Short Communication

Sorption of Pb(II) by bituminous coal

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Removal of Pb(II) on bituminous coal at different pH values has been investigated. Maximum sorption (92.52%) observed at pH 8 and this pH value has been related with pK value. Langmuir model has been used to calculate sorption capacity of bituminous coal.

Different sorbents like kaolinite, tea leaves, flyash and activated carbon have been used for the removal of Pb(II) from wastewater1-4. Bituminous coal contains organic matter with hydroxyl and carboxyl groups while it's inorganic constituents are mainly silica and alumina. It is thus expected that Pb(II) will be sorbed by the combined effect of both organic as well as inorganic matters. In view of this behaviour the present work is undertaken to study the capability of bituminous coal to remove Pb(II) from wastewater at different pH values.

Experimental procedure

The sorbent low grade bituminous coal was obtained from Bankolla Colliery, Raniganj (India). It was grinded and sieved through 45 μm sieve. Average particle size, surface area and porosity were measured as reported earlier5. The chemical constituents of bituminous coal have already been reported5.

25 mL aqueous solution of lead nitrate (100 mg L⁻¹) of desired pH was shaken continuously with 1 g bituminous coal in different glass bottles at 30°C. The sorbate solution at definite time intervals was centrifuged and the supernatant liquid was analysed by Atomic Absorption Spectrophotometer, Perkin Elmer 2380.

Results and discussion—The amount of Pb(II) sorbed (Fig. 1) increases6 from 1.126 (45.04%) to 2.313 mg g⁻¹ (92.52%) by increasing pH of solution from 2 to 8. The kinetics of sorption of Pb(II) on bituminous coal was studied using Lagergren equation7. Using this equation the straight line obtained from the plots of log (qₑ - q) vs t (Fig. 2) at different pH indicate that the process follows first order kinetics. The rate constant K was calculated at pH 2, 4, 6.5 and 8 from the slope of the plot and found to be 4.11, 4.27, 4.11 and 4.67 min⁻¹, respectively.

The equilibrium data fit well the rearranged Langmuir model5 using this model the value of Q at pH 2, 4, 6.5 and 8 have been determined from the plot Cₑ/qₑ vs Cₑ (Fig. 3) and found to be 4.121, 4.545, 6.118 and 8.889 mg g⁻¹, respectively. The metal form hydroxy complexes7 (Fig. 4) that are specifically sorbed to the greater extent. Therefore, pK (equilibrium constant) value of the reaction M²⁺ + H₂O ⇌ MOH⁺ + H⁺ determines the sorption behaviour of metals. In order to be
Fig. 3—Langmuir isotherm for the sorption of Pb(II) on bituminous coal dust [△ pH 8.0; ○ pH 6.5; ● pH 4.0; ▲ pH 2.0; Temperature = 30°C; Coal dust size = 45 μm]

Sorbed on sorbent surfaces, Pb²⁺ can also diffuse into minerals. The relative rate of diffusion of the Pb²⁺ ions into minerals increases with pH up to a maximum which is equal to pK value for the situation when Pb²⁺ = Pb(OH)⁺ on the mineral surfaces. Above this pH the Pb(OH)⁺ > Pb²⁺ and the relative rate of diffusion decreases. Maximum sorption of Pb(II) is found at ~pH 8 which is closer to pK (7.7). It has been observed that in acidic medium positively charged surface of sorbent does not favour the association of cationic sorbate species. Therefore, in alkaline medium negatively charged surface offers the suitable sites for the sorption of Pb²⁺ and Pb(OH)⁺ species.

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\begin{align*}
\text{OH}^- & \rightarrow \text{MO}^- & & \text{(1)} \\
\text{MO}^- + \text{Pb}^{2+} & \rightarrow \text{MOPb}^+ & & \text{(2)} \\
\text{MO}^- + \text{Pb(OH)}^+ & \rightarrow \text{MOPb(OH)}^- & & \text{(3)} \\
\end{align*}
\]

Organic matters with hydroxyl or carboxylic radicals as functional groups may exchange Pb²⁺ of solution as follows:

\[
\begin{align*}
\text{S} - \text{OH} + \text{Pb}^{2+} & \rightarrow \text{S} - \text{OPb}^+ + \text{H}^+ & & \text{(4)} \\
\text{S} - \text{COOH} + \text{Pb}^{2+} & \rightarrow \text{S} - \text{COOPb}^+ + \text{H}^+ & & \text{(5)} \\
\text{S} - \text{OH} + \text{Pb(OH)}^+ & \rightarrow \text{S} - \text{OPb(OH)}^+ + \text{H}^+ & & \text{(6)} \\
\text{S} - \text{COOH} + \text{Pb(OH)}^+ & \rightarrow \text{S} - \text{COOPb(OH)}^+ + \text{H}^+ & & \text{(7)} \\
\end{align*}
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(where S represents coal surface)

**Conclusion**—From the above observations it may be concluded that bituminous coal may be effectively used as sorbent for the removal of Pb(II) from water and wastewater at suitable conditions.

**References**