

STUDY ON THE NICKEL ADSORPTION CHARACTERISTICS OF LAKE SEDIMENTS AND SOIL

MA, X.^{1#} – SUN, J.^{1#} – REN, L.^{2#} – GUO, M.¹ – WANG, Y.^{1*} – HAN, X.¹

¹*College of Resources and Environment, Jilin Agricultural University, 130118 Changchun, China*

²*Hebei Puni Testing Technology Co., Ltd., 050011 Shijiazhuang, China*

**Corresponding author*

e-mail: 951254609@qq.com; phone: 86-135-0441-9456

#These authors contributed equally to this work

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Abstract. The test adopted the OECD (Organisation for Economic Co-operation and Development) guideline 106 equilibrium adsorption method (Bian et al., 2016), to explore the Ni adsorption behavior of the bottom sediment and black soil of the lake. The isothermal adsorption curve of Ni on sediment and black soil retained an “S” shape, and the Freundlich model and D-R model could sufficiently fit the adsorption of Ni by sediment and soil, and the correlation coefficient r was 0.9859~0.9963; Within 120 min, the adsorption amount of nickel in the sediment and soil reached 99.57% and 99.84% of the total adsorption amount, respectively, and reached equilibrium after 720 min. The final desorption amounts of Ni in sediments and soil accounting for 1.26% and 1.35% of the adsorption amounts, respectively. The amount of Ni adsorbed in the sediment increases with rising temperature, and the adsorption coefficient changes in the following manner: $K_f 15\text{ }^\circ\text{C} < K_f 25\text{ }^\circ\text{C} < K_f 35\text{ }^\circ\text{C}$, $\Delta G < 0$. The adsorption process of nickel on sediment and soil is spontaneous and high temperature is beneficial to this process. The removal of organic matter from sediment and soil weakened the adsorption of nickel, indicating that organic matter could improve the interception of nickel.

Keywords: *sediment, soil, Ni, adsorption, desorption*

Introduction

The content of nickel (Ni) on the earth ranks the fifth, and it generally exists in the form of ore in nature, and the Ni in the natural water body is basically in the form of sulfide and nitrate (Prithviraj et al., 2014). On October 27, 2017, the World Health Organization's International Agency for Research on Cancer announced that Ni is a class of carcinogen, which can lead to a variety of cancer lesions, such as rectal cancer, oral cancer (De Brouwere et al., 2012). Ni is non-biodegradable and persistent, and is easily enriched in soil and organisms, posing a serious threat to human health. In recent years, with the development of economy and society and the acceleration of industrialization, heavy metal pollution has become a global environmental pollution problem, especially the pollution of heavy metals to the soil environment (Kashulina et al., 2018; Abdelwaheb et al., 2017). A large amount of Ni is released into the environment through mining, atmospheric deposition, fertilizer and pesticide application, and sludge and sewage are irrigated into the soil. The Ni accumulated in the soil may remain in the soil and enter crops through planting and other agricultural activities, or enter water bodies through leaching. Part of the pollutants in the water will enter the sediment of the lake through the action of particle adsorption and sedimentation, which makes the sediment become the important “source” and “sink” of the pollutants, which will produce endogenous pollution. The sediment is an important part of the aquatic ecosystem. Heavy metal pollution can cause great harm to

aquatic organisms, and thus cause harm to human body and ecosystem (Vukosav et al., 2014). Adsorption of soil and sediment can affect Ni mobility and bioavailability, thus playing a key role in reducing further risks to the environment and humans.

Riparian belt is a transition zone between land and river, and it is an important hub connecting aquatic ecosystem and terrestrial ecosystem. Human agricultural activities are the main source of sediment input to rivers. During rainstorms, a large amount of soil, silt and other materials are transported into rivers through surface runoff, so the sediment and the shore soil have a certain correlation on the components (Zhang et al., 2018). Therefore, it is necessary to study the adsorption characteristics of nickel in sediment and shore soil, and to understand the distribution law of metal nickel between solid and liquid phases. At present, there has been some research on the adsorption of Ni in soil, Sangiumsak (2014) investigates the adsorption of Ni and Zn on different kinds of soils found in the Northeastern Thailand as silty soil and sandy soil. Peng (2017) studied the adsorption and desorption characteristics of heavy metals in soil by soil organic matter and mineral composition, and found that SOM seems to play the most important role in soil adsorption of metal Ni. At present, there are many researches on soil adsorption of heavy metals, but few researches on the comparison between soil and sediment. This paper focuses on the evaluation of the adsorption potential of heavy metal nickel in sediments and soil, and provides theoretical guidance for the prevention of heavy metal contamination of groundwater in soil and sediment.

