The University Of Sheffield.

Adsorptive Removal of Cu(II) and Zn(II) From Rainwater Runoff By Using Alum Sludge

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A WORLD TOP 100 UNIVERSITY

Overview of Rainwater Runoff Pollution

➢ **Rainwater runoff**

- Even if point source pollution is fully controlled, the compliance rate of surface water quality is only 42%-65%.
- Urban areas are 50%–100% impermeable, and urbanization increases rainwater runoff by 35%.
- Rainwater runoff is considered to be one of the main pathways for the diffusion of non-point source pollutants in the urban environment.

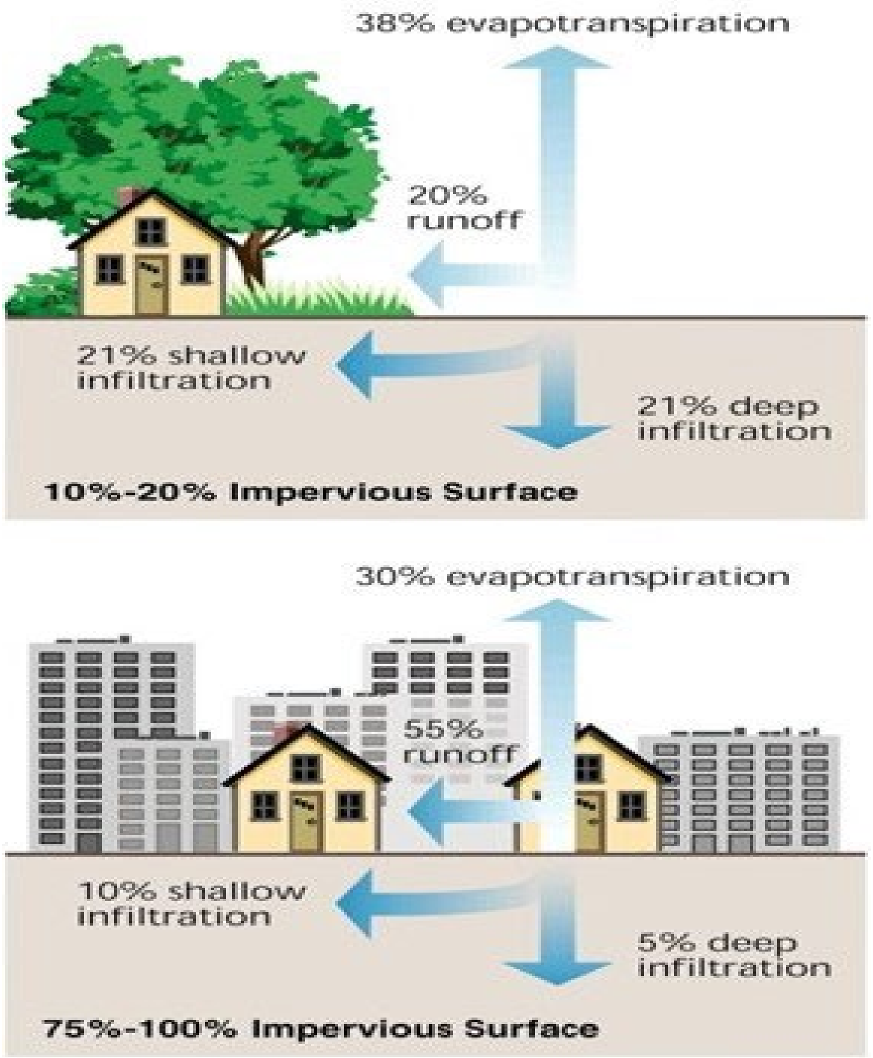


Figure 1. Impact of Urbanization on rainwater Runoff

Overview of Rainwater Runoff Pollution

➢ **Current situation**

- Up to 60% of water environmental pollution comes from non-point source pollution, and rainwater runoff accounts for 25% of it.
- Of 129 key pollutants monitored in water quality assessments, 50% are detected in urban rainwater runoff.

➢ **Pollutants**

- Metals, Nutrients, Organic Pollutants, Sediment and Pathogens

Table 1. Concentration range of some runoff pollutants

Pollutants	Concentration range（mg/L）
Total suspended solids	141-708
Total phosphorus	0.01-21.2
Ammonia	0.1-10.8
Zinc	0.001-3.05
Copper	0.001-1.36
Lead	0.0005-0.69
Chromium	0.01-0.22
Diethylhexylphthalate	0.0153-0.0609
PAHs	0.000892-0.00136
Diuron	0.000394-0.000647
PCBs	< LOQ-0.000727

Overview of Rainwater Runoff Pollution

➢ **Pollutants of Concern**

- 35%-75% of heavy metals in the total pollutant load of surface water come from urban rainwater runoff.
- Wide source
- Toxic
- Relatively high concentration
- Concentration may exceed PMTDI* standard
- Concentration can exceed the average environmental background value

Table 2. Cu(II) & Zn(II) as pollutants in runoff

Category	Sources	Toxicity	Concentration (mg/L)	PMTDI* (mg/L)
Cu(II)	Mining operations, chemical, and pharmaceutical equipment, kitchenware, paper manufacturing	Menkes, Wilson, Alzheimer's, Parkinson's diseases, damages for eye and liver, vomiting, cramps, convulsions	0.001-1.36	1.5
Zn(II)	Mineral mining, automobile tire wear, anti-corrosion materials	Depression, lethargy, respiratory diarrhea, headaches	0.001-3.05	3

