THE DECREASE IN NITRATE CONTENT OF POLLUTED WATERS BY USING WASTE WOOD AS ADSORBENT MATERIAL

SCĂDEREA CONȚINUTULUI ÎN NITRAȚI A APELOR POLUATE PRIN FOLOSIREA DEȘEURILOR LEMNOASE CA MATERIAL ADSORBANT

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Abstract. *Large amounts of waste wood obtained from logging and wood processing have found various uses in the furniture industry, agriculture, entering into various compost recipes with applications in restoring soil's fertility or as absorbent material in numerous technologies, given the porous structure and composition of such materials. In the present study, we tested the capacity of grinded sawdust, simple and activated in acidic and alkaline solutions, to retain nitrates from aqueous solutions of different concentrations. Although all the variants have given very good results, sawdust activated in a solution of hydrochloric acid registered the retention of nitrate in an amount of 99.99% at concentrations up to 250 mg / l and 99.95% for the ones up to 400 mg / l. The method may be also considered for large scale applications due to the high adsorption speed.*
Key words*: sawdust, nitrate, pollution, water, adsorption*

Rezumat. *Cantitățile mari de deșeuri lemnoase obținute în urma tăierii și prelucrării lemnului și-au găsit diverse utilizări în industria mobilei, în agricultură, intrând în variate composturi cu aplicații în refacerea fertilității unor soluri sau în diverse tehnologii ca materiale absorbante, dată fiind structura poroasă și compoziția chimică a acestor deșeuri. În lucrarea de față, am testat capacitatea rumegușului fin măcinat, simplu și activat în soluții acide și bazice, de a reține nitrații din soluții apoase de diferite concentrații. Deși toate variantele au dat rezultate foarte bune, rumegușul activat în soluție de acid clorhidric a condus la reținerea cantității de nitrat în proporții de 99,99% la concentrații de până la 250 mg/l și 99.95% la cele de până la 400 mg/l. Metoda ar putea fi luată în considerare pentru aplicații la scară largă și datorită vitezei mari de adsorbție.*
Cuvinte cheie*: rumeguș, nitrat, poluare, apă, adsorbție*

INTRODUCTION

A source of vegetable waste, which in our country has not so far been considered valuable in many industrial branches, is the significant amount of wood chips and sawdust resulting from logging and wood processing.

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Capitalization of bark and sawdust by composting did not completely solve the problem of such large quantities of waste, but can become a source of income for a number of enterprises of forest economy.

Another way in which these wood waste materials are consumed is their use as absorbent material for different substances. For example, in a pilot study made by the department of U.S. Army Corps of Engineers, they tested a technology mainly consisting of kitchen waste passing through a large cylindrical vessel filled with wood chips. Grease is removed from the liquid by absorption and filtration, being attached to the surface of the chips. The effluent from this process then passes through a secondary absorbent filter tube. (Department of the army, U.S. Army Corps of Engineers, 2008)

Another study was conducted using wood chips as absorbent material for SO_2 from air, base on the fact that this naturally porous material , especially when moistured, can adsorb and solve important amounts of sulphur dioxide. The conclusion was that moisture saturated wood chips retained about 90 times more sulphur dioxide than the dry material, for all the active concentrations used, between 1,12 - 4.60ppm. (Wang Uen-Ping, 1971)

Sawdust and wood chips were also used to remove heavy metals from industrial and mining waste waters. Especially bivalent metals were retained on spruce wood chips – Cd up to 94%, Cu - up to 81% and Zn - up to 88%. (Argun, 2008; Keng, 2013; O'Connell, 2008)

A study made in Turkey on straw, wood chips and corn stalks confirmed their capacity of removing a very wide used organophosphorus pesticide, 2,2'-dichlorovinyl-o,o'-dimehyl phosphate (DDVP, Dichlorvos) from waste waters, in a discontinued system. (Balkaya, 2002)

Sawdust and wood chips of various sizes were used in numerous studies as adsorbent materials for dyes, showing very good efficiency, especially concerning the terms of material costs. Residual wood, in natural or carbonized form, showed a higher affinity for basic dyes. (Crini, 2010)

The production of ethanol from sawdust is possible without relying on sources of edible ethanol. In "Well for Wheel", model created by Michael Wang of Argonne National Laboratories, cellulosic ethanol showed when used a reduction of green gas emissions by 80% (over gasoline) compared to corn ethanol, which showed reduction by 20 % -30%. (Nwakaire, 2013)