Materials and methods

Samples for test

Sample collection and basic physical and chemical properties

The tested sediment was taken from Xinlicheng reservoir, Changchun city, Jilin Province, China. The Xinlicheng Reservoir (125°42'57"E, 43°42'57"N) is located in the middle and upper reaches of the Yitong River, 16 km from the center of Changchun. On May 24, 2017, grab dredger was used to collect the surface layer (0-10 cm) sediments of Xinlicheng reservoir. A sampling point was set at the upstream, middle and downstream of the reservoir, and repeated collection was made for three times. After the collected samples were mixed, and after air drying in the room, impurities such as animal and plant residues and stones were removed, and then ground through a 100 mesh sieve and stored for use (Duan et al., 2016). The tested soil was taken from the soil around the entrance of Xinlicheng reservoir. After removing the plants and rocks on the soil surface, five-point sampling method was used to collect the surface soil of 0~20 cm (Wu et al., 2017). The collected samples were naturally dried, removed animal and plant residues, stones and other impurities, and ground through a 100-mesh sieve for preservation. Sampling points are shown in *Figure 1*. The basic physical and chemical properties of samples were shown in *Table 1*.

Table 1. *Physicochemical properties of test samples*

Sample	Unit weight (g·m ⁻³)	OM (g/kg)	TN (%)	TP (%)	Ni (mg·kg ⁻¹)	Mechanical composition (%)			
						Sand	Coarse silt	Fine silt	Clay
Sediment	1.79	41.23	0.15	0.12	29.93	10.48	33.97	24.12	31.43
Black soil	1.65	34.65	0.12	0.09	21.10	4.84	51.43	22.96	20.77



Figure 1. Schematic diagram of the location of Xinlicheng Reservoir in Changchun City, China

Test design

Ni isotherm adsorption-desorption

The experiment was conducted with reference to the OECD guideline 106 equilibrium adsorption test (OECD). The 1.000 ± 0.0005 g soil samples were taken in 50 ml polyethylene centrifuge tubes, according to the water-soil ratio of 20:1, added 20 ml solution containing different concentrations of Ni background, make the concentration of Ni respectively, 50, 100, 200, 300, 400, 500 $\text{mg}\cdot\text{L}^{-1}$, after shaking at a constant temperature at 25 °C until adsorption equilibrium, it was centrifuged at $4000 \text{ r}\cdot\text{min}^{-1}$ for 10 min, filtered, and the concentration of Ni in the supernatant was measured. Immediately after the adsorption, the desorption test was carried out, after removing all the supernatant, added 20 ml deionized water at 25 °C under constant temperature oscillation to desorption balance, and the concentration of Ni in the supernatant was determined.

Adsorption kinetics of Ni

According to the test method in Ni isothermal adsorption-desorption. Added 100 $\text{mg}\cdot\text{L}^{-1}$ Ni background solution 20 ml for constant temperature oscillation at 25 °C. Samples were taken at the time of 1, 5, 10, 20, 30, 60, 120, 240, 360, 480, 720 and 1440 min, respectively, and centrifuged at $4000 \text{ r}\cdot\text{min}^{-1}$ for 10 min, then filtered and determined the Ni concentration in the supernatant.

Ni adsorption thermodynamics

According to the test method in Ni isothermal adsorption-desorption. Five Groups of 20 ml solution with Ni concentration of 50, 100, 200, 300, 400 and 500 $\text{mg}\cdot\text{L}^{-1}$ were prepared, which were placed at 15 °C, 25 °C, 35 °C constant temperature to oscillate to adsorption equilibrium, centrifuged at $4000 \text{ r}\cdot\text{min}^{-1}$ for 10 min, and filtered to determine the concentration of Ni in the supernatant.