PMTDI*:provisional maximum tolerable daily intake

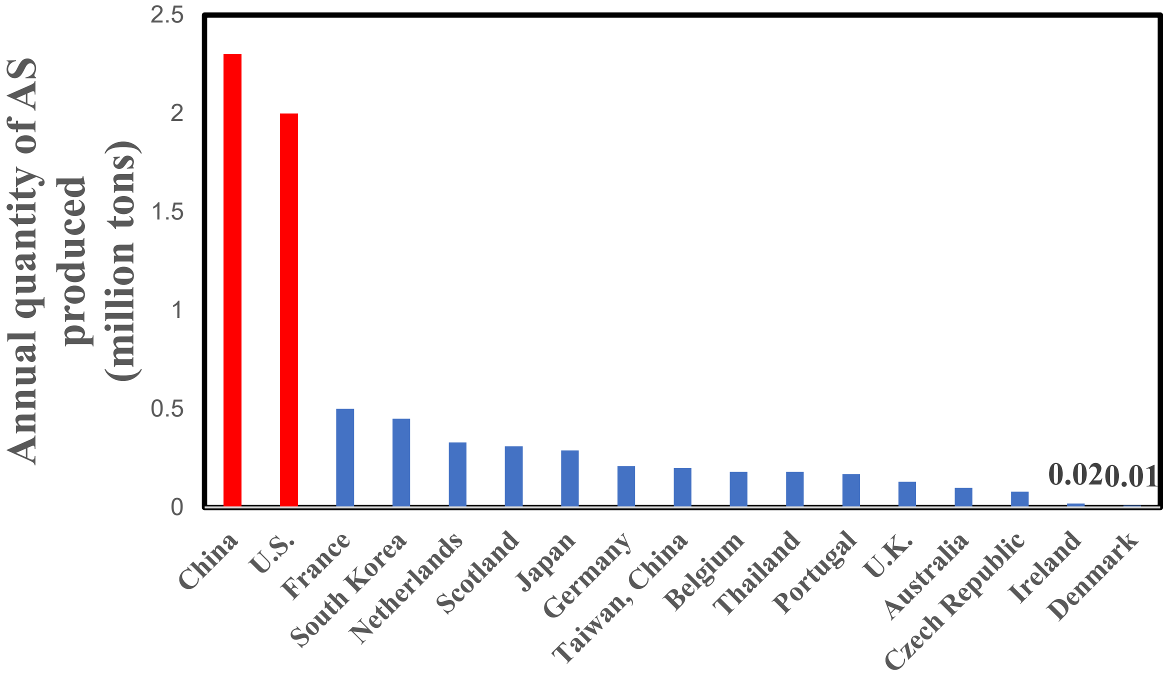
Overview of Rainwater Runoff Pollution

Rainwater Runoff

- Low Impact Urban Design and Development（NZ）
- Best Management Practice（USEPA）
- Low Impact Development（USEPA）
- Sustainable Drainage Systems（UK）
- Water Sentitive Urban Design（AUS）

Alum sludge

➢ What is Alum Sludge?



➢ Output

- A water purification plant with a water production capacity of 150,000 m^3/d can produce 10t of alum sludge per day.
- The global can produce about 10000t/d of alum sludge on average.

➢ Disposal Cost

- Australia costs $6.2 million a year to landfill or discharge alum sludge into sewers.
- Netherlands costs up to $50 million a year to dispose of it.

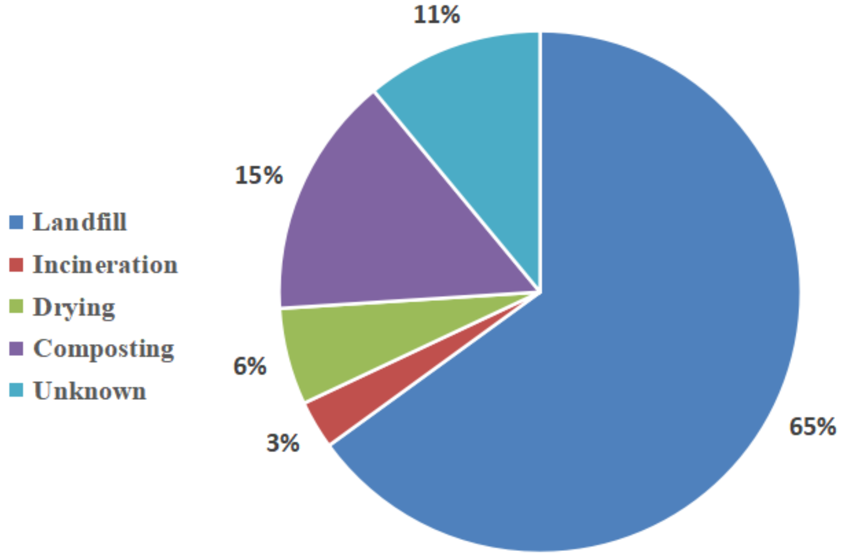
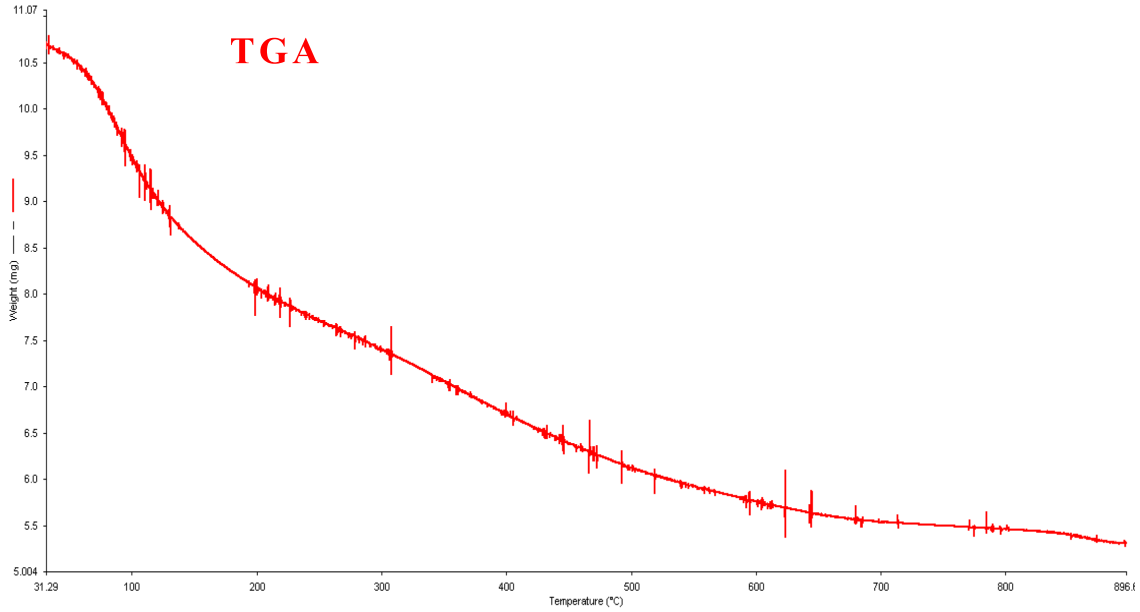


