Evaluation of the Influence of Acid Rain on the Property of Plant Mediums by Simulation

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Abstract

Acid rain has drawn much attention recently. This study was about evaluating the acid-rain-resistant and eco wall which was made of cotton fibers and Tencel fibers. In the experiment, two types of fibers were immersed in stimulated-acid-rain solutions for a week and weighted respectively after drying. This same procedure was repeated weekly three times; meanwhile, the fibers' pH values were measured daily. The result showed that cotton fibers surpassed Tencel fibers, demonstrating smaller weight losses and positive pH results. The cotton fibers were able to adjust its pH value to 6.8, which provided a suitable environment for plants.

Introduction

Natural rainwater has a pH value of 5.6 as carbon dioxide and the formation of carbonic acid in atmosphere dissolve. Herewith acid rain is defined as rain with a pH lower than 5.0, and SO_2 and NO_2 are two common atmospheric pollutants [1, 2]. Recently, acid deposition and the role of acidic air pollutants have become a major issue globally. Acid rain itself and its vapor agglutination corrode the exterior of buildings, outdoor installations and metals, especially steel. Industrial-grade functional textiles are the one of the major productive goals for textile industry in the application fields [4-8].

This paper aimed at developing a soilless culture medium out of a blend of cotton fibers and Tencel fibers, which were used as a moisture-retaining material for the moisture layer. This soil-free culture medium was expected to be installed as an eco wall attached to the surface of buildings. Soils usually have a pH value between 4.0 and 8.0, and pH 6.5 is what plants prefer [3]. Hence, the two fibers, soaked in simulated-acid-rain solutions, were observed with changes of pH value and weight loss, determining if they were qualified as culture mediums.

Experimental

Procedures

The 1.0±0.1 g cotton fibers were placed into four beakers of simulated-acid-rain solution whose pH were 5.0, 4.5, 4.0 and 3.5, respectively, and so do Tencel fibers. Fibers were soaked and well-stirred for 28 days. Their pH variations were documented daily. Every week, the fibers were dried at 70 ℃ to examine the weight loss.

Materials

Cotton fibers have a length of 20-25 mm and a fineness of 0.9-1.7 dtex. Tencel fibers with a length of 51 mm and a fineness of 1.7 dtex were manufactured by Lenzing Fibers Crimsby.

Evaluations

Acid Rain Test

The formula of the 0.1 M simulated acid-rain solution was made of Nitric Acid and Sulfuric Acid. Table 1 summarizes the four different ratios the solution formulated.

Table 1 The volume (ratio) of H_2SO_4 and HNO_3

pH	H_2SO_4(ml L^{-1})	HNO_3(ml L^{-1})
3.5	1.173	1.825
4	0.377	0.587
4.5	0.102	0.159
5	0.04	0.062

pH Value Test

Based on CNS 12639, two different fibers, weighted 1.0±0.1 g, were put into 100 ml solutions with a variety of rates of Nitric Acid and Sulfuric Acid, after which solutions with fibers were well-stirred for ten minutes at room temperature. After stirring, the solutions were measured two times.