Effects of different organic matter contents on Ni adsorption behavior

The organic matter in the sample was removed by H_2O_2 digestion method, and the experiment was conducted with reference to Ni adsorption thermodynamics.

All tests were performed in triplicate.

Data processing

Freundlich equation:

$$\lg q_{\varepsilon} = \lg K_f + \lg C_{\varepsilon}^{\frac{1}{n}} \quad (\text{Eq.1})$$

D – R equation:

$$\ln q_{\varepsilon} = \ln q_m - k\varepsilon^2 \quad (\text{Eq.2})$$

Elovich equation:

$$C = a + b \ln t \quad (\text{Eq.3})$$

Parabolic diffusion equation:

$$\frac{C}{C_{Ni}} = a + bt^{\frac{1}{2}} \quad (\text{Eq.4})$$

In *Equation 1*, $\lg K_f$ and $1/n$ respectively represent the adsorption capacity and adsorption strength of the sample to Ni; In *Equation 2*, q_m is the maximum adsorption capacity, K is a constant for the adsorption energy, ε is the adsorption potential of Polanyi. In *Equations 3* and *4*: C_{Ni} and C are the equilibrium adsorption capacity and the adsorption capacity at time t , respectively $\text{mg}\cdot\text{kg}^{-1}$; a is the adsorption constant related to the maximum adsorption amount, and b is the adsorption rate coefficient, which is a measure of how fast the reaction rate decreases with time. R value represents the correlation coefficient between variables in the sample, and the magnitude of correlation; P value is the test value, which is to test whether the two variables have the same correlation with the samples in the population from which the samples come, and $p < 0.01$ means extremely significant correlation.

Results and discussion

Adsorption-desorption isothermal behavior of Ni in sediment and black soil and its discussion

Adsorption isotherm of Ni in sediment and black soil

Adsorption isotherms of sediment and black soil on Ni are shown in *Figure 2*. It can be seen from *Figure 2* that in the experimental concentration range, when the initial concentration of Ni changes from $50 \text{ mg}\cdot\text{L}^{-1}$ to $500 \text{ mg}\cdot\text{L}^{-1}$, the isothermal adsorption line of Ni in sediment and soil showed a tendency of increasing slope, but the adsorption amount did not reach saturation, When the concentration of Ni is $500 \text{ mg}\cdot\text{L}^{-1}$, the equilibrium adsorption concentration of sediment and soil on Ni were 17.86 and $20.71 \text{ mg}\cdot\text{L}^{-1}$, respectively, and the equilibrium adsorption amount were 9642.88 and $9585.84 \text{ mg}\cdot\text{kg}^{-1}$ respectively. According to the classification of isothermal adsorption curves by Giles (1974), it can be seen that the isothermal adsorption curve of the sediment and soil to Ni is “S” type. For this “S” type isothermal adsorption line, the

data can be analyzed and fitted with Freundlich and D-R models to explain the adsorption mechanism of Ni in sediment and soil, and the fitting parameters are shown in *Table 2*.

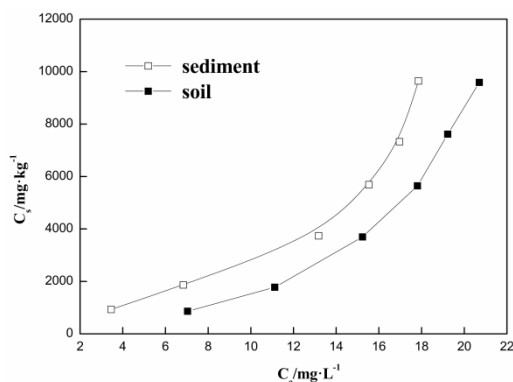


Figure 2. Adsorption isotherm of Ni in sediment and soil

Table 2. The isothermal adsorption fitting parameters of Ni in sediment and soil

Sample type	Freundlich equation			D-R equation		
	K_f	$1/n$	r	q_m	k	r
Sediment	3.1906	2.761	0.9891**	31898.2507	68.8476	0.9859**
Soil	1.2562	2.938	0.9963**	26562.0806	78.3844	0.9866**