Figure 2.Disposal of Alum Sludge

Alum sludge

➢ **Can we use alum sludge as an alternative to low cost adsorbents?**



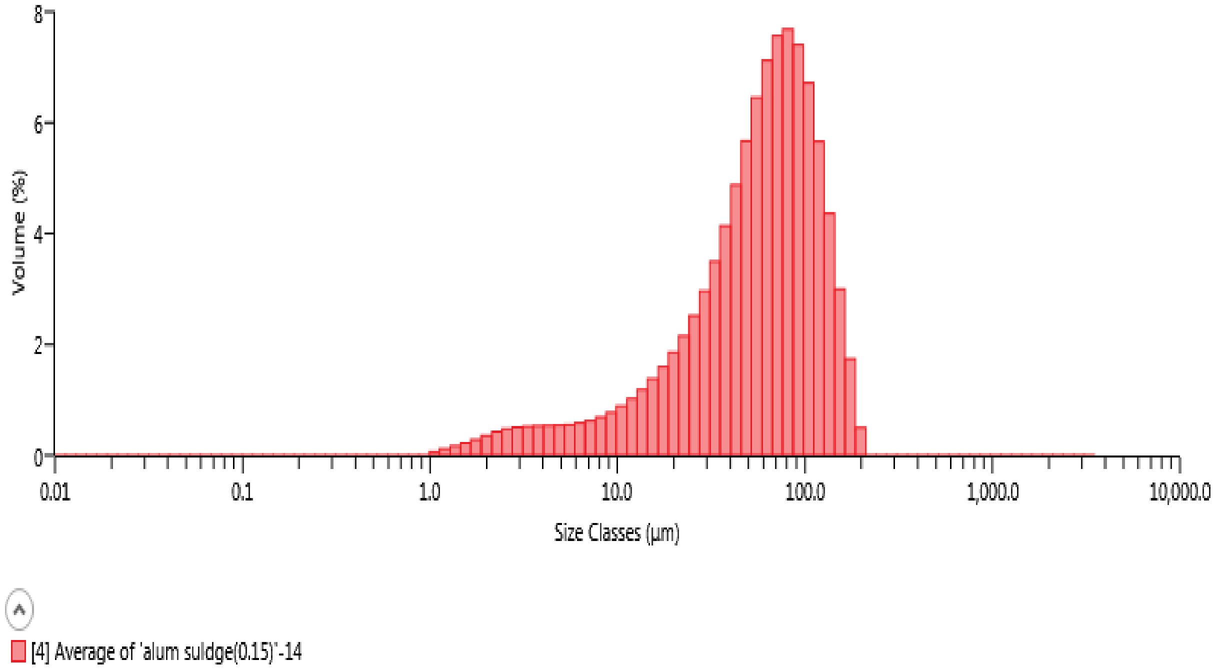
- Moisture 19%
- Organic matter 35%
- Residual 46%

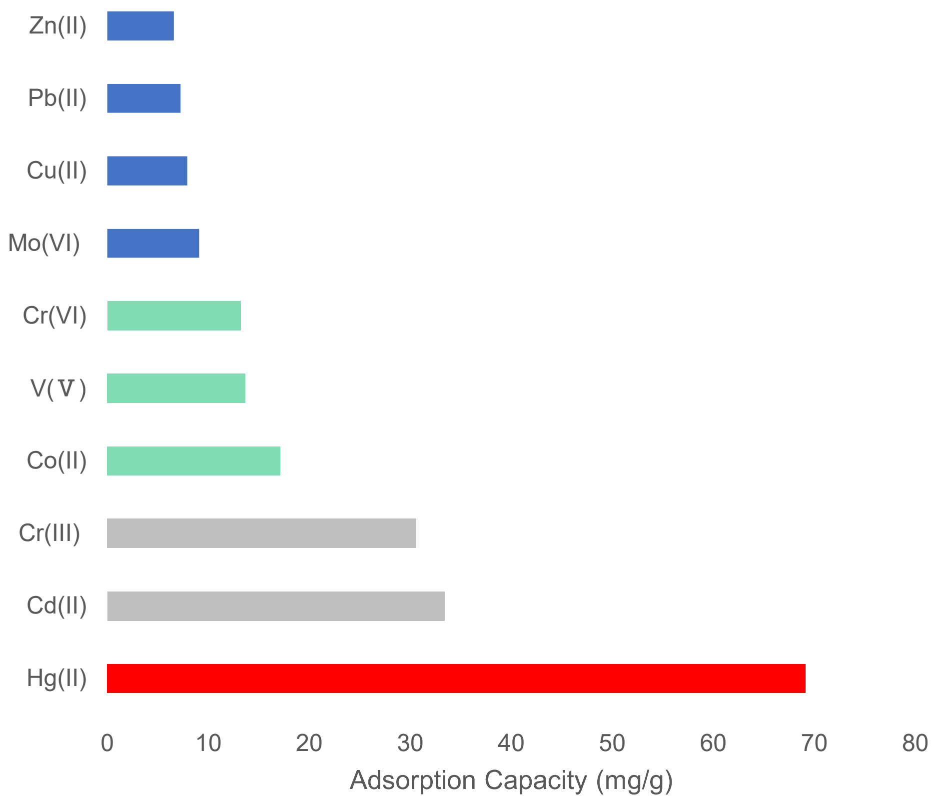
Table 3. Characterization of alum sludge

Component	Percentage (wt. %)
SiO_2	53.6
Al_2O_3	20.9
Fe_2O_3	6.6
MgO	1.9
CaO	0.3
PbO_2	0.2
CuO	<0.1
ZnO	<0.1
Cr_2O_3	<0.1
CdO	<0.1

