Scholars Journal of Engineering and Technology (SJET)
Sch. J. Eng. Tech., 2015; 3(4B):397-401
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(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

ISSN 2321-435X (Online)
ISSN 2347-9523 (Print)

Research Article

Study on Effect of Different Size Fraction Laterite Particles on Adsorption of Arsenic

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Abstract: The problem of environmental geotechnical engineering is the important problem that relates to the safety and the sustainable development of the geotechnical structure. This paper, studied the adsorption characteristics and pH of arsenic in different size of laterite particles. The test results show that the adsorption trend of arsenic by different particle size aggregates is consistent with that of the change. The isothermal adsorption process of arsenic in each particle of the particle was fitted by Langmuir equation. The effect of pH on the adsorption of arsenic in laterite was greatly. The adsorption capacity of arsenic decreased with the increase of pH value. The pH effect the greatest impact on the four types of laterite in class A, the other three types of laterite effect is almost the same, indicating that particle size range for the laterite in the middle reaches of the 0-0.005mm high off the state of iron oxide content, and pH value has a direct impact on the free ferric oxide existing forms and characteristics, and ultimately effect of arsenic ion adsorption capacity of laterite particles.

Keywords: laterite particles; arsenic; Langmuir equation; adsorption; pH value.

INTRODUCTION

The problem of environmental geotechnical engineering is the important problem that relates to the safety and the sustainable development of the geotechnical structure. Laterite is impact on the infrastructure construction of Yunnan Province (housing foundation, subgrade, slope, dam materials, etc.), agriculture, forestry, water and soil erosion and ecological environment protection is very important special soil, with high strength and low compressibility characteristics, high natural water content, liquid index, saturation and natural void ratio, shrinkage is evident, belonging to the a typical regional special soil [1-2]. The pollution caused by the pollution of the laterite has seriously threatened the safety of the structure of the laterite. Meanwhile, the pollutant passed the laterite into the water, causing the pollution of the local water resources.

Soil particle is the basic unit of soil structure, which has important influence on the properties of soil. The research shows that the different particle size of soil particles is different from the organic matter and mineral, and the binding capacity and the biological availability of the heavy metals and organic poison are different from the other aspects. At the same time, the distribution and reaction of the heavy metals in the soil particles are the important factors that affect the soil migration and the bioavailability.

Arsenic is a contaminant exists widely in the earth's crust and chemical speciation in soil can be divided into two types of organic and inorganic arsenic. In aerobic and anoxic soil environment, arsenic mainly exists in with negative charge arsenic oxyanions ($HAsO_4^{2-}$, $H_2AsO_4^-$, $H_2AsO_3^-$, $H_2AsO_3^{2-}$) form and valence respectively to+3 and+5 valence. As the content of organic arsenic in soil is very low, it is often neglected in the practice of arsenic pollution treatment. Arsenic in the soil forms is strongly dependent on soil pH and oxidation reduction potential (Eh) value. In addition, soil physicochemical properties, mineral composition, grain composition, soil containing content, degree of compaction, the temperature of the surrounding environment and arsenic ion concentration of arsenic ion in soil migration characteristics [3-4]. At present, the research on the adsorption of arsenic from clay particles is less. This paper studied the adsorption of arsenic from different particle size of laterite particles.

METHODS AND MATERIALS

The test materials

Used in the test of laterite from in Kunming, from 5 m below the surface of the unsaturated zone, Kunming in Quaternary period, the typical laterite and its natural water content rate of 15% - 20%, the dry density is 1.355 g / cm^3, through test determination of basic physical and chemical index of the soil sample and the main mineral composition as shown in Table 1 and 2. Used in the test of heavy metal pollutants hydrogen arsenate sodium ($Na_2HAsO_4 \cdot 7H_2O$) analytically pure, the reagent purity is 99%. In order to decrease interference of other ions on the results of the tests as far as possible, used in the test water deionized water.

The undisturbed soil and transported to the laboratory after dry naturally, crushed: clay particles to fine particles, almost no large particles (greater than 2mm and the mass fraction of particles of less than 5%). The soil samples over 2mm sieve after ultrasonic dispersion and centrifugal test, isolated clay (0-0.005mm, denoted as class A), powder (0.005mm-0.075mm, denoted as class B), fine to medium sand (0.075mm-0.5mm, denoted as class C) and coarse sand (0.5mm-2mm, denoted as class D) four particle level soil samples, to carry out the relevant tests.