$n = 6$, $r_{0.05} = 0.811$, $r_{0.01} = 0.917$. **indicate statistical significance at $P < 0.01$. The same below

It can be seen from *Table 2*, Freundlich equation and D-R equation were used to fit the adsorption isotherms of nickel on sediment and soil, and the correlation coefficients were above 0.98, the fitting results were all significantly correlated ($p < 0.01$). The Freundlich equation has the best fitting effect, the adsorption constant K_f represents the adsorption capacity of Ni on the sediment and the soil. The larger of the K_f , the stronger the adsorption capacity was. The adsorption coefficient K_f of Ni in the sediment was greater than that in the soil, indicating that the adsorption effect of the sediment on nickel was greater than that on the soil. When the concentration of nickel was lower than $500 \text{ mg} \cdot \text{L}^{-1}$, the adsorption of Ni on sediments and soil did not reach the saturation state, which may be due to the modification effect of nickel on the bottom sediment and soil surface, forming a new adsorption field, thus promoting the adsorption of nickel in the bottom sediment and soil (Rinklebe et al., 2017). Since the D-R equation describes an ideal adsorption state in which the pores of an adsorbent are completely filled with solutes, the calculated equilibrium adsorption q_m is an ideal state.

The desorption of Ni in sediment and black soil

The desorption amount was often used as an index to indicate the adsorption strength, and can generally be used to illustrate the bonding degree of the colloidal surface active adsorption position with heavy metal ions (Tahervand et al., 2016, 2017). The desorption isotherm and desorption rate of Ni on bottom sediment and soil are shown in *Figure 3*.

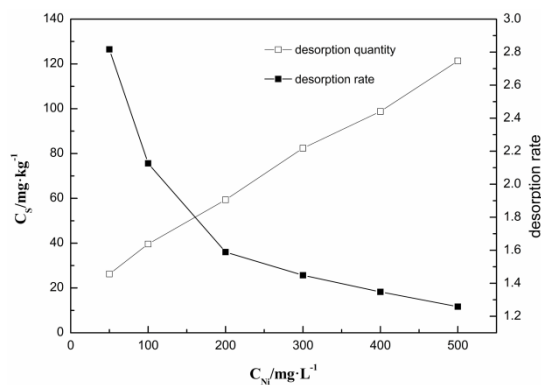


Figure 3. The desorption amount and desorption rate of Ni in sediment

As can be seen from *Figure 4*, the desorption of Ni by sediments and soil has a similar trend to that of adsorption, and the desorption of soil and sediment gradually increases with the increase of the initial Ni concentration. The final desorption of Ni by sediments and soil was $121.34 \text{ mg}\cdot\text{kg}^{-1}$ and $129.78 \text{ mg}\cdot\text{kg}^{-1}$, respectively, accounting for 1.26% and 1.35% of the adsorption capacity, respectively.