Alum sludge

➢ **Can we use alum sludge as an alternative to low cost adsorbents?**

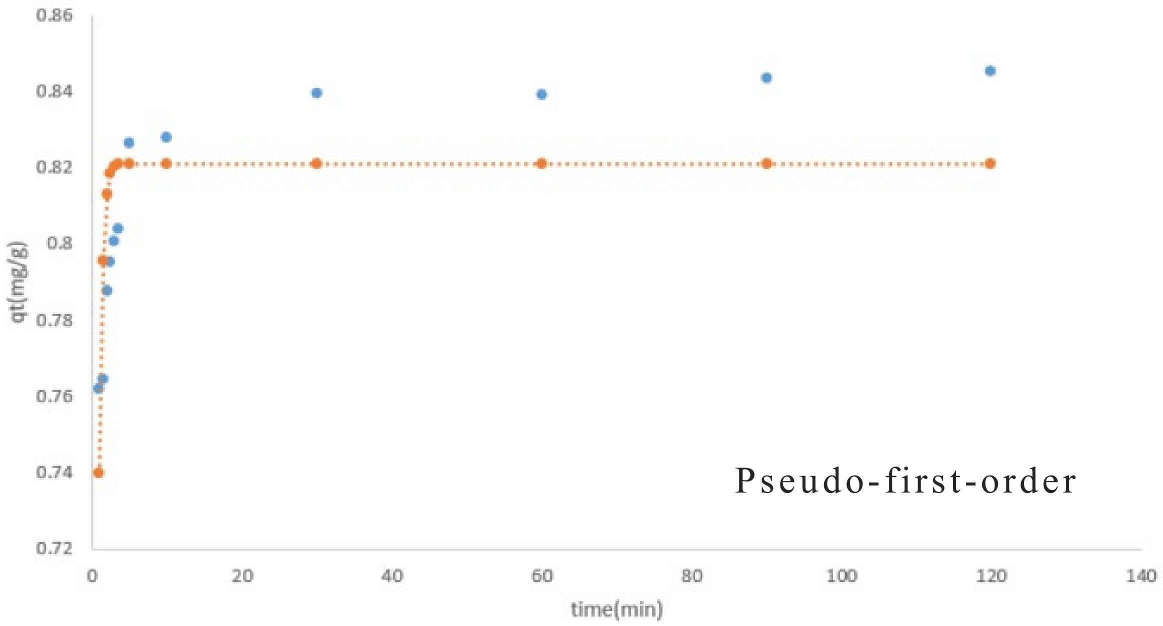


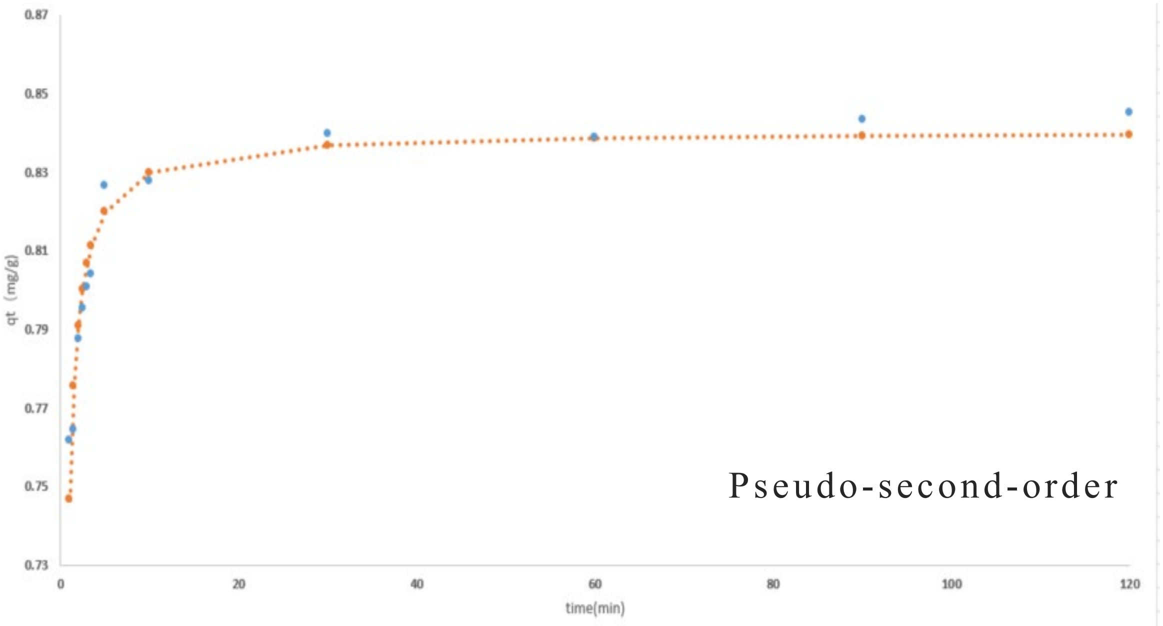


- Specific Surface Area 0.3m^2/g
- bentonite 67m^2/g ,rice straw 29.6m^2/g

Batch experiments

➢ Kinetics (Zn)