Sawdust bioreactors are a new option to reduce the amount of nitrate in drainage before reaching local surface waters. Sawdust bioreactors are also known as denitrifying bioreactors, a name that is more descriptive for the current process developing inside. Denitrification is the conversion of nitrate (NO_3^-) into nitrogen gas (N_2), which is carried out by bacteria that live in soil and also in bioreactors. (Christianson Laura, 2011)

In this paper, we used natural and activated grinded sawdust as adsorbent material for different concentrations of nitrate solutions, to see if the effluent falls under the allowable concentration for drinking water of 10 mg NO_3^-/l, even 5 mg NO_3^-/l, when preparing baby food.

MATERIAL AND METHOD

The adsorbent material was alder sawdust, grinded and sieved in order to keep only the smaller particles (fig. 1). For the control variant, the sawdust was boiled for half an hour in distilled water and then air-dried (fig. 2). The other two variants used the sawdust activated by half hour boiling in hydrochloric acid 0.1 n, respectively ammonia 0.1 n, followed by filtration and pH correction to 5.0 – 6.0 and then also air-drying (fig. 3, 4).

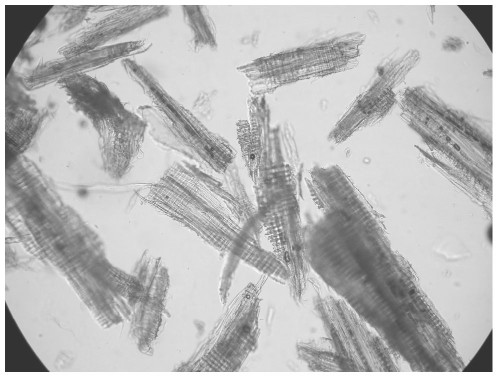

Fig. 1 -Natural sawdust

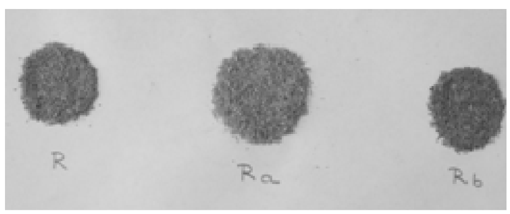

Fig. 2 - Adsorbent sawdust samples

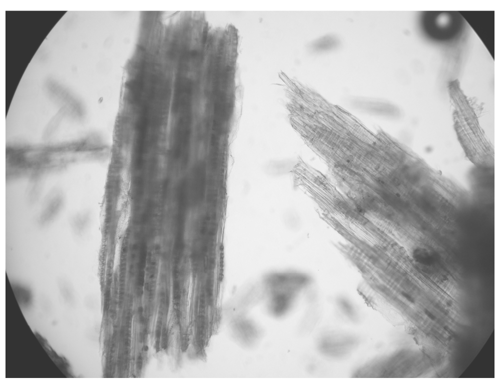

Fig. 3 - Acid activated sawdust

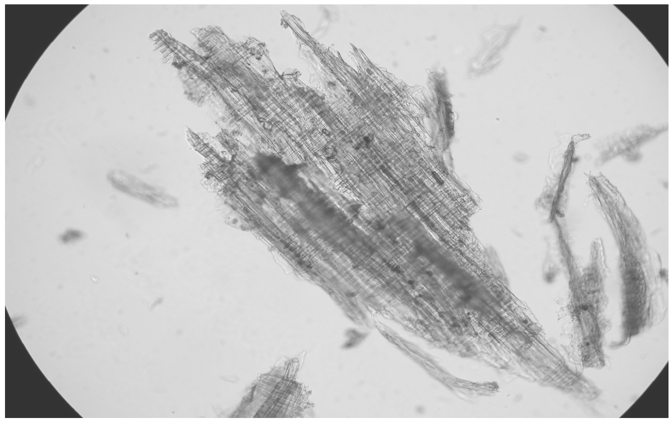

Fig. 4 - Alkali activated sawdust

The sodium nitrate solutions had initial concentrations from 50 to 400 mg NO_3^- /l. For each variant, we used 1 g of adsorbent material and 40 ml of nitrate solution, stirred continuously for 15 minutes, then filtered. We used Griess colorimetric method to determine the amount of nitrate in the filtrate of each variant.

