Removal of heavy metal ions by the Zeolitized FWG

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Introduction:

Formed waste glass (FWG) and zeolitized FWG was developed by recycling one way bottle such as wine bottle. FWG is high water absorbing property and has many microscopic pores. It has been confirmed that FWG material can be applied to the water purification system in rivers, etc.

In this paper, batch tests with aqueous solution of several heavy metals using zeolitized FWG are carried out. From these test results, the removal characteristics of the zeolitized FWG were discussed.

Materials and methods:

The waste glass after conducted following process: crushing, mixing with some additive materials, melting at 800~900℃ in a special furnace, it is combined with Na-Zeolite to form the functional material (Zeolitized FWG) and removal of heavy metal ions is investigated by this material.

Batch adsorption experiments were carried out by stirring 150g of Zeolitized FWG with 3 liters of aqueous solution of Cd(II), Pb(II), Zn(II), and Cr(VI) with an initial concentration in the range of 1 to 10 mg/l, at various retention times under a constant temperature. Continuous mixing was provided during the experiments with a constant agitation. Similar batch experiments were carried out using activated carbon for comparison.

Results and discussion:

Several experiments were conducted for the determi the adsorption isotherm and examined the kinetic behaviors.

Removal of Cd(II), Pb(II), Zn(II) and Cr(VI) on Zeolitized FWG was observed with respect to time. Maximum adsorption rate of most of heavy metals occurred within the first 1 hour, after that it decreased. This means that, at first, all adsorbent surfaces are vacant and the solute concentration gradient is high, and then the heavy metals removal rate decreases significantly due to the decreasing in adsorption surface. (Fig.1)

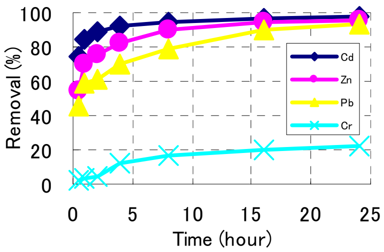

Fig.1. Adsorption of metal ions on Zeolitized FWG

The results also shown that removal capacity for Cd(II) > Zn(II) >Pb(II), according to the affinity of metallic ions for Zeolitized FWG; Cd(II) > Zn(II) >Pb(II). Removal of Cr(VI) was much less because Cr(VI) is high oxidizer, in solution it exists in the form of $(CrO_4)^{2-}$, $(HCrO_4)^{-}$, or $(Cr_2O_7)^{2-}$, that are disadvantage for ion-exchange on Zeolitized FWG material. From this phenomenon, it can be supposed that the metal ions biding to Zeolitized FWG was an ion-exchange mechanism which involves electrostatic interaction between the negatively charged groups in the Zeolitized FWG and metallic cations. Removal of heavy metals by Zeolitized FWG at different initial concentrations were also examined and in all cases the shape of the removal vs. time curves was similar to that observed in Fig.2.

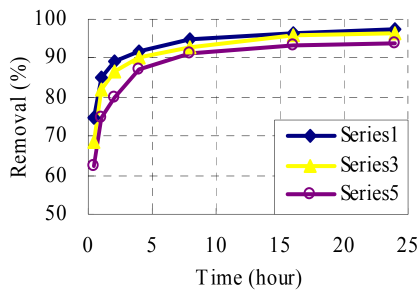

Fig.2. Adsorption of Cd(II) on zeolitized FWG at different concentrations

The saturation period of the adsorption was entirely independent on the initial concentration. The results on the effect of contact time for the removal of heavy metals with different initial concentrations show that time state is 24 hours to reach equilibrium. The effects of variation in these parameters on heavy metal ions removal were quantified in terms of their plateau of 24h values. The dependence of the processes of heavy metals removal on different initial concentrations (1~10mg/l) were illustrated in Fig.3.

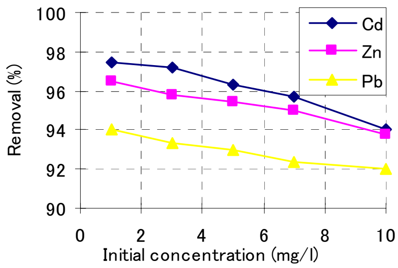

Fig.3. Effect of initial concentration on removal of metal ions

The removal of Cd(II) ions decreased from 97.5% (0.0195 mg/g) to 94% (0.189 mg/g), Zn(II) from 96.5% (0.0193) to 93.8% (0.187) and Pb(II) from 94% (0.019) to 92% (0.184) by increasing the concentration from 1 to 10 mg/l at Zeolite-FWG dose of 50g/l.The increase in initial heavy metal concentration decreased the percentage of the removal and increased the amount of heavy metal ions uptake per unit mass of the adsorbent (mg/g).

