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WOOD-FIBROUS SORBENTS FOR PURIFICATION OF EFFLUENT FROM HEAVY METALS

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Abstract

Pollution of the water sources by heavy metals is a great problem on a world scale. Heavy metals are one of the most dangerous polluters of waste and surface waters used for irrigation. At many industrial processes effluent consists of high concentration of toxic heavy metal ions – copper, zinc, lead, cadmium, aluminum, iron, magnesium, chromium, cobalt etc. At present time these polluters have been removed by different methods. Chemical precipitation, extraction by solvents, dialysis or electro-dialysis, electrolytic extraction, evaporation methods, ion-exchange pitches, adsorption on charcoal etc. have been used. In most cases the results of different methods of chemical precipitation do not satisfy the requirements in the accepted international standards. For the moment alkaline precipitation is the cheapest and widespread method for purification of industrial waters. However, by this method the amount of unwanted polluted precipitation is high. Ion-exchange is efficient at purification of solutions from metal ions, but the synthetic pitches used for that are too expensive. Adsorption can be used as one economical and acceptable method for removal even of traces of metal ions from solutions.

Key words: heavy metals, adsorption, sorbents, purification of waters

In recent years the wide-spread carbon sorbents are commonly used for physicochemical treatment of effluent. The most used sorbents are charcoal (Sego et al., 1977), peat, lignin (Shukla and Sakhande, 1990; 1991; 1992), chitin and chitosan (Bicovens and Kokorevics, 1998) etc.

Matis and Zouloulis (1994) applied an industrial biomass for removal of cadmium and other heavy metals from the effluent.

The application of highly efficient wood-fibrous adsorbents is of great importance because during the processing of wood and fibrous materials, as well as their household use, a significant amount of secondary materials with high sorption capacity are released. Adsorption can be used as one economical and acceptable method for removal even of traces of metal ions from solutions (Morita et al., 1987; Suemitsu et al., 1986) Of special interest are technical hydrolytic lignin (THL), dropping the wood hydrolysis; bark and saw-dust after machining of wood; wool combings (WC) and secondary materials from textile industry and way of living.

The indicated materials are especially suitable for making highly efficient sorbents by reason of their strongly developed inner and outer surface, a macro and a micro porous structure as well as possessing varying functional groups.

This work presents results of researching sorbent properties of shown wood-fibrous materials towards zinc ions in industrial effluent and waters in order to select efficient composites for purifying waters from heavy metals.

MATERIAL AND METHODS

The sorbent properties of the following materials were studied:

1. Highly yield fibrous material (HYFM).
2. Barks of poplar (BP) – broken in advance with fraction size from 0.5 to 1 mm.
3. Wool combings (WC).
4. Technical hydrolytic lignin (THL) – by-product of the hydrolysis at wood production.

The experiments were carried out in two directions:

1. Studying the sorbent ability of the above pointed wood-fibrous materials in quantities as follows: THL – 4 g; BP – 4 g; HYFM – 2 g; WC – 1 g, for purification of industrial effluent from zinc.

2. Examination: in a separating funnel 50 ml of effluent were pouring towards the weighed amount of materials, staying for 5 minutes and flowing out for 10 minutes. The purifying process is 8-time divisible till a transition of 400 ml.

Studying the kinetics of sorption at BP and WC towards zinc in water solutions in different concentrations:

Water solutions of zinc sulphate are used with concentrations of zinc ions: 50 mg/l; 100 mg/l; 150 mg/l.

The experiments are carried out with 0.5 g – of WC and 2 g – of BP and 50 ml – of solutions by each. The

Table 1. Test results of industrial effluent

№	Index name	Unit of measurement	Test results
1.	pH		7.85
2.	Inorganic substances	mg/dm^3	36.40
3.	Lead	mg/dm^3	0.33
4.	Cadmium	mg/dm^3	0.10
5.	Zinc	mg/dm^3	8.30
6.	Copper	mg/dm^3	0.02
7.	Iron	mg/dm^3	0.03

Table 2. Sorption of zinc ions by wood-fibrous materials

№	Amount of passed effluent, ml	Sorbent quantity of zinc ions, mg/g			
		HYFM	**WC**	**BP**	**THL**
1.	50	2.4	4.0	0.7	0.13
2.	100	2.7	4.9	1.3	0.85
3.	150	3.0	6.2	1.6	1.03
4.	200	3.1	6.9	1.7	1.20
5.	250	3.6	8.0	1.9	1.38
6.	300	3.7	8.0	2.0	1.63
7.	350	3.7	8.0	2.0	1.63
8.	400	3.7	8.0	2.0	1.63