THE TEST PROGRAM

Isothermal adsorption test

The temperature of the test was 25℃. Each group of test soil and water ratio was fixed at 10 g/L, initial arsenic concentration increased from 0 mg/L to 500 mg/L, to maintain the pH value of the solution was 7. The test fitted with a specimen of the centrifugal tube number, placed in a thermostatic shaker, to 180 rpm speed oscillation for 24 h, centrifugal filtration after a certain volume of liquid, under the condition of 5% acidity with thiourea As (V) is reduced to As (III), by hydride occurrence- Atomic Fluorescence Spectrometry of arsenic concentrations were measured, arsenic adsorption capacity by arsenic starting concentration and the equilibrium concentration difference calculation.

PH effect test

The size equal to the amount of laterite (0.3 g) and solution (200 mg/L and 30 mL) were placed in a plurality of centrifuge tube. Initial pH value adjusting range is 3 to 10 with 0.1 M hydrochloric acid solution and sodium hydroxide solution, in order to understand the impact of changes in the pH of solution of arsenic adsorption effect, will be equipped with a sample of the centrifuge tube is arranged in the thermostatic shaker, fixed temperature of 25℃, with 180 rpm speed oscillation after 24 h determination of arsenic concentration.

In order to ensure the reliability of the test results, all experiments were carried out for the average of 2 groups of parallel tests, and the initial concentration of arsenic was tested by the blank sample test. The adsorption capacity of Q_e for arsenic can be expressed as follows:

$$Q_e = (C_0 - C_e) \times \frac{V}{W} \quad (1)$$

Where Q_e is adsorbed amount, mg/g; C_0 is initial concentration of arsenic, mg/L; C_e is the arsenic equilibrium solution concentration, mg/L; W is the quality of soil, g; V is the volume of equilibrium solution, mL.

Data processing

The laterite fractions of arsenic adsorption process by analysis with Langmuir equation and the measured data with SPSS13.0 linear correlation analysis, and isothermal adsorption curve and the isothermal adsorption equation fitting, then calculated the parameters of isothermal adsorption equations shows in Table 3. This paper uses Origin9.0 software to graphics.

$$\frac{1}{Q_e} = \frac{1}{Q_m} + \frac{1}{K_L Q_m C_e} \quad (2)$$

Where Q_m is the maximum adsorption capacity, mg/g; K_L is Langmuir adsorption coefficient, L/mg; and other parameters are shown with the formula above.

RESULTS AND ANALYSIS

Analysis of laterite composition

Test of Kunming typical laterite, first of all to the chemical components in soil were determined, to confirm the source of pollutants, in order to simulate the natural state migration of pollutants under the better in the groundwater. The contents of various chemical compositions of Kunming typical laterite in Table-1 and Table-2.

Table-1: The properties of laterite

Bound water					relative density	Particle composition（%）			
natural moisture content （%）	Plastic limit （%）	Liquid limit （%）	Plastic limit index	Liquid limit index		2-1 mm	1-0.075 mm	0.075-0.005mm	≤0.005 mm
23.3	28.1	48.3	20.2	1.24	2.79	4.2	10.3	40.3	45.2

Table-2:The chemical composition of laterite

Chemical composition	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**K_2O**	**Na_2O**	**CaO**	**P_2O_5**	**MgO**	**Others**
Content（%）	38.43	31.52	26.78	1.62	0.54	0.52	0.13	0.08	0.38

The table shows:

(1) the main component of laterite for silica, alumina and ferric oxide, stable compounds, for steady chemical Compound, which also contains a small amount free material, when the basic concentration lower than the state regulations will not cause pollution to groundwater.

(2) A few heavy metals in the soil and the poisonous and harmful trace elements content, and most of the poisonous and harmful trace elements in the compound form, it is difficult to directly cause pollution of groundwater.

Adsorption of arsenic by different particle size laterite particles

The isothermal adsorption of arsenic at different concentrations was shown in Fig 1. From Fig. 1 we can see that adsorption of arsenic in different particle sizes of clay particles are with the increase of arsenic concentration in equilibrium liquid and increased, the particle size of laterite particles of arsenic adsorption capacity with increasing particle size increased adsorption capacity decreased gradually. This is because the smaller the soil particle size, the greater the surface area, the more adsorption sites, the more adsorption capacity of arsenic. Another major cause of this result may be related to the content of organic matter in the laterite particles of different particles. In general, organic matter content is positively related to the amount of adsorbed. The more organic matter content, the more the physical adsorption capacity, the more important it is the adsorption of other adsorption sites, and the more adsorption ability.

