Ammonia Removal in Wastewater by Ca-P (calcium polymer) from Disposable Diapers Recycling System.

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1. Abstract

"Waste to new material" is one of the new concepts by "*de-incineration*" and recycling of adult disposable diapers. By their recycling system it will be possible to produce soil conditioner and to grow completely natural cotton. An innovative recycling system has been outlined by Fukuoka University but what about the Nitrogen abatement in the released wastewater? Johkasou simplest apparatus (without anaerobic tank) is only effective in BOD and COD reduction. After recovering the resources from used diapers, the authors were interested in the characteristics of absorbing polymer dehydrated with $CaCl_2$ (Ca-P). In fact, Ca-P is effective in Ammonia-Nitrogen reduction. But should Ca-P be spread inside Johkasou or should the latter be complemented with a filter column containing Ca-P? Which is the reduction mechanism: ions exchange or absorption of ammonia? This paper wants to answer these questions.

2. Introduction

The adult disposable diaper market is growing more and more in Japan. Japan's population can be defined a super-aging society because people over the age of 65 are the 23%[(2)] of the total. With the progress of aging society, the amount of disposable diapers for adults is supposed to increase in parallel as shown in Figure1.

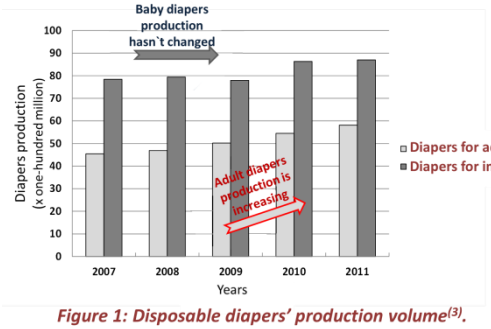

Figure 1: Disposable diapers' production volume[(3)].

Japan depends on the importation of many natural resources and with the increasing use of disposable diapers, the amount of pulp demand from tropical rain forests in Asian countries increases[(1)]. While the biggest amount of adult and baby diapers waste is produced at home and, therefore, collected by the municipalities or by private companies and burned together with the other municipal waste, adult disposable diapers collected from hospitals and care houses are sent to special smaller incinerators[(4)] (fed with less than 100 tons/d). Nowadays, the latters have been prohibited from operating because their batch type running system implies a higher probability to originate dioxins as the temperature is not constant.

The authors have focused on the resource recovery system of used disposable diapers for ten years and developed the new system without incineration of used diapers for the prevention of global warming. This new system needs the wastewater treatment facility after separating the pulp from used diapers. But the wastewater treatment by Johkasou is not sufficient for a good ammonia removal and this is the reason why Calcium Polymer (Ca-P) shall be exploited.

3. Method and Materials

In order to understand the best way and mode to achieve ammonia removal using Calcium Polymer, a series of laboratory experiments was done: **batch type tests** first and **semi-continuous column tests**, with a laboratory filter column simulator shown in Figure2, then.

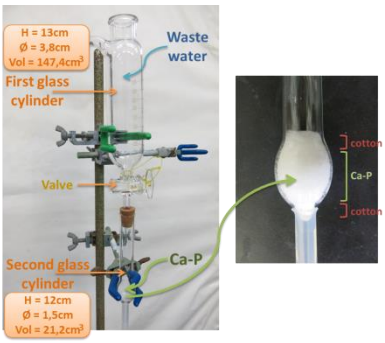

Figure 2: Filter column simulator.

To obtain the dehydrated polymer, the procedure was the following (see Figure3):

Figure 3: Steps to obtain Ca-P.

- Cutting the new diaper and recovering of sodium polyacrylate (solid form),
- Adding water and mixing to enable absorption by the polymer (gel),
- Adding $CaCl_2$ and water and mixing to enable the polymer dehydration (NB. an amount of 3000 mg$CaCl_2$/l or more is needed. If less, the polymer would stay in its gel phase.),
- Filtering water plus dehydrated polymer in order to recover the latter.

Laboratory measurements included: Ammonia investigation using the spectrophotometer and ions investigation using the Atomic absorption spectrophotometer.