Table 3. Sorption of zinc ions by barks of poplar

Adsorption time (min)	Sorbent – barks of poplar								
	initial concentration **50 mg/l**			initial concentration **100 mg/l**			initial concentration **150 mg/l**		
	mg/l	mg/g	%	mg/l	mg/g	%	mg/l	mg/g	%
0	50.0	0	0	100.0	0	0	150.0	0	0
3	40.2	20.1	80.0	80.0	40.05	80.0	121.2	60.6	80.8
10	41.0	20.5	82.0	83.6	41.80	83.6	126.0	63.0	84.0
30	41.2	20.6	82.5	84.1	42.05	84.1	129.0	64.5	86.0
60	41.3	20.7	82.7	84.0	42.00	84.0	129.4	64.7	86.3
90	41.3	20.7	82.7	84.5	42.25	84.5	129.3	64.7	86.2

Table 4. Sorption of zinc ions by wool combings

(min)	Wool Combings								
	initial concentration **50 mg/l**			initial concentration **100 mg/l**			initial concentration **150 mg/l**		
	mg/l	mg/g	%	mg/l	mg/g	%	mg/l	mg/g	%
0	50.0	0	0	100.0	0	0	150.0	0	0
3	41.5	83.0	83.0	83.8	167.6	83.8	129.7	259.5	86.5
10	41.7	83.5	83.5	85.1	170.2	85.1	132.0	264.0	88.0
30	41.7	83.4	83.4	85.6	171.2	85.6	132.1	264.3	88.1
60	41.8	83.6	83.6	85.8	171.6	85.8	132.2	264.3	88.1
90	41.8	83.6	83.6	85.8	171.6	85.8	132.2	264.3	88.1

kinetics of zinc ions adsorption has been studied for durations of 3, 10, 30, 60 and 90 minutes in temperature of 200 °C. After finishing the determinate time, the resultant tests have been strained through ordinary filter and in it the content of non-adsorbed zinc ions is fixed by atom-adsorbing spectrum photometry.

RESULTS AND DISCUSSIONS

Study of industrial effluent

The presented data show that the amount of zinc is the highest in comparison to that of lead, cadmium and copper (Table 1). This predetermined the further analysis for evaluation of the ability of wood-fibrous materials to sorb zinc ions.

It was established that the higher the amount of effluent passing through wood-fibrous materials the higher quantity of arrested zinc ions are obtained till a moment of saturation and an arrest of the sorption process. In the case of WC, the saturation of the sorbent with zinc ions is achieved at an amount of passed effluent of 250 ml, and in the other 3 cases – this amount is 300 ml. The increase of arrested ions quantities can be explained by gradually swelling of the wood-fibrous material which leads to increasing their adsorption capacity.

The comparison of the data for the four wood-fibrous materials shows that they have high adsorption ability. The study on adsorption kinetics of the fibrous material WC and of barks of poplar with water solutions of zinc sulphate showed that the poplar barks possess better adsorption capability (Table 2).

Table 3 reflects the results related to sorption of zinc ions depending on the duration of adsorption in water solutions containing three different concentrations of poplar barks, presented as: a sorbent quantity in mg/l; amount of adsorbed zinc ions in mg/g and percentage of the occupied sorbent surface. From these results it appears that:

– the balance of the process at lower concentrations occur relatively more quickly in comparison with that at the higher – at 50 mg/l around the 10-th minute and at 150 mg/g, respectively, around the 30-th minute;

– by increasing the concentration of zinc ions in water solutions the extraction percentage increases.

The data in Table 4 characterize the sorption of zinc ions in water solutions on different concentrations of wool combings depending on the duration of the process. Also at this sorbent material, dependencies similar as those at the barks of poplar were observed.

Summarized can be said that under the same conditions of the process WC shows much higher sorption capacity. This is probably due to its well developed inner and outer surfaces and also a higher content of functional groups possessing ion exchange properties.

CONCLUSIONS

Based on the studies conducted in this work, following major conclusions can be done:

• The studied wood-fibrous materials: highly yield fibrous material (HYFM), barks of poplar (BP), wool combings (WC) and technical hydrolytic lignin (THL), have high sorption capacity to zinc ions in wide concentration range of water solutions.

• In effluent with low concentration by increasing the amount of passed water through the sorbents a gradual increase of arrested zinc ions happens, a following saturation and an arrest of the sorption process.

• A sorption balance at WC and BP with lower concentrations occurs relatively faster than that with higher concentrations.

• By increasing the concentration of zinc ions in water solutions the rate of extraction increases.

• WC shows higher sorption capacity compared with BP.

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