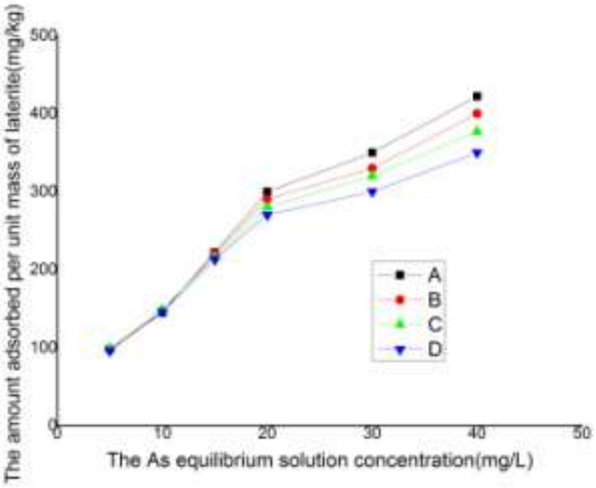

Fig-1: Adsorption isothermal curve of arsenic by different particle size for laterite particles

Fig. 1 shows that the adsorption trend of arsenic by different particle size aggregates is consistent with that of the change. That is, when the liquid equilibrium arsenic concentrations of 0-20mg/L, arsenic adsorption with the equilibrium concentration changes larger adsorption curve steeper, when the equilibrium concentration 20 to 40 mg/L, arsenic adsorption changes slowly, curve tends to be gentle. This shows that in the equilibrium concentration is low, soil surface has more adsorption sites, the adsorption is not saturated, adsorption rate is very high; then with the increase of the concentration of arsenic, soil surface adsorption sites gradually covered, adsorption capacity increases slowly, curve tends to be gentle, reached the adsorption equilibrium, which may and arsenate ions first to occupy a weaker affinity for low-energy adsorption sites on. Adsorption at the beginning stage, the soil surface has more adsorption sites and low concentrations of arsenate ions quickly into the soil surface adsorption point position. With external arsenate concentration increased, soil surface low ceiling dotted bit gradually saturated and arsenate ions into higher affinity of high-energy point position, at this time for the adsorption reaction rate slowed down, the adsorption rate decreased. Studies have shown that the adsorption of arsenate ion in soil is divided into two processes, arsenate ions from the solution phase to the solid phase of soil surface; the second is arsenate ion again from the surface into the soil solid phase process. The process of the preceding is a rapid reaction, and the solid diffusion process is a slow process.

The isothermal adsorption process of arsenic in each particle of the particle was fitted by Langmuir equation, and the fitting parameters of the isothermal adsorption were shown in Table-3. From table 3-3 shows that the particle size of clay particles with the Langmuir isotherm adsorption equation fitting effect is good, the correlation coefficient (R^2) between 0.8654-0.9912, which, with particle size for 0.5mm-2mm coarse fitting effect best (R^2=0.9912).

Table -3:The fitting parameters of Langmuir adsorption equation for arsenic by different particle sized laterite particles

Particle size（mm）	**The fitting parameters of Langmuir adsorption equation**		
	K_L（L/mg）	**Q_m（mg/g）**	**R^2**
0-0.005	1.73	860.5	0.9865
0.005-0.075	1.56	604.5	0.8654
0.075-0.5	1.63	512.9	0.8995
0.5-2	1.53	578.8	0.9912

The Langmuir equation, the larger the parameters Q_m means of arsenic adsorption capacity of soil is stronger, from table-3 is not difficult to see that the laterite of arsenic in the overall adsorption ability is strong, and the. Class A range of particle size 0-0.005mm laterite particle efficiency of adsorption capacity of the strongest, class C particle size range for fine 0.075-0.5mm sand adsorption capacity of the weakest, analysis the main reasons are:

(1) The content of the laterite particles in the middle of the clay is 0-0.005mm, and the content of the iron oxide in the middle reaches of the laterite is higher, and the ability of adsorbing arsenic ions is stronger.

(2) The finer the laterite particles, the bigger the surface area of the particles, the stronger the adsorption of pollutants.

pH values for arsenic adsorption

The adsorption of arsenic on the laterite was greatly affected by the initial pH value of the solution, and Fig. 2 the influence of the pH on the arsenic adsorption capacity of the different particles in the solution. Fig. 2 shows that the effect of pH on the adsorption of arsenic in red soil was greatly. The adsorption capacity of arsenic decreased with the increase of pH value. When the system pH = 3-8, with the increase of pH, the adsorption quantity of arsenic in red soil is gradually decreased, and the optimum adsorption pH of the laterite particles is 4-7. However, when the system pH>8, the adsorption capacity of As on the laterite was greatly reduced. The exchange mechanism exists in As in soil solution. When the solution is acidic, hydroxide ions to the solution of the little, almost no arsenate anions compete with the adsorption sites, arsenate ion adsorbed to the soil particle surface, adsorption quantity is very large; when increasing the pH value, the solution of hydroxide ions gradually increased hydroxide will and arsenate anions compete adsorption sites, thereby reducing the arsenic adsorption.