Results and Discussion

The pH value of cotton fiber

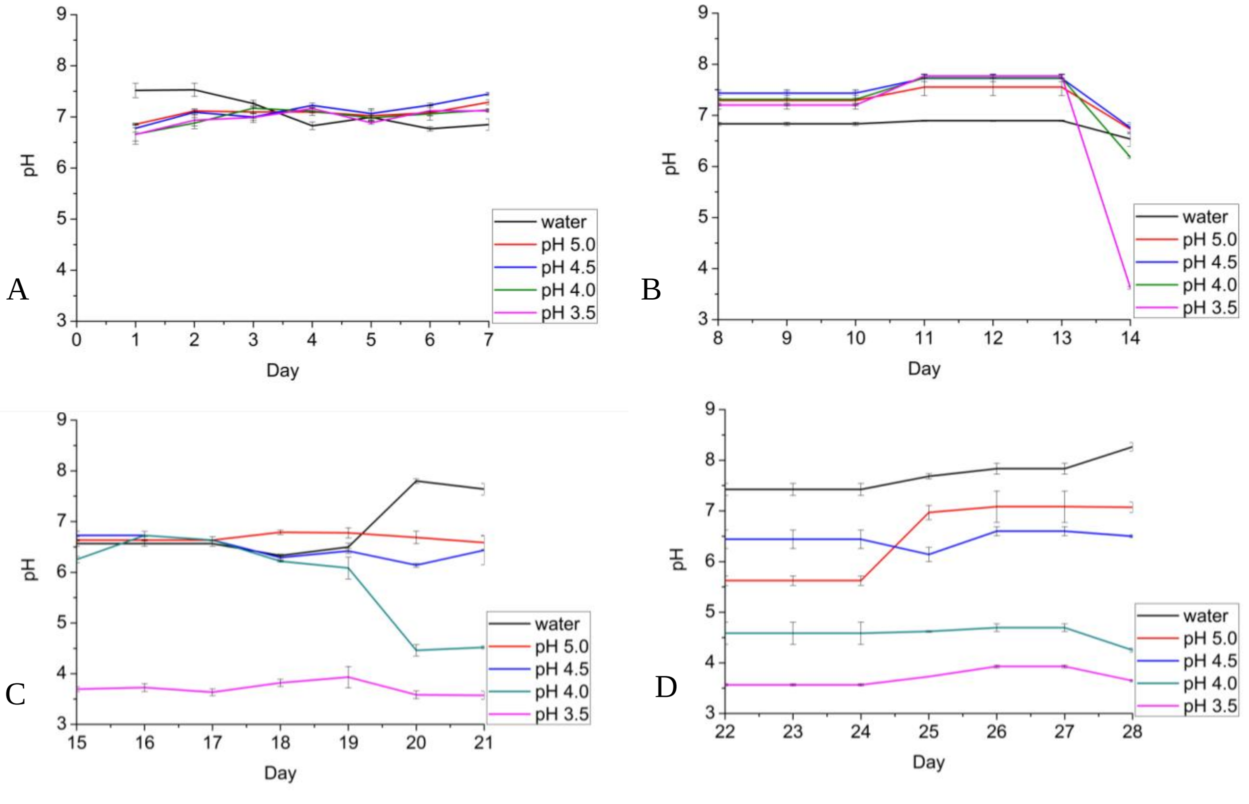

Figure 1: The pH value variations in the cotton fibers immersed in the simulated-acid-rain solutions with different pH values.

Table 1 shows the pH value variations. In the first 14 days, the solution's pH continued rising until it was similar to that of the fibers. On the 15th and 28th days, the solutions had a pH value of 3.5 or 4.0, which stopped fluctuating by the fibers' pH value.

The cellulose fibers had poor acid endurance. At room temperature, the cotton fibers decomposed shortly after being immersed in 1-3 % mineral acid; furthermore, the strength elongation also went down dramatically. When being immersed in solutions of 65-95 % H_2SO_4 or 40-45 % HCL, the cotton fibers decomposed immediately at room temperature. In low acid solution, only minor decomposition in cotton fibers could be observed, despite of a high temperature. The decomposition started from the amorphous region while the crystallized region was still acid-resistant.

The acid liquor continued corroding the cotton fibers when they were dried and weighted. The drying was as harmful as sunshine. Figure 1 indicates that cotton fibers soaked in pH 3.5 declines on the 15th day; consequently, the cotton fibers were eroded extremely severely in this meta-acid environment. Same result was achieved on the 20th day. (CV% was between 0.35 to 0.01 %.)

The pH value of Tencel fibers

For 28 day, the Tencel fibers were immersed in simulated-acid-rain solutions with different pH. Figure 2 demonstrates the solution's pH daily variations. By comparing Figure 1 (a) and Figure 2 (a), we can conclude that cotton and Tencel fibers were not acid-resistant. Nevertheless, based on Figure 2 (c) and (d), when Tencel fibers were immersed in solutions were with pH 4.0 and pH 3.5, the amorphous regions were destroyed completely (CV% was between 0.38 % and 0.01 %).

