The Development of Hydrogel Polymer from Diapers Waste with The addition of Straw Nano Fibers as The Growing Media of Green Beans Plant

C L Imalia, 1, G A Selviana 1, A Chafidz 2, and Haryanto 1,*

1Chemical Engineering Department, Universitas Muhammadiyah Purwokerto, Purwokerto 53182, Indonesia

2Chemical Engineering Department, Universitas Islam Indonesia, Yogyakarta 55584, Indonesia

*Corresponding Author: harymsl@gmail.com

Abstract. The increase in diaper usage gives a serious contribution to environmental pollution. The hydrogel in diaper waste can be an alternative growing media. But, the growing media must have enough nutrition to fulfil the plant's need. Therefore, some amounts of filler are necessary to be added to the growing media of diapers waste hydrogel. This research aimed to find out the characteristics of diapers waste hydrogel, the effect of adding straw nano fiber towards the release constant rate, and the growth of green beans. The hydrogel of diapers waste was loaded with various concentration (0%, 1%, 5%, 10%, 15%, and 20%) of straw nanofibres and dried at 40°C for 3 days. The results show the morphology of the diapers waste hydrogel surface more dense with the addition of straw nanofibres. The release rate constant value increased with the increasing of straw nanofiber content. In this research, it can be proved that diaper waste hydrogel can be developed as the growing media, especially for green bean plant.

1. Introduction
Along with the development of technology, the use of disposable diapers for toddlers is increasing because it is considered more practical for both toddlers and housewives. The increase use of disposable causes new problems, i.e. environmental pollution. Disposable diapers are discarded and not utilised. But in terms of technology and the economy diapers can be utilised as useful materials [1].

Based on that condition, the existence of diaper waste disturbing society. As happened in Surabaya, the governor of East Java received a notice from the environmental consultant and the lecturer of environmental engineering on the presence of alleged violations of the Law No. 32, 2009 about environmental management and constitution No. 18/2008 on Waste management. East Java Government is considered not to manage garbage properly, especially baby diapers [2].

Inside the diapers, there are the hydrogels. The hydrogel functions are to absorb and store water and nutrients for plants in large quantities. The hydrogel can decompose through decay by microbes so that the product is safe to use. The hydrogel is insoluble in water, but it only absorbs and releases the water and nutrients proportionally when needed by plants. Thus the plant will always have water supply and nutrients at all times. The hydrogel is able to absorb water as much as 100-200 times the weight of the hydrogel itself. This hydrogel can be used for soil replacement media and mixed planting media on potted plants, farmland, plantations, forests etc. Hydrogel helps to reduce the volume and frequency of plant watering.
As the development of technology, Hydrogel has been widely utilised in various ways, such as water-absorbent gel on diapers, media planting, soil improvement, fertiliser, drug release control, and so on [3,4]. Besides, the hydrogel from diapers waste can be an efficient and practical planting medium without having to cultivate routinely. Concerning this, the hydrogel is used as an alternative to planting media.

The production of green beans in Indonesia is still low and does not meet domestic needs. One of the causes of low green beans is the low level of soil fertility. One of the efforts that can be done to improve soil fertility is the supply of nutrients through fertilisation. Fertilisation is intended to meet the need for adequate amounts of nutrients to support vegetative and generative growth of crops. One effort to increase the production of green beans and soybeans is to add organic ingredients that can meet the nutritional needs of green beans. Straw fibre is an organic material that can be an additional material of planting hydrogel from waste diapers [5-7].

The utilisation of straw waste has not been optimal yet. Rice straw that is usually only burned in paddy fields often causes air pollution (CO₂, NOₓ, SOₓ) that can harm the environment [8]. The benefits of using straw waste include straw waste to be wasted, improving the physical properties and chemical soils, increasing water resistance so that soil moisture can be maintained, providing the microelements needed plant, and improve fertiliser efficiency (reduce the use of chemical fertilisers), suppress the cost of use of fertilisers and can ultimately increase production. The contents of some rice straw waste nutrients are: macro element Nitrogen (N) 2.11%; Phosphorus (P₂O₅) 0.64%; Potassium (K₂O) 7.7%; Calcium (Ca) 4.2%; and micro Elements Magnesium (Mg) 0.5%; Cu 20 ppm; Mn 684 ppm and Zn 144 rpm [8].

The hydrogel in diaper waste can be used as an alternative growing media. But, the growing media must have enough nutrition to fulfil the plant's need. Therefore, some amounts of filler are necessary to be added to the growing media of diapers waste hydrogel. This research aimed to find out the characteristics of diapers waste hydrogel, the effect of adding straw nanofibre towards the constant release rate, and the growth of green beans.