This may be due to at higher initial concentrations the ratio of initial number of moles of Cd(II), Pb(II), Zn(II) to the available surface area was high, hence fractional adsorption became dependent on initial concentration. For fixed adsorbent dose, the total available adsorption sites were limited, on the other hand, the same amount sorbate is adsorbed, therefore, a higher initial concentration, a low removal percentage.

In order to validate Zeolitized FWG as an adsorbent for heavy metals removal, its adsorption potential was compared with activated carbon. Adsorption data for a wide range of metals ions concentrations were described by adsorption isotherms, such as the Freundlich or Langmuir isotherms, which related to the relation of the adsorption density q_e to equilibrium adsorbate concentration in the bulk fluid phase, Ce. The parameters (K_f, n, Q_{max}, b) of Freundlich and Langmuir formula for the adsorption of metal ions on Zeolitized FWG and activated carbon materials were calculated from intercept and slope of the linear plots of qe versus Ce, $\log(q_e) = \log K_f + n \log C_e$ and $\frac{1}{q_e} = \frac{1}{Q_{\max} \cdot b \cdot C_e} + \frac{1}{Q_{\max}}$ (respectively data not shown). The obtained Freundlich and Langmuir curves for adsorption of metal ions on Zeolitized FWG and activated carbon were shown in Fig.4

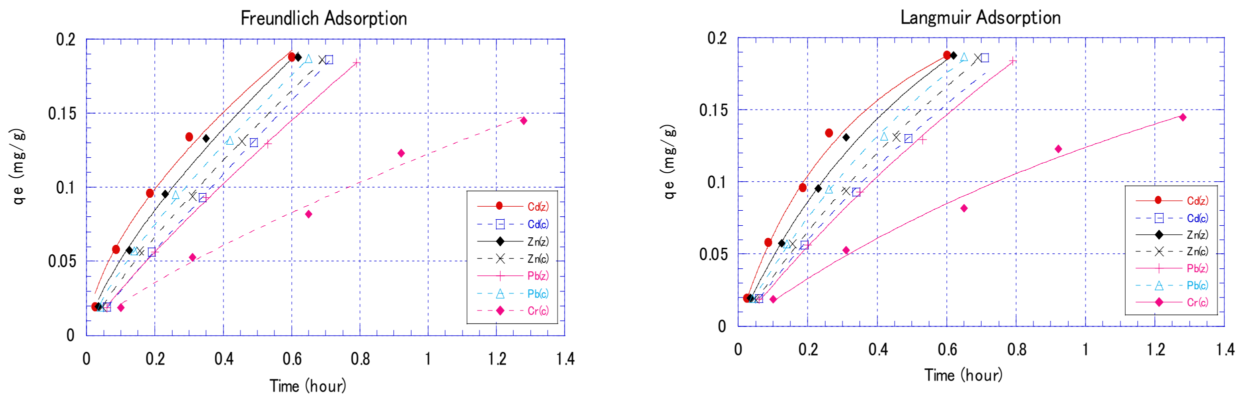

Fig.4. Adsorption isotherm of heavy metal ions onto Zeolitized FWG and activated carbon

It may be observed that the removals of Cd(II) and Zn(II) by Zeolitized FWG were higher than those by activated carbon, contrary, the removal of Pb(II) by Zeolitized FWG was lower than that by activated carbon. The removal of Cr(VI) by Zeolitized FWG was relatively low. The adsorption capacity for these materials was probably related to the sorption mechanism of both ion exchange and surface adsorption.

Conclusions:

It is suggested that Zeolitized FWG is a good material which can adsorb heavy metals. The order of adsorption potential of metals on Zeolitized FWG under same conditions is Cd(II) > Zn(II) > Pb(II) >Cr(VI). Generally, the adsorption isotherms of heavy metal ions by Zeolitized FWG are better fitted to the Freundlich formula than to Langmuir formula.