# REMOVAL OF LEAD (II) FROM AQUEOUS SOLUTION BY SORPTION ON NATURAL HEMP FIBERS

**Lavinia TOFAN [1], Carmen PADURARU [1], Irina VOLF, Catalin BALAN [1]**

[1] „Gh. Asachi" Technical University of Iaşi

**Abstract**

The sorption process plays an important role in removing heavy metals such as lead from aqueous environments. In recent years, the applications of low cost sorbents have been widely studied for heavy metal ions removal from wastewaters. Natural materials that are available in large quantities or certain wastes from industrial and agricultural operations have the potential to be used as low cost sorbents, as they represent unused resources, with wide availability and are environmentally friendly. However, the necessity for investigating more and more natural and waste materials is still very important in order to obtain the best material for industrial applications. In this context, natural hemp fibers have been evaluated for Pb (II) sorption from diluted aqueous solutions. In order to establish the optimum conditions, the effect of initial pH of solution, hemp dose, Pb (II) initial concentration, and temperature and contact time of phases on the Pb (II) sorption by natural hemp has been studied. It has been found that in the studied initial pH range of 2- 5, the sorption increases with pH increasing. The values of the Pb (II) sorption percentage increase with increasing hemp dose. The amount of Pb (II) retained on hemp fibers increase with increasing Pb (II) concentration in initial solution, but the sorption percentage decreases. The temperature has a favorable effect within the batch sorption under study. The Pb (II) amounts retained on hemp increase with contact time of phases increasing. The results of this study suggest that natural hemp could be a viable and potential sorbent for the removal of Pb (II) from wastewaters with low content of the tested cation.

**Key words**: lead, hemp fibers, removal, sorption.

Lead is a significant heavy metal which is released into the environment in a high number of ways, including lead acid batteries, pulp and paper, petrochemicals, refineries, printing, pigments, photographic materials, explosive manufacturing, ceramic, glass, paint, oil, metal, phosphate fertilizers, electronic goods, wood production and also combustion of fossil fuel, forest fires, mining activities, automobile emissions, sewage wastewater and sea spray (Conrad, K., Hausen, H.C.B., 2007).

Lead is known to damage the kidney, liver and reproductive system, cellular processes and brain functions, The toxic symptoms are anemia, insomnia, headache, dizziness, irritability, weakness of muscles, hallucination and renal damage (Yavuz, O, et.al., 2007).

A wide variety of strategies have been developed for removal of heavy metals from aquatic ecosystems, including lead ions. Sorption technology is generally preferred for heavy metals removal, due its high efficiency, easy operation, competitive performance availability of sorbents with different features and economical feasibility. Recently, several industrial wastes, agricultural by – products and material abundant in nature have been used for wastewater treatment in order to reduce operational costs (Babel, S., Kurniawan, T., 2003; Sud, D., Mahajan, G., Kaur, M.P., 2008).

In particular, hemp is a commonly available unconventional material that can be efficiently used for heavy metal removal from wastewaters.

The performances of hemp as sorbent is based on its remarkable fundamental features: low cost, availability, high mechanical strength and porosity, hydrophilic character, fast sorption, tolerance to biological structures, easiness in functionalization, possibility of being used as fibers and filters.

Previous studies have reported the sorption capacity of hemp fibers in natural and modified forms for Cr (III), Cu (II), Ag(I), Cd(II) and Zn(II) ions (Tofan 2000; Paduraru 2002; Tofan 2004; Tofan 1999; Tofan et al. 2001; Tofan et al 2001; Paduraru, 2008). The aim of this work is to emphasize the behavior of natural hemp fibers in batch retention of Pb(II) from very diluted aqueous solutions.

## MATERIAL AND METHOD

The hemp fiber, a cellulosic natural plant material with chemical composition recorded in *(tab.1)* have been used in this study.

Table 1

**Chemical composition of hemp**

| | | | |
|---|---|---|---|
| Cellulose (%) | 74-75 | Ash (%) | 0.82 |
| Hemicellulose(%) | 18.4-15.4 | Xylans (%) | 3.0- 7.0 |
| Lignin (%) | 3.7 | Proteins(%) | 0.5 – 1 |
| Waxs (%) | 4.04 | Pectins (%) | 4.0 –8.0 |

Hemp fibers were purified by boiling for 4h in a solution containing soap and soda ash, followed by washing several times with water, rinsing with doubly distilled water, drying in an oven at 45$^0$C.