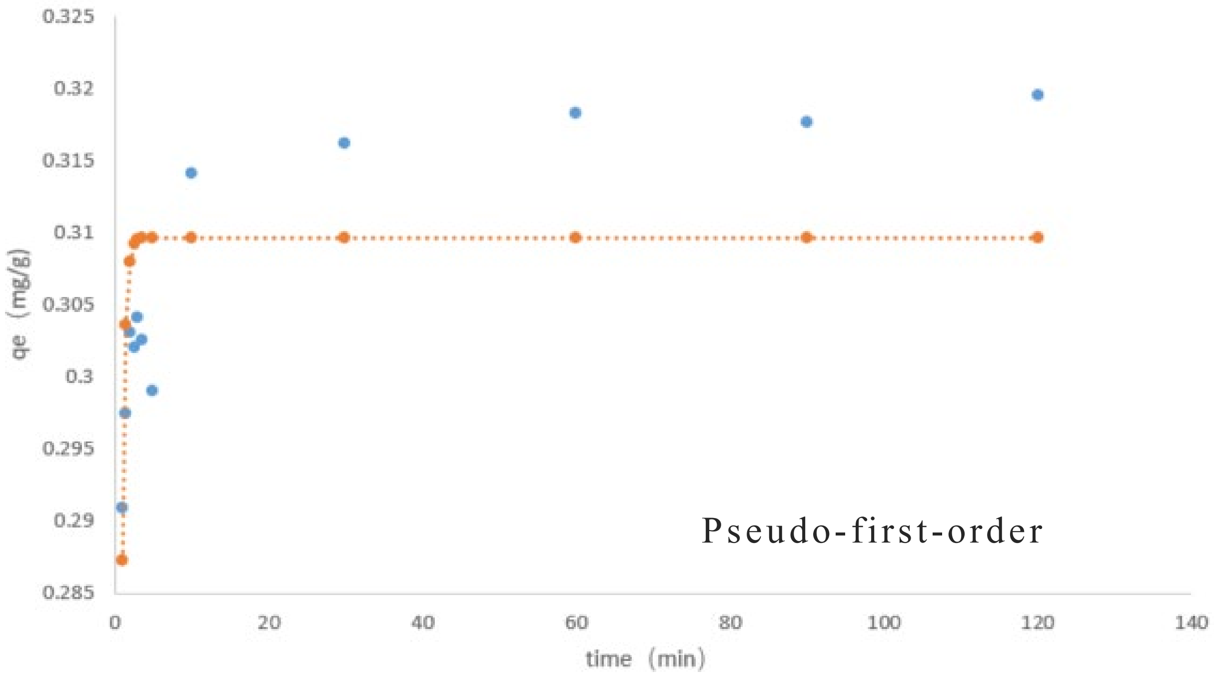


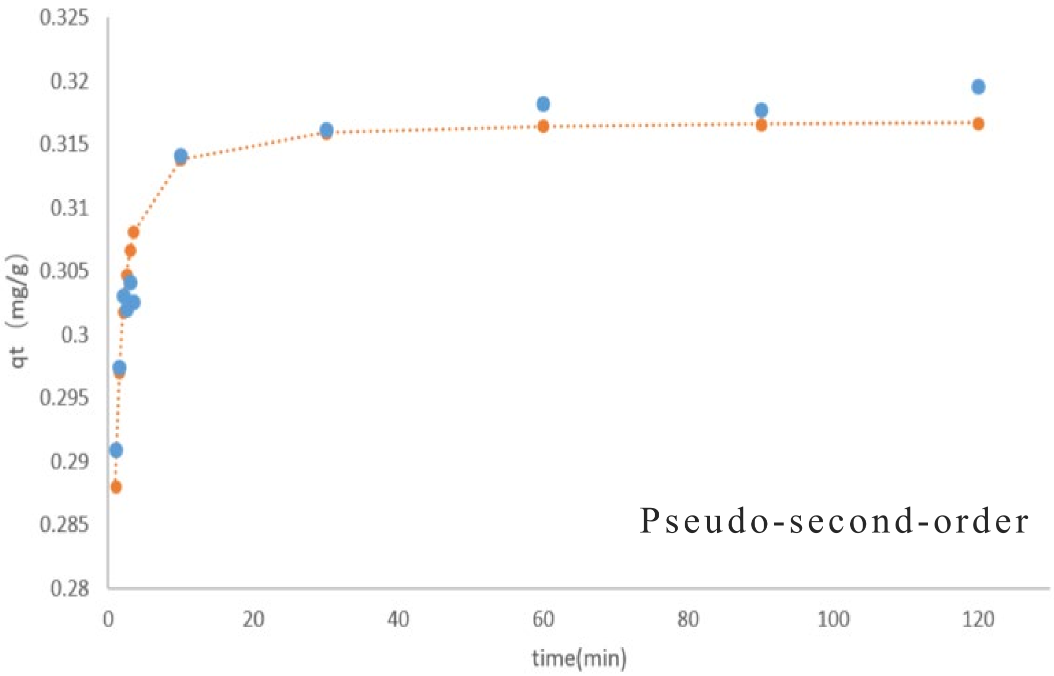


Metal ions	Pseudo-first-order			Pseudo-second-order		
	R^2	Q_e(mg/g)	K_1(1/min)	R^2	Q_e(mg/g)	K_2(1/min)
Zn(II)	0.48	0.82	2.31	0.82	0.37	41.51

Batch experiments

➢ Kinetics (Cu)

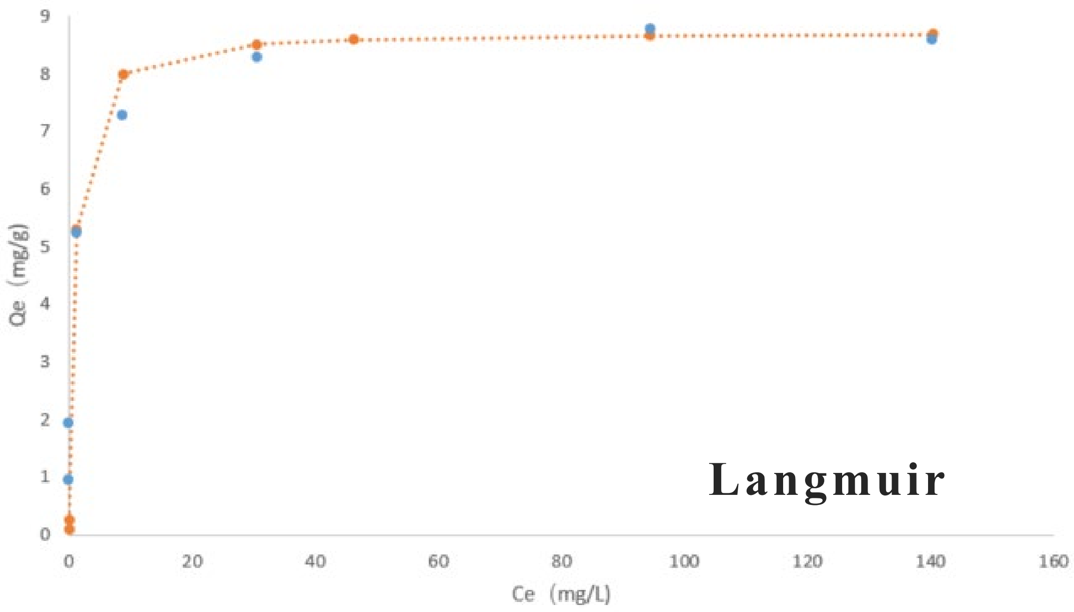


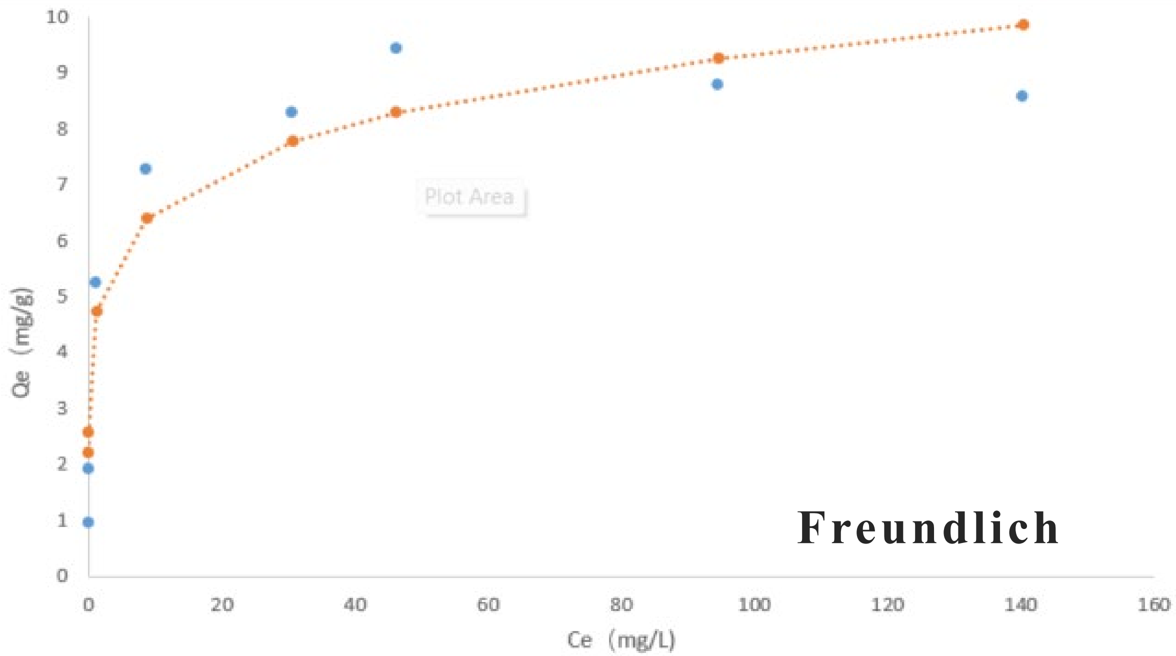


Metal ions	Pseudo-first-order			Pseudo-second-order		
	R^2	Q_e(mg/g)	K_1(1/min)	R^2	Q_e(mg/g)	K_2(1/min)
Cu(II)	0.39	0.31	2.63	0.93	0.32	31.37