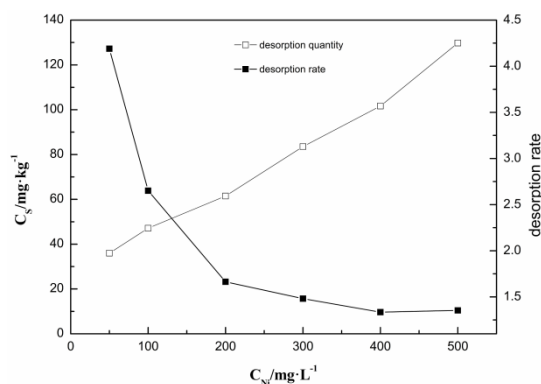


Figure 4. The desorption amount and desorption rate of Ni in soil

It can be seen that the adsorption capacity of sediments and soil to Ni was strong, while the desorption capacity was weak. The desorption amount of Ni in sediments was slightly less than that in soil. When the adsorption capacity was low, Ni occupies a high energy adsorption point, and the adsorption was mainly specific adsorption, so the desorption of Ni was difficult. When certain saturation was reached, specific adsorption points gradually decrease, and adsorption of heavy metals in stable sediments and soil was reduced, making it easier to desorption, so desorption also increased (Arancibia et al., 2015). The sediment contains more organic matter than the soil, so it has a stronger adsorption ability to nickel and a stronger fixation ability, leading to less desorption. Low Ni desorption may be the buffer of sediment and soil against heavy metal pollution (Davari et al., 2015). The desorption process can be regarded as the reverse process of soil adsorption process, and all factors affecting adsorption affect the desorption. The desorption data of Ni in sediment and soil are fitted with the Freundlich equation and the D-R equation, and the results are shown in *Table 3*.

Table 3. Isothermal desorption fitting parameters of Ni in sediment and soil

Sample type	Freundlich equation			D-R equation		
	K_f	n	r	q_m	k	r
Sediment	0.7218	0.5727	0.9706**	197.7315	82.1164	0.9338**
Soil	1.1054	0.6496	0.9724**	151.2162	61.7417	0.9052**

$n = 6$, $r_{0.05} = 0.811$, $r_{0.01} = 0.917$

As can be seen from *Table 3*, the correlation coefficient of desorption isotherm of nickel in sediment and soil of Freundlich equation was 0.9937~0.9937, K_f (sediment) < K_f (soil). The adsorption capacity of sediment on Ni was strong, but its desorption capacity was weak. Ni adsorbed on sediments and soil is not easy to desorption. Kaur (2018) proposed to use hysteretic coefficient (HI) as a quantitative indicator of the irreversible adsorption degree of the compound in soil.

$$HI = (q^d - q^s) / q^s$$

In the formula, q_d and q_s respectively refer to the adsorption concentration of Ni in the soil during adsorption and desorption at a certain temperature $mg \cdot kg^{-1}$. When $0.7 < HI < 1.0$, the desorption rate was similar to the adsorption rate, and the adsorption isotherm coincides with the desorption isotherm. When $HI < 0.7$, the desorption rate was lower than the adsorption rate, and the desorption process was positive hysteresis. When $HI > 1.0$, the desorption process was negative hysteresis (Mosqueravivas et al., 2018). It can be seen from *Table 4* that as the Ni concentration of the background solution increases, the desorption hysteresis coefficient gradually decreases and was much smaller than 0.7, indicating that the desorption rate was much smaller than the adsorption rate. When the initial concentration was the same, $HI_{\text{sediment}} < HI_{\text{soil}}$, indicating that the Ni adsorbed on the sediment was more difficult to desorption than the soil.

Table 4. Ni desorption hysteresis coefficient HI at different concentrations

Initial concentration (mg/L)	50	100	200	300	400	500
Sediment	0.0290	0.0217	0.0161	0.0147	0.0131	0.0127
Soil	0.0437	0.0273	0.0169	0.015	0.0135	0.0137

Adsorption kinetics of Ni in sediment and black soil

The change of Ni adsorption amount with sediment and black soil with time is shown in *Figure 5*. As can be seen from *Figure 5*, the whole adsorption process can be divided into two stages, namely, rapid adsorption stage and slow equilibrium stage. The concentration of Ni in the solution decreased rapidly in 0-120 min, and the concentration of Ni in the solution was gradually balanced in the 120-1440 min solution. In the 0-120 min, the adsorption amount of Ni to the sediment and soil accounted for 99.57% and 99.84% of the total adsorption, respectively. At the adsorption equilibrium, the maximum adsorption capacity of sediment and soil to Ni was 1881.60 and 1804.58 $mg \cdot kg^{-1}$. Because there are more adsorption sites on the

surface of the sediment and soil, Ni can be quickly adsorbed. When more and more adsorption sites are occupied, the reaction rate decreases until the adsorption reaches equilibrium. Ni may form a complex when adsorbed in the sediment and soil, so that the heavy metals adsorbed on its appearance are transferred to the inside of the particles and precipitate on the sediment and soil surface, so that the adsorption of the sediment and soil to the Ni was getting smaller, and finally until it tended to balance (Peng et al., 2018). And the reduction agent in the sediment and soil dissolves from the solid phase to the water phase is a slow dissolution process (Huang et al., 2018).

