Supporting Information

Table S1 Ion concentrations of real low-strength municipal wastewater

Ion type	Na^+	NH_4^+	K^+	Mg^{2+}	Ca^{2+}
Concentration (mg/L)	71.3	25.2	10.4	34.4	102
Concentration (mmol/L)	3.10	1.40	0.26	1.43	2.55

Session 1 Column tests for ammonia removal by powdered resin

Since the particle size of powdered resin was much smaller than traditional bead-shaped resin, fluidized-bed reactor cannot be used for powdered resin to avoid loss from the reactor. Thus, a new kind of film reactor was developed, in which powdered resin was evenly deposited on top of the filter element (polyester fibers) to form a thin resin film (Fig.S1). Feed solution flowed down through this thin film, making ammonia ions contact sufficiently with powdered resin.

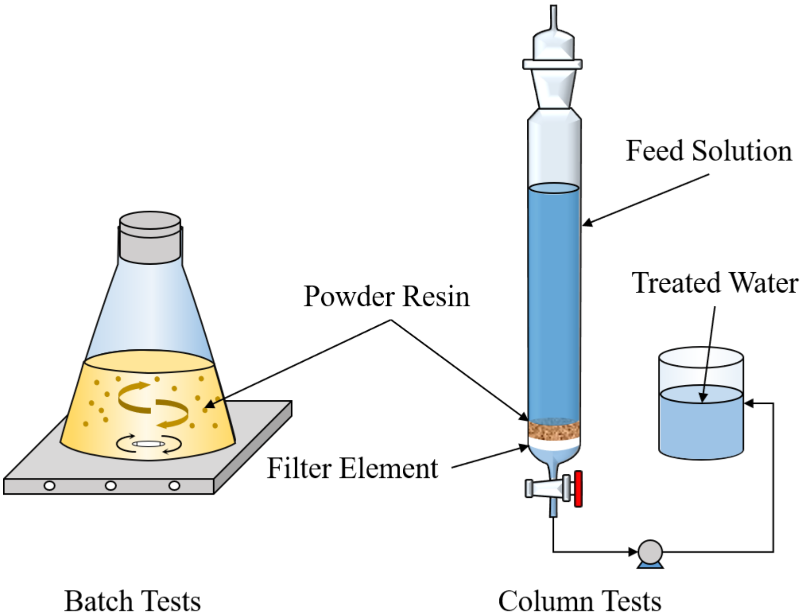


Figure S1. Schematic of batch and column tests for ammonia removal by powdered resin.

Session 2 Long term stability

To test the long-term stability of powdered resin after several regeneration cycles, adsorption capacity with different initial concentrations (20, 100 and 300 mg/L) was depicted in Fig.S2. Because of difference in initial concentration, adsorption capacity distributed in different ranges, around 5 mg/g at 20 mg/L, 17 mg/g at 100 mg/L and 32 mg/g at 300 mg/g. However, as illustrated in Fig.S2, only small changes can be observed in adsorption capacity. This means that the adsorption capacity of powdered resin was not significantly influenced by number of regeneration cycles over the tested range. Similar results were also gained by previous studies. In practical applications, long term stability should be tested according to different regeneration solutions, such as NaCl and NaOH with different proportions.

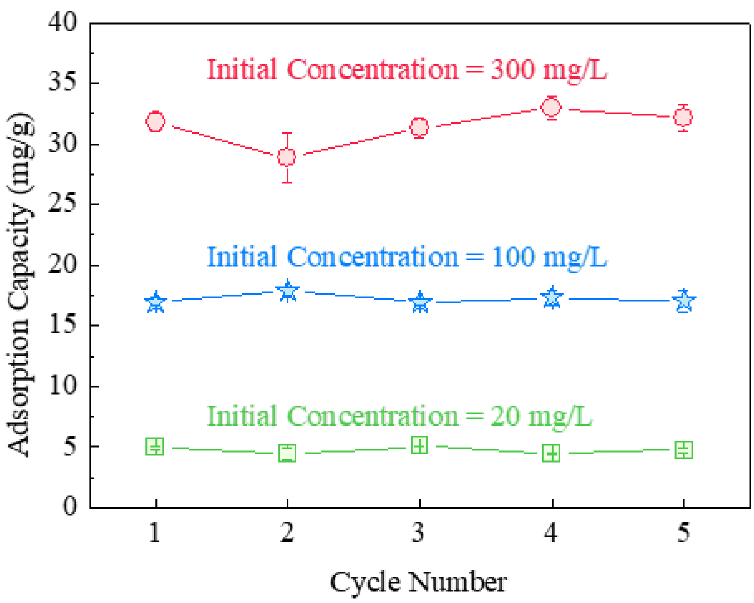


Fig. S2 Adsorption capacity of powder resin after several regeneration cycles with different initial concentrations.