Batch experiments

➢ **Isotherm （Zn）**

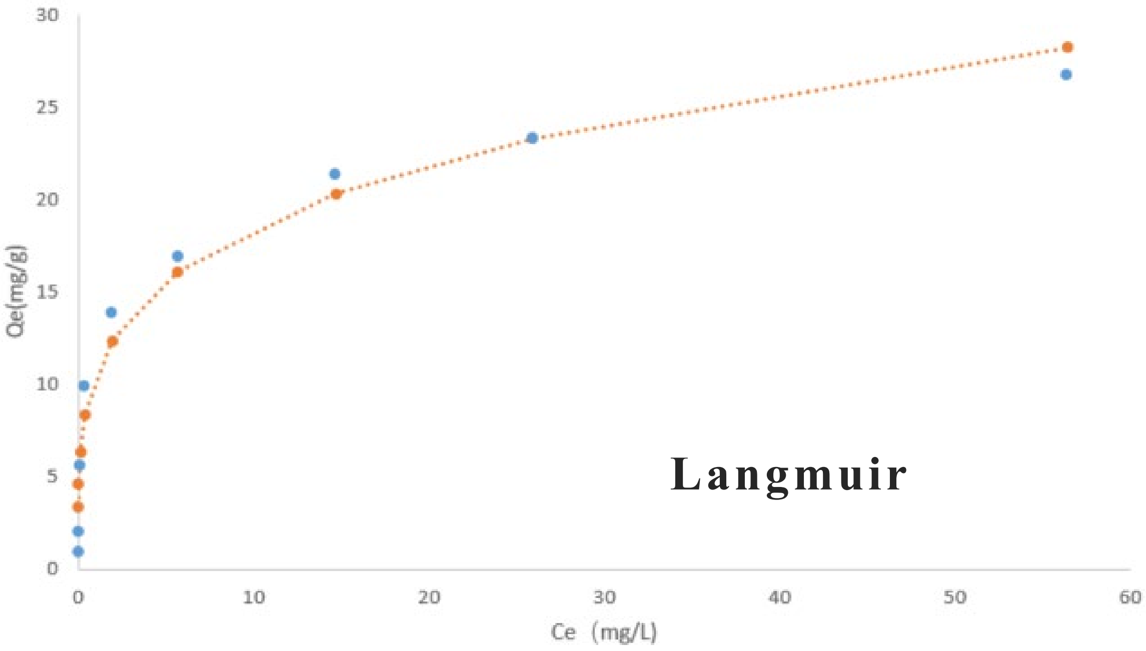


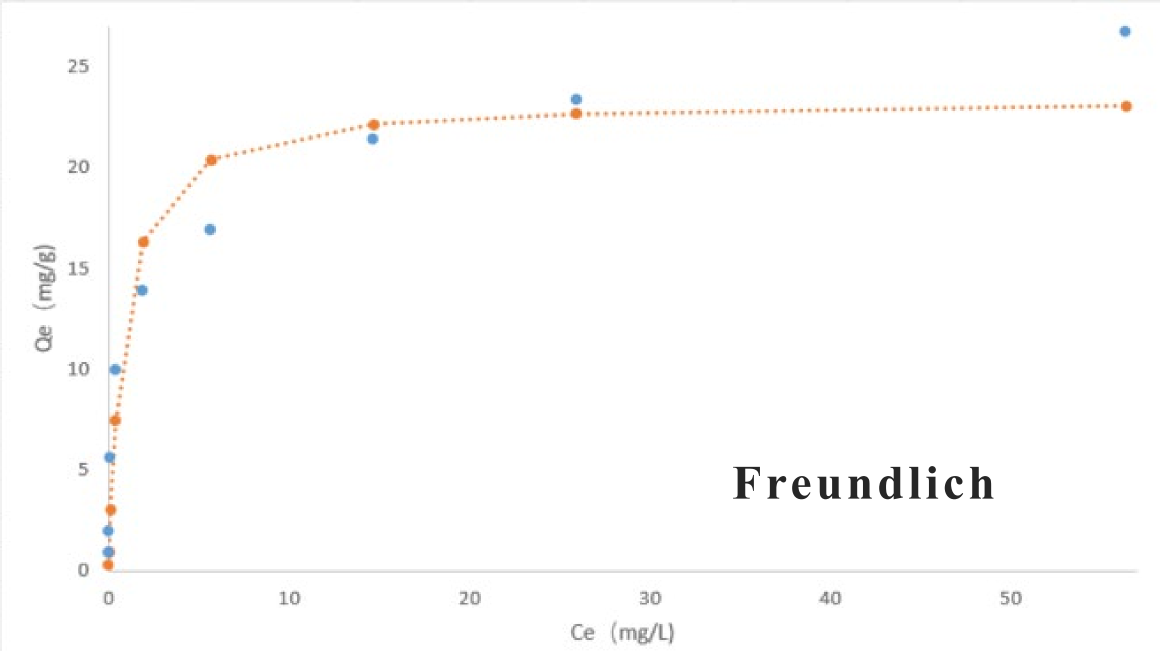


Metal ions	Temperature (℃)	Langmuir				Freundlich		
		Q_e(mg/g)	K_L（L/mg）	R_L	R^2	K_F((mg/g)(L/mg)1/n)	n	R^2
Zn(II)	25	8.74	1.23	0.29	0.94	4.57	6.44	0.91

Batch experiments

➢ Isotherm (Cu)