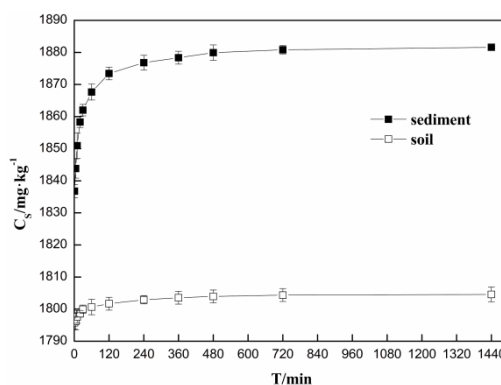


Figure 5. The adsorption kinetic curve of Ni

In this experiment, Elovich equation and parabolic diffusion equation were used to fit the adsorption kinetics of Ni in sediment and black soil. The relevant parameters of the fitting are shown in *Table 5*. It can be seen from *Table 5* that Elovich equation has a good fitting effect on the adsorption kinetics of Ni in sediments and black soil, indicating that the adsorption kinetics process is non-uniform diffusion process, and the reaction process is controlled by multiple mechanisms such as diffusion, dissolution and mineralization. The adsorption fitting coefficient r of Ni in lake bottom sediment and soil was 0.9827 and 0.9895, respectively. The greater the constant a value in the Elovich equation, the greater the adsorption rate, so the adsorption amount of the sediment is greater than the adsorption amount of the soil. The fitting of adsorption by parabolic diffusion equation is relatively poor, and the correlation coefficients r were 0.7905 and 0.8813, respectively. In the above model fitting, it can be inferred that the diffusion of particles is not the only mechanism controlling the adsorption process, which is also adsorbed by other adsorbents (Zhu et al., 2015).

Adsorption thermodynamics of Ni in sediment and black soil

The adsorption of Ni by sediment and black soil over time are shown in *Figures 6* and *7*. As can be seen from *Figures 6* and *7*, in the test temperature range, with the increase of temperature, the adsorption amount of sediment and soil to Ni increases gradually, and the adsorption does not reach saturation. The increase of temperature was beneficial to the adsorption of Ni by sediment and soil, and the reaction can be determined to be an endothermic reaction. Heavy metal Ni has good hydration in the test temperature range. When the metal Ni was adsorbed by sediment and soil, it lost its hydrating shell. The process of nickel losing hydrated shell requires some energy, and the process of removing water molecules is endothermic. The higher the temperature is,

the more favorable it is for the Ni adsorbed on the bottom sediment and soil surface to diffuse into the particles. It is also a benefit for external complexity and internal complexity. It also facilitates the combination of thermodynamic unstable state to stable state transition. Therefore, the adsorption of nickel in sediments and soil increases with temperature.

Table 5. Parameters of the kinetics adsorption models for Ni in sediment and black soil

Soil type	Elovich equation			Parabolic diffusion equation			
	a	b	r	a	b	s	r
Sediment	1836.8507	6.8847	0.9827**	293.8471	0.1789	6.3016	0.7905**
Black soil	1795.5288	1.2942	0.9895**	267.2892	0.0346	6.7273	0.8813**

n = 12, r_{0.05} = 0.0576, r_{0.01} = 0.708

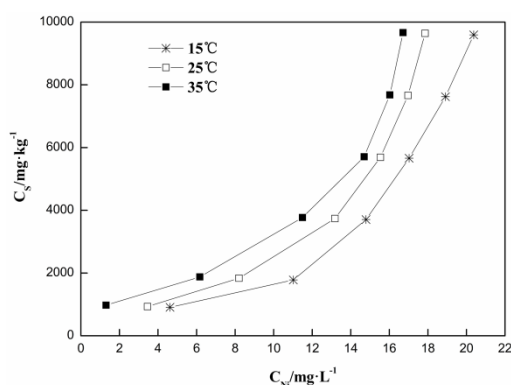


Figure 6. The effect of different temperature on the adsorption of Ni in the sediment