Stock solutions of 2190 mg/L were prepared by dissolution of $Pb(NO_3)_2$ and standardized gravimetrically. Working solutions of Pb(II) were prepared by appropiate dilutions of stock solutions.

The optimum conditions of Pb(II) sorption on hemp have been established by batch experiments. For this purpose, samples of about 0.25g hemp were equilibrated with 50mL of each aqueous solution containing defined amount of metal ion.

The mixture was then filtrated and the solution was analyzed for the cation content. The Pb(II) concentrations in solutions have been determined by atomic absorption spectrometry

The parameters characteristic for Pb(II) sorption on hemp was calculated from the difference between the initial and final concentrations of the solutions, as follows:

Sorption percentage, R (%) : $R = [(C_0 - C)/C_0].100$

Retained amount of metal ion, q (mg/g): $q = [(C_0 - C)/G].V$

where: $C_0$ = initial concentration of metal ion (mg/L); C = cation concentration after sorption (mg/L); V = volume of solution (L); G = weight of hemp fibers (g).

## RESULTS AND DISCUSSIONS

The idea of this unconventional natural cellulosic material use for the batch retention of zinc (II) ions is based on the presence of some potential chelating groups (hydroxyl, carbonyl, methoxy) in the structure of the cellulose and lignine structure (*fig.1).*

Figure 1 **Electron micrograph of hemp fibers**

The effect of solution acidity on Pb (II) sorption by untreated hemp was studied in the initial pH range of 2 – 5 and is shown in (*fig. 2*) In this pH range no $Pb(OH)_2$ precipitation takes place.

***Effect of initial pH***

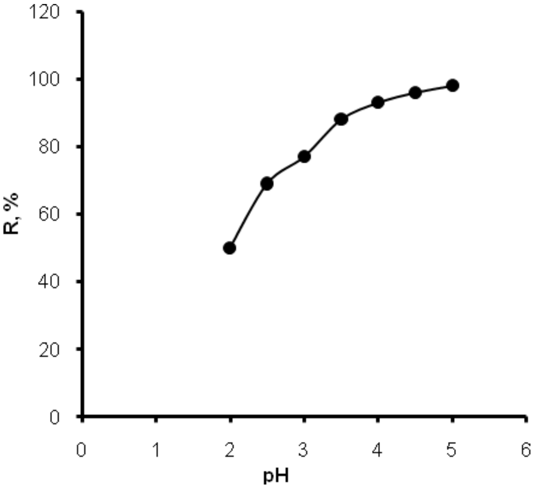


Figure 2 **Influence of initial pH on Pb(II) – natural hemp batch sorption system($C_0$= 32 mg/L; 0.25 g of hemp; contact time= 24 hours)**

As can be seen from (*fig. 2)*, the smallest retention of Pb(II) was found at pH=2 (reached by acidification with $HNO_3$ solution). Then the sorption increases with pH increasing. The highest Pb(II) retention is reaching at initial pH=5 from unbuffered solutions.

For this reason, the subsequent dependences have been studied from solutions of pH=5 obtained by the simple dilutions of initial solutions. The pH dependence in the Pb(II)–natural hemp batch sorption system might be due to the dissociation of superficial functional groups, resulting in negative charges at the active sites on the hemp surface that would allow $Pb^{2+}$ ion to be chemisorbed.

***Effect of hemp dose***

The influence of hemp dose has been investigated from solutions of initial concentration equal to 95 mg/L. The resulting dependence is given in (*fig. 3).*

As follows from (*fig. 3)*, the values of the sorption percentage increased with increasing hemp dose. This trend is in good agreement with higher number of available sites of the natural hemp for lead (II) binding. At the maximal dose of 40 mg hemp /L, the percentage of Pb(II) retention reached a value of 96 %.

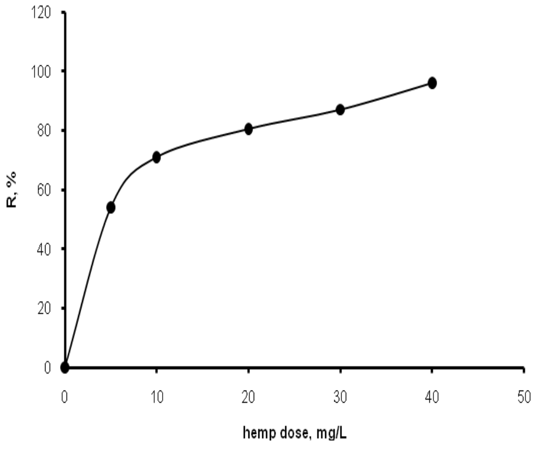


Figure 3 **Percentage of Pb(II) retention as function of hemp dose (pH=5, $C_0$=95mg/L, time contact =24h)**