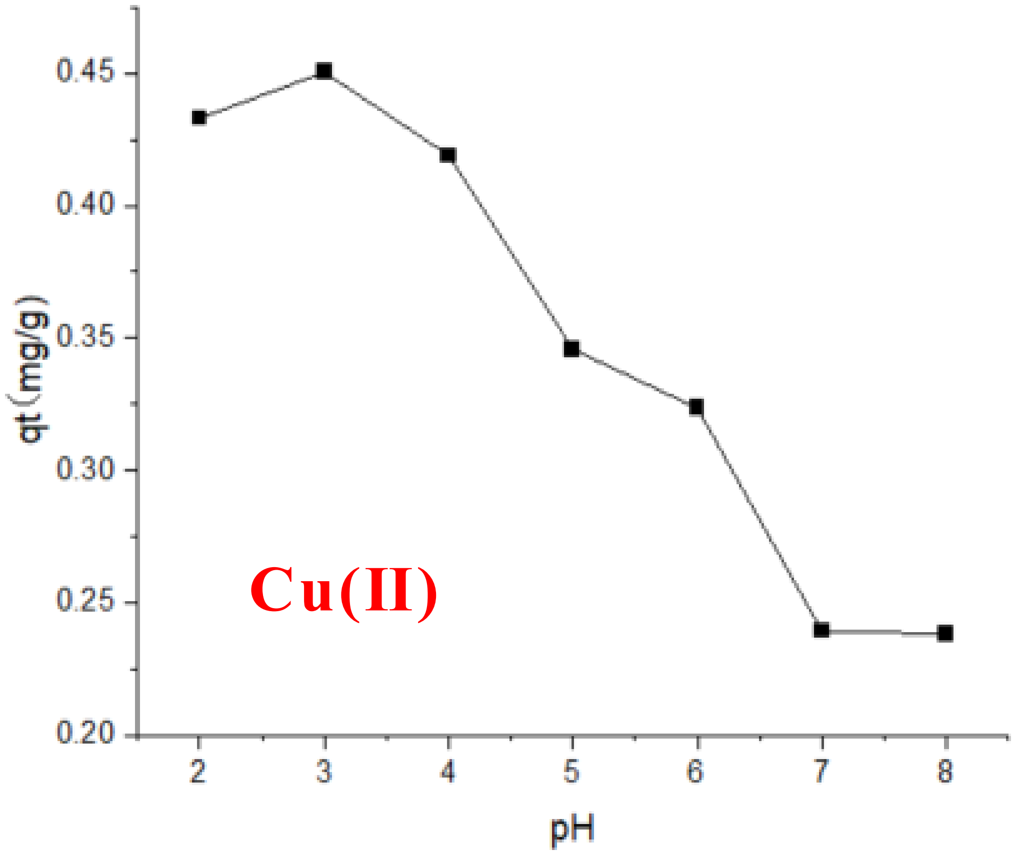


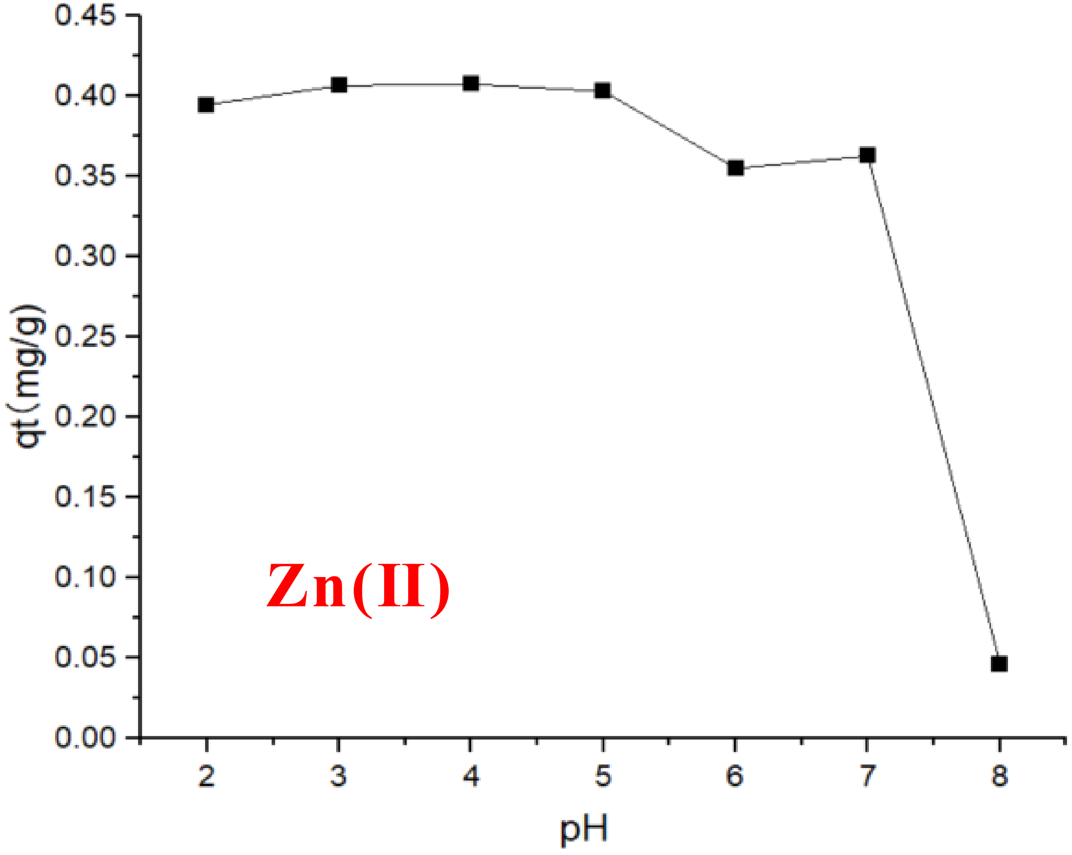


Metal ions	Temperature (℃)	Langmuir				Freundlich		
		Q_e(mg/g)	K_L (L/mg)	R_L	R^2	K_F((mg/g)(L/mg)1/n)	n	R^2
Cu(II)	25	23.4	1.19	0.3	0.93	10.51	4.08	0.97

Batch experiments

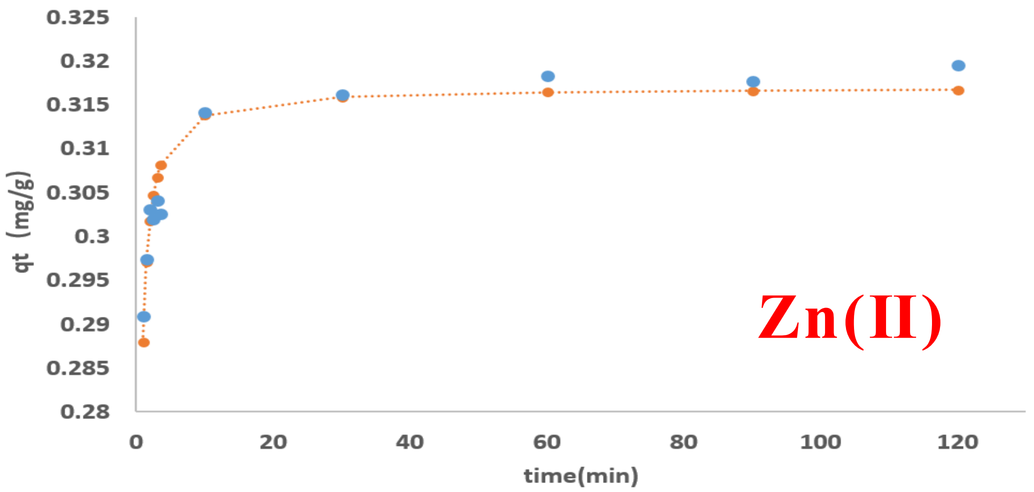
➢ **Effect of pH on Adsorption Capacity**