Session 3 Langmuir model

Langmuir model (Eqs. (1)) was used to describe the ammonium equilibrium adsorption characteristics of the powdered resin.

Langmuir model: $$AC = \frac{k_L c_t q_{max}}{1+k_L c_t} \quad (1)$$

where AC (mg/g) is the amount of ammonium exchanged by the powdered resin at equilibrium concentration c_t (mg N/L); q_{max} (mg/g) represents the maximum monolayer adsorption capacity of the adsorbent; k_L (L/mg) is the Langmuir constant, which is related to the free energy of adsorption.

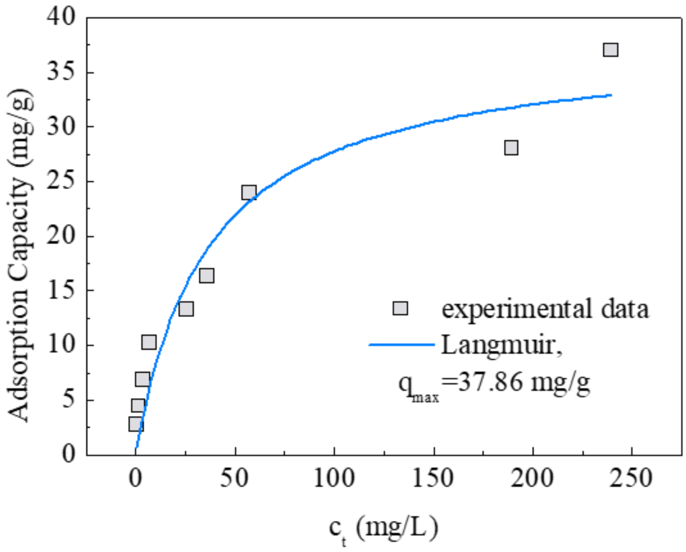
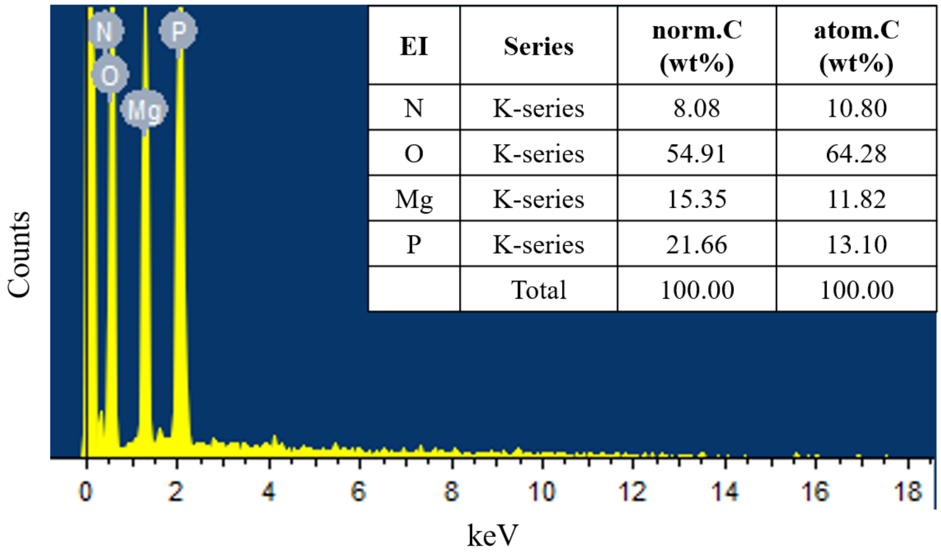


Fig.S3 Experimental data of normal resin for ammonia adsorption fitted to Langmuir model.

Session 4 EDX analysis

The EDX analysis of precipitates generated (pH=10) was shown in Fig.S4. Similar results were also gained in some other previous studies. Thus, it can be concluded that struvite can be gained successfully.