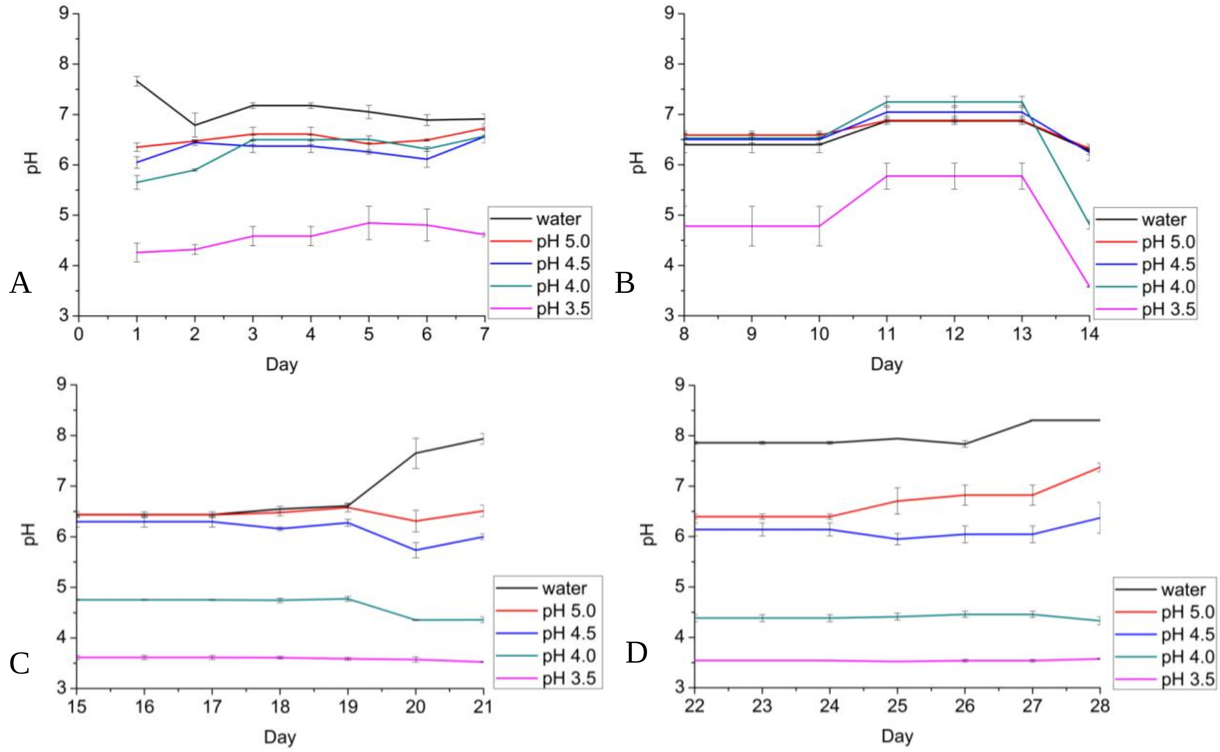

Figure 2 The pH value variations in the Tencel fibers immersed in simulated-acid-rain solutions with different pH values.

Rate of Weight Losses

The cotton fibers and the Tencel fibers were dried up and weighted weekly. The results showed that both weight losses were resulted from acid hydrolysis. Figure 3 indicates that the weight losses of fibers in pH 3.5 solution were greater than that of water. The dried fibers declined to absorb humidity from the air due to Taiwan's humidity which might affect the result. Each of the fiber, regardless of its types, had different degree of crystallizations, which were responsible for different weight losses. (CV% was lower than 0.01 %.)

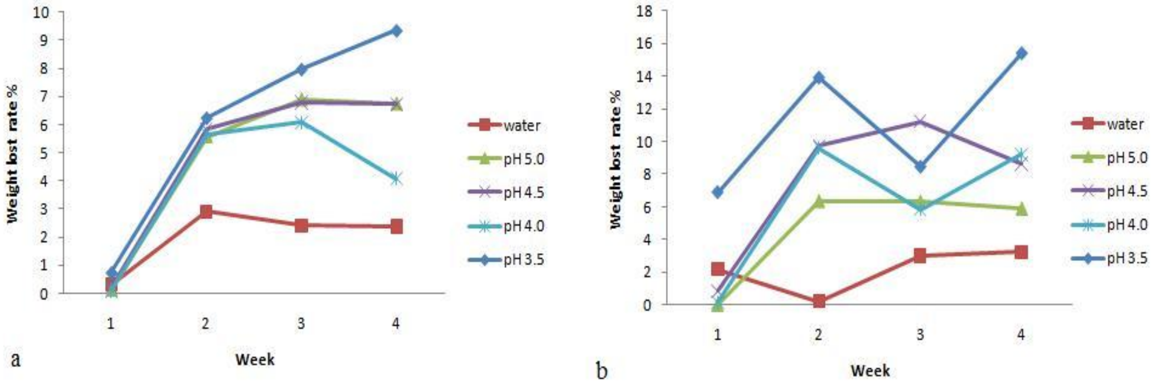

Figure 3: The weight losses of (a) cotton fibers and (b) Tencel fibers.

Conclusion

In this research, the acid-rain-resistant and ecological wall which was made of cotton fibers and Tencel fibers was evaluated successfully. After documenting the pH variations for a month, we concluded that the cotton fibers were easier to neutralize the solution than the of the Tencel fiber. The solution's pH stopped responding to the cotton fiber's pH on the 12th day. Furthermore, the Tencel fibers displayed more weight losses than the cotton fibers did. As the eco walls made of Tencel fibers were more fragile than that of cotton fibers, cotton fiber could be added to strengthen the eco walls as well as to promote the walls' water absorption ability.

Acknowledgement

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