4. Results

Batch type tests have shown that retention time is not important. Ca-P immediately catches NH_4^+. Here an example of ammonia reduction rates in relation with the amount of dehydrated polymer added to the samples.

To obtain the five 200ml samples, 1000ml of leachate from Seibu Leachate Treatment Plant were used. To the latter 20ml of Standard Ammonia Solution (1000ppm) were added, in order to have an added concentration of 20ppm of NH_4OH. Each sample was covered and subjected to 5 minutes magnetic stirring. Seibu's leachate itself contains around 50mg/l of ammonia, therefore a 100 dilution was applied after filtration. The NH_4-N reduction rate increases until 4g.

18/11/2013	N H₄ (mg/ l)	Reduction rate (%)
leachate	60,1	0
leachate + **1** g Ca-P	58,3	2,9
leachate + **2** g Ca-P	45,5	24,2
leachate + **4** g Ca-P	38,0	36,8
leachate + **6** g Ca-P	38,3	36,1

Table 1: Ammonia concentration and reduction rate.

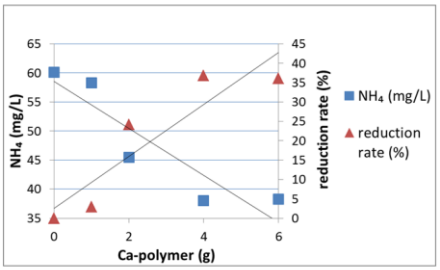

Figure 4: Ammonia concentration and reduction rate.

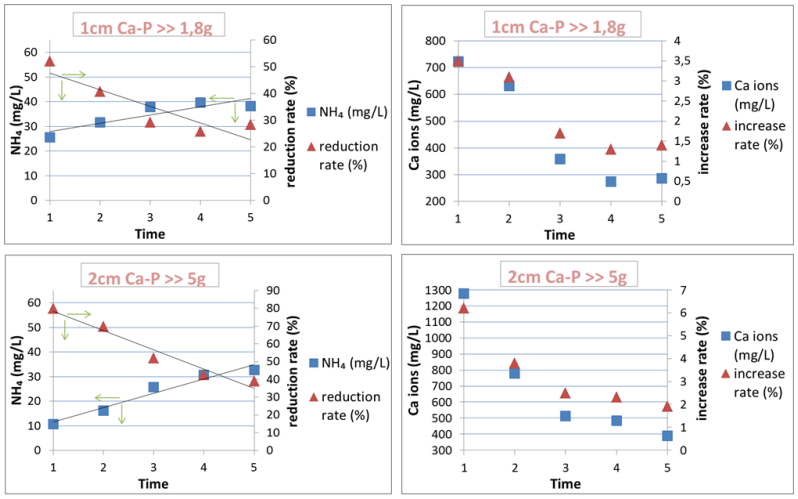

Figure 5: Ammonia and Calcium ions variations using the filter column (1cm Ca-P >> 1,8g and 2cm Ca-P >> 5g).

Using the filter column a great ammonia reduction can be achieved but that reduction decreases with time (Figure5). This is the consequence of the saturation of the Ca-P layer. Besides ammonia, Ca^{2+} ions were investigated. Ions exchange process doesn't involve just Ca^{2+} and NH_4^+ but also the other ions present in the leachate. This has been understood after making a balance between the milliequivalents of the different ions (Table2).

	Ca^{2+} (mEq)	NH_4^+, Na^+, K^+, Mg^{2+} (mEq)
1cm >> 1,8g	0,62	0,69
2cm >> 5g	1,2	1,48

Table 2: Cations balance.

5. Conclusions and future objectives

It can be stated that • Ca-Polymer is really effective in reducing ammonia concentration inside wastewater, • long time is not needed for Ca-P to act (Johkasou should be complemented with a filter column); • ion exchange is the ammonia removal mechanism; • Ca^{2+} ions are released from the Ca-P and replaced by NH_4^+, K^+, Na^+ and Mg^{2+} ions; • a great ammonia reduction can be achieved using the filter column but that reduction decreases with time; • two or three filter columns should be placed one after the other to reach a ≈90% ammonia reduction.

One of the future objectives is the even further exploitation of the used Ca-P as a fertilizer.

References

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