour fluid:

$$K_k = 1.008(\gamma H^{+} + \gamma Al^{3+} + \gamma Fe^{2+} + \gamma Mg^{2+} + \gamma CO_3^{\ 2-} - \gamma HCO_3^{-}) \quad (4)$$

(2) Alkaline fluid:

$$K_k = 1.008(\gamma Mg^{2+} - \gamma HCO_3^{-}) \quad (5)$$

In the formula, Kk is the corrosion coefficient; γ is the milligram equivalent per liter of ion content, in mEq/L.

If the corrosion coefficient Kk>0, it is called corrosive water; If the corrosion coefficient Kk<0 and Kk+ $0.0503Ca^{2+}>0$, it is called semi corrosive water; If the corrosion coefficient Kk<0 and $Kk+0.0503Ca^{2+}<0$, it is called non corrosive water. According to the analysis of geothermal fluids, the geothermal water in the Lindian area belongs to weak alkalinity, with pH values greater than 7. Therefore, the calculation formula for alkaline water is used for calculation and analysis. The calculation results are shown in Table 7, and the corrosion coefficients Kk are all less than 0, and $Kk+0.0503Ca^{2+}$are all less than 0. Therefore, the geothermal fluid is non corrosive water.

Table 7. Evaluation of Geothermal Fluid Corrosion

Well No.	pH	Corrosion coefficient	K_k+0.0503Ca^{2+}	Evaluate Results
Well Linre 2	8.38	-15.12	-14.92	Non corrosive water
Well Linre 3	8.40	-21.62	-21.37	
Well Linre 5	8.30	-20.75	-20.48	
Well Linre 34	8.62	-2.11	-1.96	
Well Linre 43	8.79	-10.31	-10.11	

4.2.7. Evaluation of Geothermal Fluid Scaling

4.2.7.1 Evaluation of Scaling Properties of Geothermal Fluids

Referring to the industrial scale H_0 (mg/L) used to measure the scaling ability of geothermal fluids, the calculation formula is as follows:

$$H_0 = S + C + 36\gamma\, Fe^{2+} + 17\gamma\, Al^{3+} + 20\gamma\, Mg^{2+} + 59\gamma\, Ca^{2+} \qquad (6)$$

In the formula, S represents the suspended solids content in the geothermal fluid, in mg/L, which can be almost ignored; C is the colloid content C=SiO_2+Fe_2O_3+Al_2O_3, in mg/L; γ is the milligram equivalent per liter of ion content, in mEq/L.

When the scale H_0 is less than 125, there is very little scale in the geothermal fluid; When the pot scale H_0 is between 125 and 250, the geothermal fluid has less pot scale; When the pot scale H_0 is between 250 and 500, there is more pot scale in geothermal fluids; When the scale H_0 is greater than 500, there is a lot of scale in the geothermal fluid. As shown in Table 8, the scale of the geothermal fluid in the study area ranges from 43.57 to 59.35, with less scale.

Table 8. Comprehensive evaluation of geothermal fluid scaling property

Well No.	S	C	Fe^{2+}	Al^{3+}	Mg^{2+}	Ca^{2+}	H_0	Evaluate Results
Well Linre 2	0	33.34	0.11	0	0.1	0.2	51.10	Less pot fouling
Well Linre 3	0	33.05	0.001	0	0.0625	0.2475	48.94	
Well Linre 5	0	30.01	0.001	0	0.104	0.2685	47.97	
Well Linre 34	0	30.89	0.049	0	0.102	0.1505	43.57	
Well Linre 43	0	47.518	0	0	0	0.2005	59.35	

4.2.7.2 Evaluation of Calcium Carbonate Scaling Trend in Geothermal Fluids

Evaluating the trend of calcium carbonate scaling in geothermal fluids in the research area can provide a theoretical basis for descaling in future geothermal resource development. There are two methods for judging the scaling trend of calcium carbonate:

(1) When the chloride ion content in geothermal fluids is less than 25% molar equivalent, the Rezno index (RI) can be used to qualitatively evaluate the scaling of calcium carbonate in geothermal fluids. The calculation formula is:

$$RI = 2pH_s - pH_a \qquad (7)$$

$$pH_s = -\lg[Ca^{2+}] - \lg[ALK] + Ke \qquad (8)$$

In the formula: RI is the Rezno index; PH, is the calculated pH value; PHa is the measured pH value of geothermal fluid; [Ca^{2+}] is the molar concentration of calcium ions in the geothermal fluid, in mol/L; [ALK] is the total alkalinity, i.e., the molar concentration of heavy carbonate, unit: mol/L; Ke is a constant, and when the total solid content is 200-6000mg/L, the value ranges from 1.8 to 2.6. If the temperature is greater than 100 ℃, the low value is taken, and if the temperature is less than 50 ℃, the high value is taken.