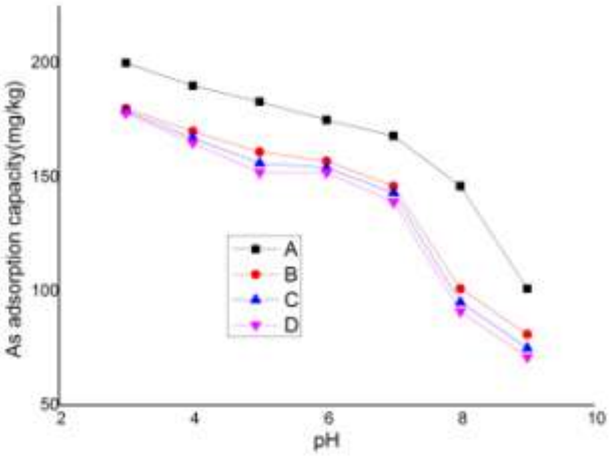

Fig 2 Effect of pH on adsorption of arsenic

Fig. 2 also shows that the pH effect the greatest impact on the four types of laterite in class A, the other three types of laterite effect is almost the same, indicating that particle size range for the laterite in the middle reaches of the 0-0.005mm high off the state of iron oxide content, and pH value has a direct impact on the free ferric oxide existing forms and characteristics, and ultimately effect of arsenic ion adsorption capacity of laterite particles.

CONCLUSION

(1) The main component of laterite for silica, alumina and ferric oxide, stable compounds, for steady chemical Compound, which also contains a small amount free material, when the basic concentration lower than the state regulations will not cause pollution to groundwater.

(2) A few heavy metals in the soil and the poisonous and harmful trace elements content, and most of the poisonous and harmful trace elements in the compound form, it is difficult to directly cause pollution of groundwater.

(3) The adsorption trend of arsenic by different particle size aggregates is consistent with that of the change. That is, when the liquid equilibrium arsenic concentrations of 0-20mg/L, arsenic adsorption with the equilibrium concentration changes larger adsorption curve steeper, when the equilibrium concentration 20 to 40 mg/L, arsenic adsorption changes slowly, curve tends to be gentle.

(4) The isothermal adsorption process of arsenic in each particle of the particle was fitted by Langmuir equation, The laterite adsorption ability of the laterite was the strongest in the range of the size of 0-0.005mm, and the main reasons were analyzed that the content of the laterite particles in the middle of the laterite is 0-0.005mm, and the content of the iron oxide in the middle reaches of the laterite is higher, and the ability of adsorbing arsenic ions is stronger. The more fine the laterite particles, the bigger the surface area of the particles, the more the ability to adsorb the pollutants.

(5) The effect of pH on the adsorption of arsenic in laterite was greatly. The adsorption capacity of arsenic decreased with the increase of pH value. When the system pH = 3-8, with the increase of pH, the adsorption quantity of arsenic in red soil is gradually decreased, and the optimum adsorption pH of the laterite particles is 4-7. However, when the system pH>8, the adsorption capacity of arsenic on the laterite was greatly reduced. The exchange mechanism exists in arsenic in soil solution.

(6) The pH effect the greatest impact on the four types of laterite in class A, the other three types of laterite effect is almost the same, indicating that particle size range for the laterite in the middle reaches of the 0-0.005mm high off the state of iron oxide content, and pH value has a direct impact on the free ferric oxide existing forms and characteristics, and ultimately effect of arsenic ion adsorption capacity of laterite particles.

ACKNOWLEDGEMENT

This research was financially supported by the National Science Foundation (51168022) and the scientific research key fund project of Education Department of Yunnan Province (2013Z114).

REFERENCES

1. Li Jingchang,Wei Zhongding; Quality and proposition of groundwater. Beijing:China Building Industry Press,1983;148-173(in Chinese)
2. Shen Jingwen; The proposition of fertilizer pesticide and wastewater irrigation in groundwater. Agricultural Environment Protection, 2009; 11(3):137-139.
3. Wang Yunquan, Ren Deyi; The differential element leaching experimental investigation of the coal and combustion product. Environmental Science, 1996; 17(1):16-17.
4. Komnitsas K, Bartzas G, Paspaliaris I; Efficiency of limestone and red mud barriers: Laboratory column studies. Minerals Engineering, 2004; 2:183-194.
5. Peng Zezhou, Ynag Tianhang; Aquatic environment mathematical model and application. Beijing: chemical engineering industry press, 2007; 1(1):5-94.