El	Series	norm.C (wt%)	atom.C (wt%)
N	K-series	8.08	10.80
O	K-series	54.91	64.28
Mg	K-series	15.35	11.82
P	K-series	21.66	13.10
	Total	100.00	100.00

Fig. S4 EDX analysis of struvite when pH value was 10.

Session 5 Mass balance

All reagents used in the imitated wastewater were chloride salts. Thus, Cl^- was the only anion that existed in the feed solution. In the first stage crystallization, Na_2CO_3 was added in the reactor, precipitates of $CaCO_3$ was gained. Thus, Cl^- remained in the feed solution with a small amount of CO_3^{2-}. In the IE process, only cations reacted with powdered resin. The composition of the anions was constant. In the regeneration process, NaCl solutions were used. Thus, the anions were still the same. In the second stage crystallization process, Na_2HPO_4 was added to the reactor with the generation of struvite. A small amount of HPO_4^{2-}, $H_2PO_4^-$ and PO_4^{3-} were introduced to the system. In conclusion, Cl- remained in the feed solution with a small amount of CO_3^{2-}, HPO_4^{2-}, $H_2PO_4^-$ and PO_4^{3-} introduced in the system.

As for the cations, Ca^{2+}, Mg^{2+}, NH_4^+ existed in the feed solution at the beginning. In the first stage of crystallization, 97.5% of Ca^{2+} was removed with the generation of $CaCO_3$. In the IE process, Mg^{2+} and NH_4^+ were adsorbed by the powdered resin in the adsorption process and regenerated by NaCl in the regeneration process. Only a small amount of them existed in the outflow (14.48% of Mg^{2+} and 9.40% of NH_4^+). In the second stage crystallization process, most Mg^{2+} and NH_4^+ were transferred to the struvite with a small amount remained in the concentrated solution.

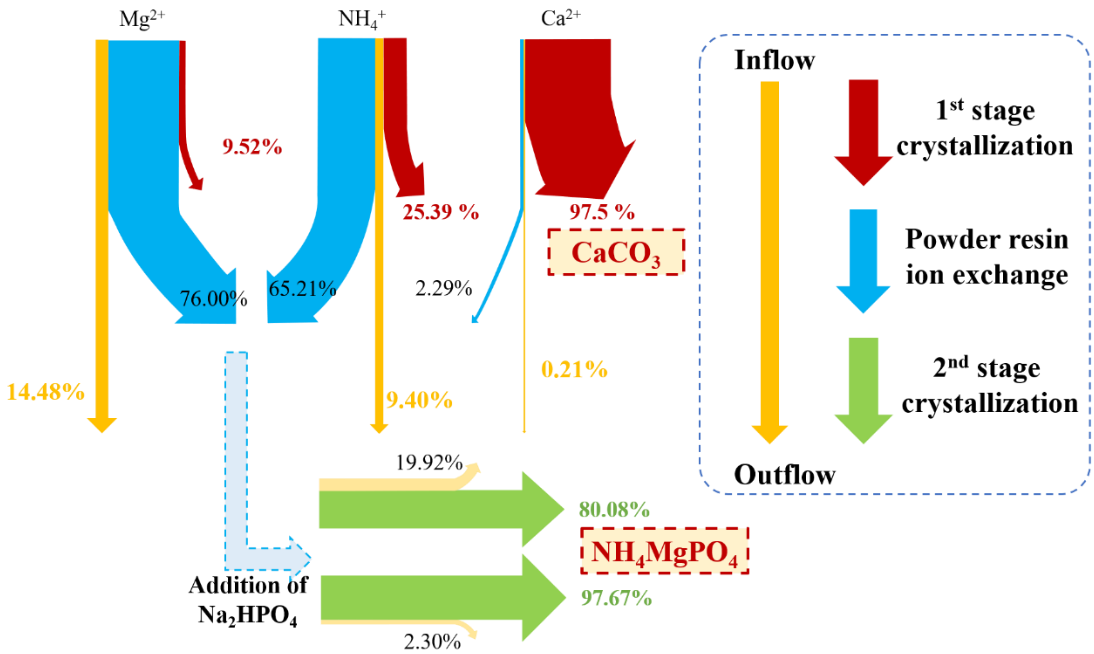


Fig. S5 Mass balance of cations in the two-stage crystallization process.