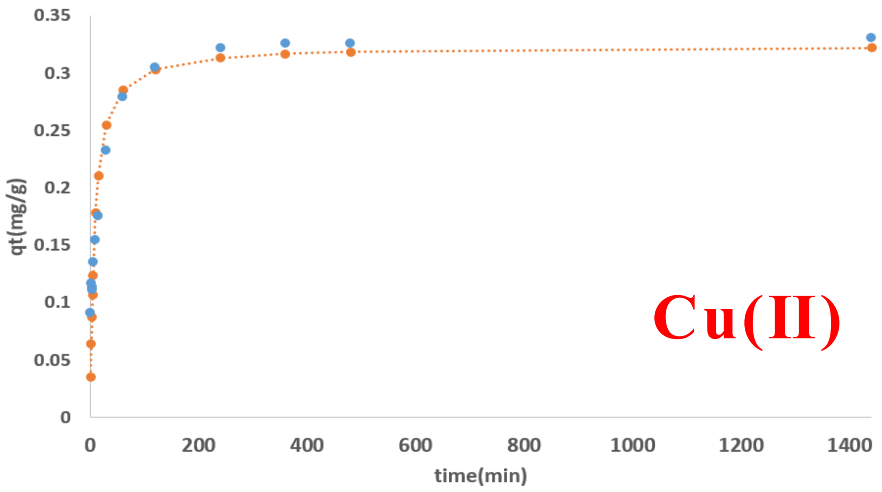


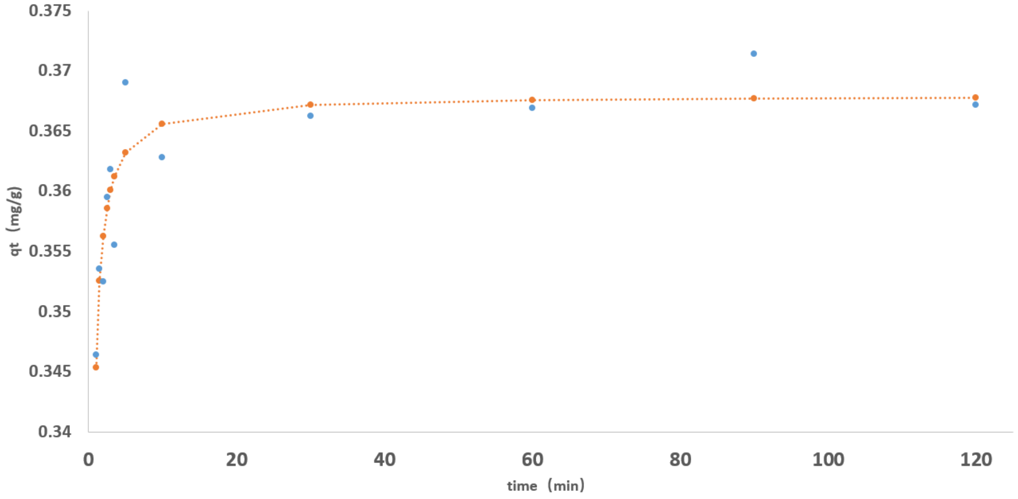


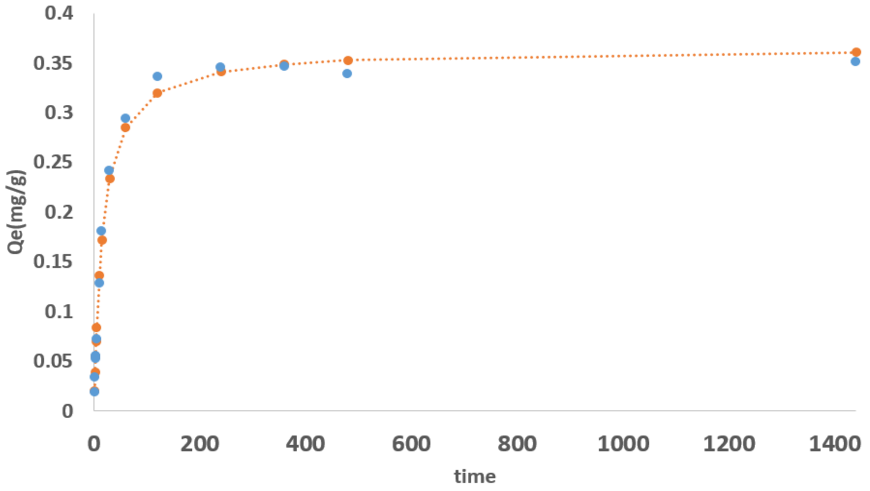
Batch experiments

- Different particle size









< 0.125mm

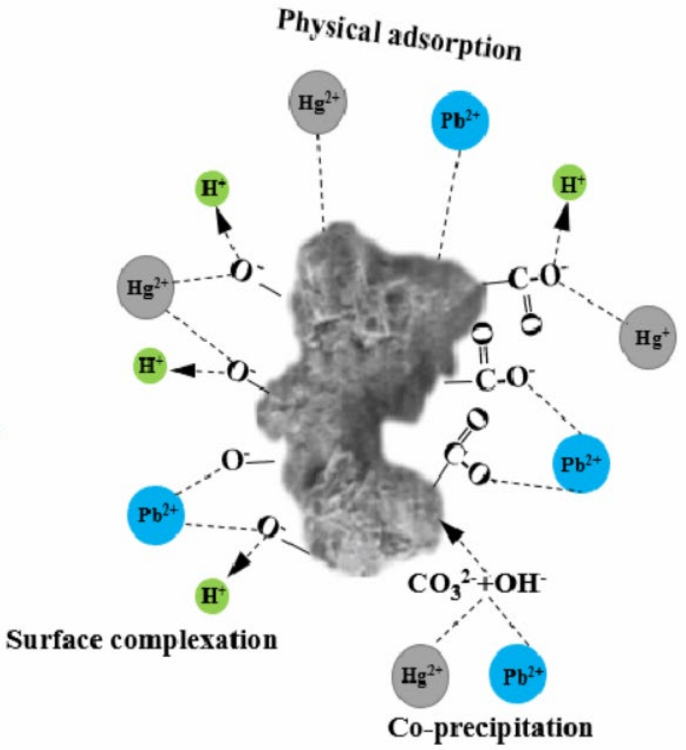
1-2mm

conclusion

➢ Possible chemical adsorption mechanism

- Alum sludge is an effective adsorbent to remove Cu(II) and Zn(II).
- In addition to physical adsorption, the adsorption process of copper and zinc was also accompanied by chemical reactions, which may involve surface precipitation and ion exchange.
- The possible mechanisms include hydroxyl substitution, surface complexation, co-precipitation, and physical adsorption such as van der Waals forces.

Alum sludge




Thanks!