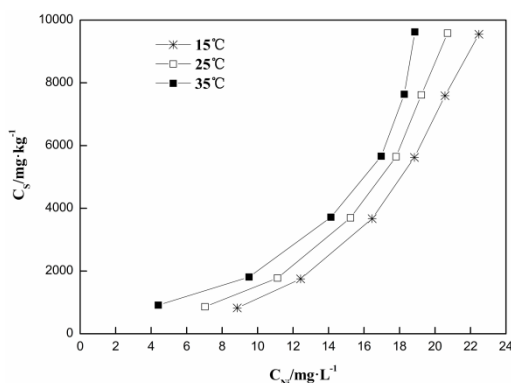


Figure 7. The effect of different temperature on the adsorption of Ni in the soil

When the temperature at 15 °C, 25 °C and 35 °C sediment and soil on the adsorption thermodynamics equation of Ni fitting results as shown in Table 6. The adsorption thermodynamics of sediment and soil on Ni is well correlated with the thermodynamic fitting of Ni on sediment and soil. The coefficient *R* is between 0.9491 and 0.9975. Sediment and soil on the adsorption of Ni coefficient $K_f 15^\circ\text{C} < K_f 25^\circ\text{C} < K_f 35^\circ\text{C}$, show

that the higher the temperature, the stronger the adsorption capacity of sediment and soil nickel. The adsorption reaction can be determined as endothermic reaction.

Table 6. The isotherm adsorption parameters of Ni at different temperatures

Sample type	Temperature (°C)	Freundlich equation			D-R equation		
		K_f	n	r	q_m	k	r
Sediment	15	1.9583	0.3554	0.9923**	24814.9828	70.5966	0.9786**
	25	3.1904	0.3621	0.9786**	28899.0866	63.7658	0.9483**
	35	17.0777	0.4513	0.9617**	21947.8305	44.4613	0.9246**
Soil	15	1.0453	0.3419	0.9829**	25954.7285	88.6074	0.9832**
	25	1.2568	0.3406	0.9946**	26562.0767	78.3846	0.9723**
	35	1.4630	0.3384	0.9724**	27134.1593	69.9409	0.9438**

$n = 6$, $r_{0.05} = 0.811$, $r_{0.01} = 0.917$

According to the K_f in the Freundlich equation at different temperatures, the enthalpy change and entropy change are calculated by $\ln K_f$ and $1/T$, $\Delta G = \Delta H - T\Delta S$. It can be seen from Table 7 that the ΔG at different temperatures were less than zero, as the rise of environmental temperature, ΔG gradually reduced. It was indicated that the adsorption process of Ni on sediment and soil is spontaneous, and the high temperature is favorable for the spontaneity of adsorption, which is consistent with the fitting results of Langmuir equation and Freundlich equation (Wu et al., 2013; Turp, 2018). It can be seen from the table that $\Delta H > 0$ of Ni in the sediment and soil is indicated as an endothermic reaction. ΔG and ΔH indicated that sediment and soil buffer capacity of Ni, and may have a seasonal migration and activity (Guo et al., 2012).

Table 7. The thermodynamic parameters of Ni in sediment and soil

Sample type	Temperature °C	ΔG KJ·mol ⁻¹	ΔH KJ·mol ⁻¹	ΔS KJ·(mol·K) ⁻¹
Sediment	15	-1.1707	79.5104	0.2804
	25	-3.9703		
	35	-6.7706		
Soil	15	-0.2308	12.4508	0.0403
	25	-0.6704		
	35	-1.1102		

Effect of organic matter content on adsorption characteristics of Ni

The Ni adsorption by sediment and soil before and after the removal of organic matter are shown in Figures 8 and 9. As can be seen from the figure, when organic matter was removed from sediments and soil, and the Ni concentration in the solution was 500 mg·L⁻¹, the adsorption capacity of sediments and soil on Ni decreased by 2.17% and 1.7%, respectively. The above phenomenon indicates that the presence of organic matter can increase the adsorption of Ni by sediment and soil. In the experiment, according to the formula of: contribution rate = $(Q_{\text{original}} - Q_{\text{removal}}) / Q_{\text{removal}}$. According to this formula, the contribution rate of organic matter in sediment and soil to

Ni was 2.06% and 1.73% respectively. The higher the content of organic matter is, the greater the contribution rate of organic matter to Ni was, and the adsorption point of sediment to Ni after removing organic matter is greater than that of soil.