When RI>7, the geothermal fluid does not scale; When RI=6-7, slight scaling occurs; When RI=5-6, moderate scaling occurs; When RI=4-5, severe scaling occurs; When RI<4, severe scaling occurs.

Table 9. Comprehensive evaluation of the scaling trend of geothermal fluid calcium carbonate

Well No.	Ca^{2+} (mol/L)	HCO_3^- (mol/L)	pHa	pHs	Ke	RI	Evaluate Results
Well Linre 3	0.000247	0.021506	8.40	7.87	2.6	7.34	No scaling
Well Linre 5	0.000268	0.020684	8.30	7.76	2.5	7.22	
Well Linre 34	0.00015	0.002196	8.62	8.78	2.3	8.94	

(2) When the chloride ion content in geothermal fluids exceeds 25% molar equivalent, the stretching index (LI) can be used to determine the scaling trend and corrosiveness of calcium carbonate in geothermal fluids. The calculation formula is:

$$LI = \frac{Cl^- + SO_4^{2-}}{ALK} \qquad (9)$$

In the formula: LI is the stretching index; Cl^- is the concentration of chloride ions in the geothermal fluid, in mg/L; SO_4^{2-} is the concentration of sulfate ions, in mg/L; ALK is the total alkalinity, i.e., the concentration of heavy carbonate, in mg/L.

When LI>0.5, there is no scaling and corrosiveness; When LI<0.5, scaling may occur and there is no corrosiveness; When 0.5<LI<3.0, there is slight corrosion; 3.0<LI<10.0, with strong corrosiveness.

Table 10. Comprehensive Evaluation of Scaling Trend and Corrosiveness Degree of Geothermal Fluid Calcium Carbonate

Well No.	Cl-(mg/L)	SO_4^{2-}(mg/L)	ALK (mg/L)	LI	Evaluate Results
Well Linre 2	780	0.4	921	0.85	No scaling, slightly corrosive
Well Linre 43	569.2	22.5	624.2	0.94	

4.2.8. Evaluation of Geothermal Fluid Bubbling

The foaming coefficient (F) is mainly determined by the following formula:

$$F = 62\gamma Na^{+} + 78\gamma K^{+} \tag{10}$$

In the formula, F is the foaming coefficient; γNa^+ is the ion content, in mmol/L; γK^+ is the ion content, in mmol/L.

Table 11. Evaluation results of geothermal fluid bubbling

Well No.	F	Evaluate Results
Well Linre 2	2434.24	Bubbling geothermal water
Well Linre 3	1979.67	
Well Linre 5	2060.16	
Well Linre 34	444.12	
Well Linre 43	1784.79	

4.2.9. Comprehensive Evaluation of Boiler Water Use

According to the corrosion and scaling evaluation of five geothermal wells in the Lindian area, the results show that the geothermal fluid is non-corrosive water, with little pot fouling. However, it is bubbling geothermal water and needs to be treated before it can be utilized. It is recommended to use a heat pump system combined with a plate heat exchanger for geothermal heating. By using heat pump technology, the geothermal fluid can reach 7 °C from high temperature, and one cubic meter of geothermal water can extract 46500W of heat. The geothermal fluid can be discharged below 10 °C, which is energy-saving and environmentally friendly.

5. Conclusion

(1) The cations in geothermal water are mainly Na^+, while the anions are mainly HCO_3^- and Cl^-. The hydrochemical types are mainly low salinity $Cl{\cdot}HCO_3$-Na type and $HCO_3{\cdot}Cl$-Na type.

(2) The five geothermal wells in the Lindian area are comprehensively named as medical geothermal water containing fluorine, metasilicic acid, and metasilicic acid, which has a high medical effect on diseases. Moreover, the water temperature in the area is relatively high, and the daily water inflow is high. This has broad prospects for establishing large-scale bathing and recuperation centers.

(3) Except for zinc and free carbon dioxide, all other projects in geothermal water do not meet the standards, and are not suitable for developing drinking mineral water.

(4) The sensory indicators and general chemical indicators of hot mineral water do not meet the hygiene standards for drinking water and are not suitable for use as drinking water.

(5) The water quality of the 5 geothermal wells in the research area is saline alkali water and heavy saline alkali water, which is not suitable for direct irrigation of agriculture.

(6) Five geothermal wells in the research area can all be used as water for fisheries.

(7) After certain treatment, the geothermal water in the research area can be used for geothermal heating.

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