RESULTS AND DISCUSSIONS

The considered adsorbent mater ial succeeded to remove almost the entire amount of nitrate from the samples, especially for the variants with activated forms. We tested solutions only up to 400 mg/l but given the obtained results, we estimate that even higher concentrations could be removed from natural or wastewaters by this simple procedure.

The data regarding the percentage of nitrate retained by one gram of sawdust from the initial amount and the realized adsorption coefficient are presented in tables 1 and 2 and comparatively, in figure 5.

Table 1

Percentages of removed nitrate amounts

Conc. ion / Sample	50 mg/l	100 mg/l	150 mg/l	200 mg/l	250 mg/l	300 mg/l	350 mg/l	400 mg/l
Natural sawdust	99.7278	99.7776	99.8281	99.5748	99.6423	98.5187	98.5217	98.6697
Acid activated sawdust	99.9882	99.9932	99.99077	99.99195	99.9901	99.9585	99.9547	99.9556
Alkali activated sawdust	99.8882	99.9226	99.9432	99.9561	99.9566	99.9557	99.9595	99.9409

Table 2

Adsorption coefficient values

Conc. / Sample	50 mg/l	100 mg/l	150 mg/l	200 mg/l	250 mg/l	300 mg/l	350 mg/l	400 mg/l
Natural sawdust	98.157	196.53	297.93	391.87	490.75	588.41	680.26	787.94
Acid activated sawdust	100.31	199.75	296.42	394.29	494.41	593.23	690.02	797.25
Alkali activated sawdust	98.626	198.653	299.77	393.29	496.407	591.92	688.426	793.34

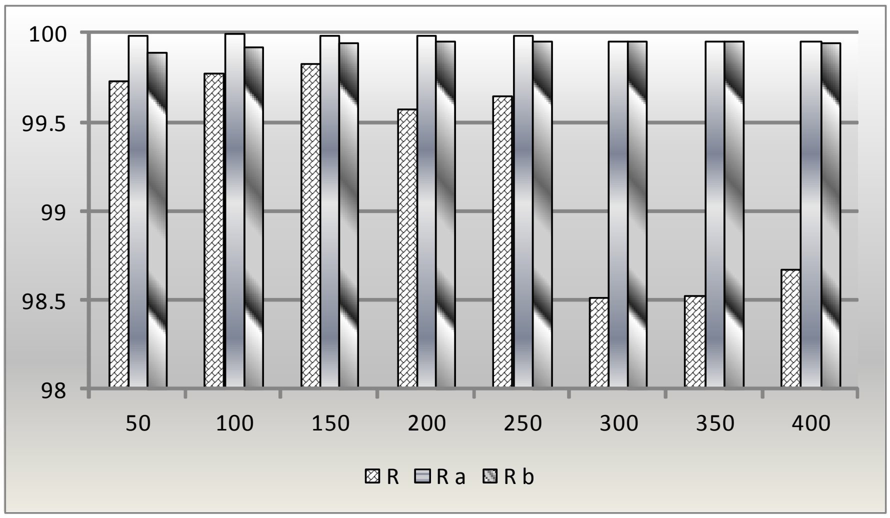

Fig. 5 - Percentages of nitrate amounts removed by simple (R), acid activated (Ra) and alkali activated (Rb) sawdust

Furthermore, the activation process, with acidic or alkaline solutions does not require high concentrations and long reaction time, being available for large-scale applications. The actual absorption process is very simple and efficient; working with small samples, we preferred stirring the adsorbent with the nitrate solution, but for larger water quantities the process can be conducted in cylindrical vessels in continuous flow, by gravitational means or under minor pressure or statically in large chambers filled with adsorbent sawdust.

CONCLUSIONS

1. Sawdust obtained from alder wood proved excellent adsorption capacity for nitrate solutions in various concentrations, estimating that higher amounts of nitrate can be removed;

2. The activation procedure improved the material adsorption activity, especially when realized in acidic solution, in a very short period of time;

3. For all nitrate concentrations, the acid activated sawdust retained the considered ion over 99.9%;

4. The alkali activated sawdust retained almost as well at smaller concentrations and similar for the concentrations over 300 mg NO_3^-/l;

5. The method proved effective for decreasing nitrate levels in wastewaters or in natural waters in order to be safe for consumption, even for small children.

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