There was a significant correlation between the adsorption amount and the content of organic matter. The reason may be that the organic matter entered the sediments and soil to form humus after microbial action. Humus contains carboxyl, phenol hydroxyl and alcohol hydroxyl. These groups can easily complex or chelate with heavy metal elements to form stable compounds, thus improving their adsorption capacity. In addition, polar groups in sediment and soil organic matter, such as hydroxyl group and carboxyl group, can make sediment and soil surface have a large amount of negative charge, thus enhancing the electrostatic adsorption of nickel (Refaey et al., 2014; Yin et al., 2016).

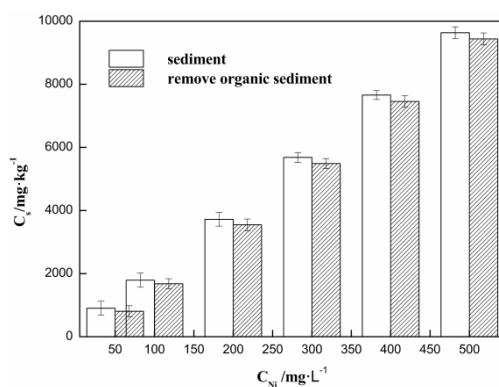


Figure 8. Adsorption isotherm of Ni under removal of sediment organic before and after

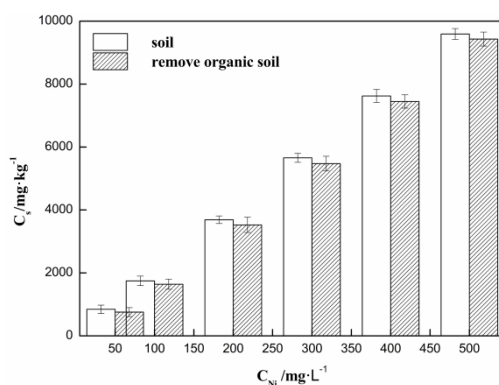


Figure 9. Adsorption isotherm of Ni under removal of soil organic before and after

Conclusion

The adsorption characteristics of Ni on the sediment of the lake and the black soil on the shore show that the adsorption of Ni on the sediment was larger than that in the soil, and the adsorption process can be fitted with the Freundlich model and the D-R model. The Freundlich model can better fit the adsorption of Ni by sediment and soil. The correlation coefficient r were 0.9891 and 0.9963, the final desorption amount of sediment and soil to Ni are 121.34 and 129.78 $\text{mg}\cdot\text{kg}^{-1}$, which accounts for 1.26% and 1.35% of adsorption, respectively. The initial concentration was the same,

$HI_{\text{sediment}} < HI_{\text{soil}}$, indicated that the sediment had a stronger retention capacity to Ni than the soil. The adsorption kinetics of nickel in sediments and black soil can be well fitted by Elovich equation. In the experimental temperature range, the adsorption amount of Ni on the sediment and soil gradually increased with the increase of temperature, and the ΔG value of adsorption thermodynamic parameters is less than 0, which indicates that Ni adsorption process on sediment and shore soil is spontaneous. After removing organic matter, the adsorption capacity of bottom sediment and soil on Ni was weakened, and the adsorption capacity was reduced by 2.02% and 1.70%, respectively, indicating that organic matter could enhance the retention capacity of Ni. These factors may limit or enhance the transport or absorption of metal Ni in soil. This work provides a theoretical framework for the prediction of metal adsorption characteristics and provides a potential help for the prediction of bioavailability, fate and transport of heavy metals in newly contaminated areas. Meanwhile, the interaction between Ni and other heavy metals is expected to be considered in future studies.

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