### *Effect of initial Zn(II) concentration*

The amount of Pb(II) retained on the hemp fibers(q) increased with increasing Pb(II) concentration in initial solution (*tab. 2*). On the other hand, the Pb(II) amount increasing results in the decrease of the sorption percentage, R% *(tab. 2).*

Table 2

**The effect of initial Pb(II) concentration on its sorption by natural hemp**

| Cation concentration in initial solution | q, mg/g | R, % |
|---|---|---|
| 32 | 8.05 | 98.2 |
| 54 | 10.07 | 91 |
| 73 | 12 | 88.5 |
| 95 | 14.5 | 79 |
| 115 | 16.9 | 65.2 |
| 140 | 18.20 | 59.8 |

The enhancement of the metal uptake on higher Pb(II) initial concentration might be due to the high values of initial number of Pb (II) mmoles / limited number of available binding sites ratio. The access of Pb(II) ions is hindered probably by the occupation of the total active sites on the hemp. As a consequence, the percentages of Pb(II) retention decreased. This trend leads to the conclusion that the natural hemp can be efficiently used in the removal of Pb(II) ions from wastewaters with low contents of the tested cation.

## CONCLUSIONS

Natural hemp exhibits reasonable sorption properties with potential applicability in removal recovery of Pb(II) ions from wastewaters. In the studied initial pH range of 2-5 the sorption increases with pH increasing. The highest Pb (II) retention is reaching at initial pH=5 from unbuffered solutions. The values of the sorption percentage increase with increasing hemp dose. The amount of Pb(II) retained on the hemp fibers increases with increasing Pb(II) concentration in initial solution, but the sorption percentages decrease.

## BIBLIOGRAPHY


**Babel, S., Kurniawan, T., 2003** – *Low–cost adsorbents for heavy metals uptake from contaminated water:a review,* J. Hazard. Mater., vol. B97, p. 219 – 243.

**Conrad, K., Hausen, H.C.B., 2007** – *Sorption of zinc and lead on coir,* Bioresour. Technol., vol.98(1), p.89 – 97.

**Paduraru, C., Tofan, L., 2002** - *Equilibrium Studies for the Sorption of Metal Ions onto Hemp*, Cell. Chem. Technol.,vol.36 (3-4)**,p.** 375-380.

**Paduraru, C., Tofan, L., 2008** - *Investigations in the possibility of natural hemp fibers use for Zn(II) removal from wastewaters,* Environmental Engineering and Management Jornal,vol 7(6), p.687 -693.

**Sud, D., Mahajan, G., Kaur, M.P., 2008** – *Agricultural waste materials as potential adsorbent for sequestering heavy metal ions from aqueous solutions – a review,* Biores. Technol., vol.99, p. 6017 – 6027.

**Tofan L., Gherasim O., Paduraru, C., Toma, O., 2001** - *Hemp Impregnated with □ - benzoinoxime for Removal of Copper ( II ) Pollutant Ions,* Anal. St. Univ. "Al.I. Cuza" Iasi, Section **II,** p. 81-85.

**Tofan, L., Paduraru, C, 2000** - *The Hemp–A New Fibrous Natural Unconventional Sorbent*, Bulletin of the Polytechnic Institute of Iasi, Chemistry and Chemical Engineering, fasc. XLVI(L), (3-4),p. 113-118.

**Tofan, L., Paduraru, C., 2004** - *Sorption Studies of Ag (I) , Cd (II) and Pb (II) Ions on Sulphidryl Hemp Fibers*, Croat. Chem. Acta, vol. 77 (4), p. 581-586.

**Tofan, L., Paduraru, C., 1999** - *Removal of Copper (II) Ions Traces from Waste Waters by Sorption on Hemp Modified with α – Benzoinoxime*, Journal of Balkan Ecology, vol. 2 (3**),p.** 106-112.

**Tofan, L., Paduraru, C., Toma, O., 2001** - *Hemp Fibers Impregnated with Alizarine S as Unconventional Material for Cr ( III ) ions in Technological Systems*, Scientific Annals of State University of Moldavia, Chisinau, p. 204 – 208.

**Yavuz, O., Guzel, R., Ayalin, F., Tegin, F., Ziyadanogull, R., 2007** – *Removal of cadmium and lead from aqueous solution by calcite,* Polish J. of Environ. Stud., vol.16(3), p.467-471.