2. Materials and methods
This research was conducted in the laboratory of Polymer and Hydrogel Research Center, Universitas Muhammadiyah Purwokerto. The materials used in this research works are diapers, straw nanofiber, aquades, KOH 4%, and NaClO₂ 5%.

2.1. Preparation of straw nanofibres
Preparation begins by drying the rice straw under the sunlight. The dry weighed straw then be processed by cutting with a size of 1-2 cm. Then straw was grounded using a blender to get a powder. Then screened with a screening of 100 mesh. 10 gr of straw fibre that has been sieved then soaked and stirred in 200 ml solution of KOH 4% at 80 °C for one hour. The solution then was bleaching twice using NaClO₂ 5% at 70 °C for 1 hour while stirring. After washing, the treatment using KOH 4% at 80 °C was repeated, then washed again to remove the alkali residue. The final stage was mechanical treatment. The material was homogenised using a mixer at a speed of 22,000 rpm for 10 minutes.

2.2. Preparation of hydrogel of diapers waste
Various concentration of straw nanofibres was added into 2 grams of diapers that already dissolved in water. Afterwards, it was put into the oven and heated at 40°C for 3 days. The hydrogel was then analysed with various procedures.

2.3. Analysis of hydrogel
The various analysis was to know the characteristic of hydrogel from diapers waste. FTIR analysis, SEM morphology analysis, the effect of the addition of straw Nanofibres on the growth of green bean seeds and the kinetics of Straw nanofibres release in water were studied in this research.

3. Results and Discussion
Analysis of the chemical functional group of hydrogel using FTIR
The figure shows the FTIR Spectra of the waste-diapers hydrogel with the addition of straw nanofibres and the pure one. The diapers with the addition of straw nanofibres have a higher intensity compare with the pure one. It may be caused by the increasing of a hydroxyl group from straw nanofibres into the hydrogel.

3.1. Analysis of the morphology of waste diapers hydrogel

The morphology of waste diapers hydrogel can be seen from Scanning Electron Microscope (SEM) analysis as shown in Figure 2 and Figure 3. The morphology of straw nano fibers-loaded hydrogel looked more dense. This is likely due to the addition of the straw nano fibers can cover the structure formed on the hydrogel so that it looks more dense.
3.2. The kinetics of Straw nanofibres release in water

In a Nanofiber release system required kinetics equations to estimate the rate of release of Nanofibers on certain conditions/concentrations and estimating the nanofibers release mechanism. The rate of release of nanofibers into Aquadest is tested with the theoretical rate of Higuchi model kinetics which depicts the release of nanofibers from an insoluble matrix.

\[ Q = kH t^{1/2} \]

Where Q is the concentration and kH is the rate constant of release. The obtained data is shown in the table as the correlation between the concentration of straw nanofibres and constant rate.

| Concentration | kH     |
|---------------|--------|
| 1%            | 0,0201 |
| 5%            | 0,1187 |
| 10%           | 0,1483 |
| 15%           | 0,2077 |
| 20%           | 0,2175 |

Based on Table 1, it can be seen that the higher the concentration of straw nanofibres, the higher constant rate of nanofiber release (kH). It may be caused by the bigger difference of concentration the bigger driving force for diffusion and moreover, the durability of the hydrogel structure is lower at higher concentration of straw nanofibers which diapers so nanofibers which indicated more easily leave the tissues.

3.3. Effect of the addition of straw Nanofibers on the growth of green bean seeds

| Day | The concentration of straw nanofibers | The growth of green beans seed |
|-----|--------------------------------------|-------------------------------|
|     | 0% | 1% | 5% | 10% | 15% | 20% |
| 1   | -  | -  | -  | 0,5 cm | 0,5 cm | 0,5 cm |
| 2   | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm |
| 3   | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm |
| 4   | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm | 0,5 cm |
Based on the observation, on the planting media of diapers without mixing with soil, the seeds of green beans still live and grow for four days. It shows that the growing media fulfil the need for plants on adequate nutrient and mineral elements. The availability of nutrient and mineral elements in hydrogel affects the green bean growth process.

4. Conclusion
From the results and discussion, we can conclude that the addition of straw nanofibers on the diapers waste change the morphology of hydrogel and increase the rate constant according to the Higuchi equation. Moreover, it can be proved that the growing media can be developed by adding the straw nanofibers on the diaper waste.

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