The Effects of CNF on Storm Water Remediation

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Background

TEMPO Cellulose Nanofibrils (CNF) are oxidized nanoparticles of plant fibers made from the cell wall. Cellulose nanofibers are the world's most advanced biomass material. Lightweight and elastic, these fibers present high barrier properties with regard to oxygen and other gases (Uddin, 2018). This sustainable material offers a better solution than a chemical based compound that may contain carcinogens used to flocculate (cause to stick together) and settle out micro particles of dust and oil in waterways. It is the micro particles that cause water to be cloudy. This is known as turbidity. CNF proposes to eliminate turbidity before the water encircles back into the waterways. Also, it creates low environmental impact in its production and disposal. A natural based compound is preferable because if offers the convenience of being renewable, non carcinogenic, biodegradable and a low cost way to remove micro size particles.

Curriculum Connections

8.E.1.3 - Predict the safety and potability of water supplies in North Carolina based on physical and biological factors including temperature, dissolved oxygen, pH, nitrates, turbidity and bio-indicators. Also see 8.E.1.4 re: good human health.

Introduction

This research addresses the environmental concern of storm water run off in urban areas and construction sites. The water collected by catchment ponds contains dust and oil particles suspended throughout the water. If these particles are not settled out before the water is sweep back into the waterways, it will cause high turbidity , which is both unhealthy because it causes a decrease in the oxygen level of the water; and unappealing which causes a decrease in use of the water. It is environmentally and economically necessary to remediate storm water runoff.

Figure 1: *From left to right: Krystal Williams – student researcher, Maya Foxworth – student researcher, Juanita Purdy – CTI Fellow, Dr. Todd Coolbaugh – Assistant Professor discuss the results of the research*.

Procedure

CNF Solution was made by adding 1g of CNF dissolved in 1mL of DI (Deionized) H_2O

Soil Samples were composed of 50g of the various types of soil suspended in 500mL of DI H_2O

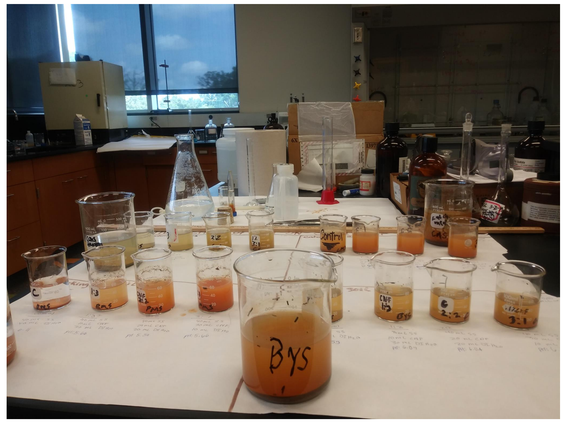
Calcium Chloride Solution consist 147g of $CaCl_2$ dissolved in 100mL DI H_2O.

1. Four soil samples were made by combining 50 g of soil to 500mL of Deionized Water (DI). The four soil sample were taken from a **1. construction site, 2. catchment pond, 3. parking lot and 4. backyard**. The mixture was mechanically stirred for 30 minutes. This result in a soil suspension of each sample.
2. The CNF was added to 100 ml of soil suspension in varying proportions. See figure 2.
3. The pH of each soil sample was measured before and after the addition of CNF.
4. A secondary soil sample was made using 100 ml of each soil suspensions, combined with 50 ml of calcium chloride solution and 25 ml of the CNF solution.

Figure 2: Each soil sample comprised of the following amount of varying ratios of CNF to DI water.

- Control – no CNF – 40 ml DI water
- 10 ml of CNF to 30 ml of DI water
- 20 ml of CNF to 20 ml of DI water
- 30 ml of CNF to 10 ml of DI water

Figure 3: *Lab display of the four soil samples indicates different levels of turbidity using CNF in varying proportions. Turbidity indicates that micro particles are still present in the water.*



Results

For the primary soil sample, the control of the parking lot soil sample was the only sample that indicated water clarity. There were no micro particles indicated in the water, they all appeared to have settled out. Although the other samples settle at varying degrees, the end results were cloudy water. So the CNF in varying proportions alone was not effective in remediating the types of simulated storm water used in this research. However, when the calcium chloride was added to the secondary soil sample, all four samples resulted in flocculation of the soil particles and produce water clarity with the micro particles settling to the bottom of the beaker. The pH was measured for each soil sample and as noted in the research literature (Tang, 2017) the pH range between 4.0 to 6.5 in conjunction with CNF tends to produce the most clarity.

Figure 4: When measuring absorbance, the suspended particles block the photons which would result in higher light absorption numbers (Goodner, 2009) the numbers below indicate very little blockage.

ALL SOIL TYPES RESULTED IN FLOCCULATION OF THE SOIL PARTICLES AND SETTLEMENT OF THE MATERIAL AT THE BOTTOM OF THE BEAKER.

	Light Absorption	pH	Depth of Flocculation
Construction	.005	5.90	1.8 mm
Catchment	.039	5.84	1.9 mm
Backyard	.010	5.93	2.1 mm
Parking lot	.005	6.59	2.0 mm

Figure 5: *Adding Calcium Chloride to CNF resulted in water clarity and settling of all micro particles and sediment for all four soil samples .*

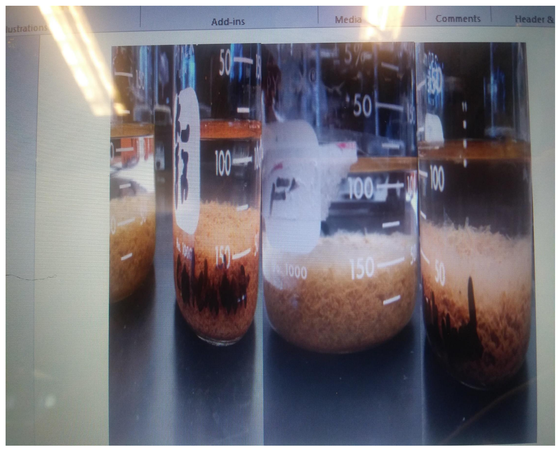
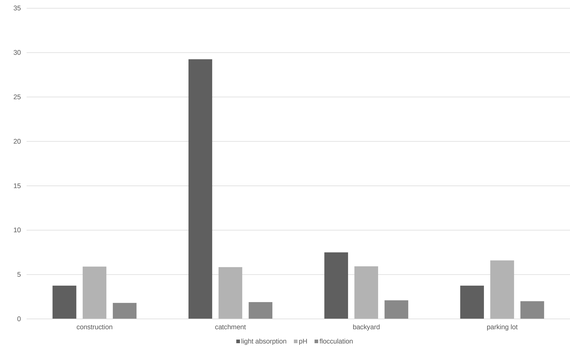


Figure 5: *What this tells us is that the CNF acting in conjunction with the calcium chloride solution have remove most of the micro particles scattered throughout the water and have settled them to the bottom of the beaker. Most of the light is making it through the sample. Catchment soil had the least absorption; however the absorbance for all soil samples is pretty reasonable.*



Conclusions

As a single agent, CNF was not able to remove the micro particles that causes turbidity in the water. The CNF, through it ability to produce a negatively charged surface, the particles on the surface was unable to create a bond with the particles that already carried a negative charged. However, when a buffer such as calcium chloride was added, the CNF was able to produce flocculation (clumps of particles) and cause them to settle out in order to produce crystal clear water.

Further Research

Further research using CNF would be in the area of optimal usage of the solution. At higher concentrations of CNF, the soil suspension became gel which indicates there can be too much CNF added to soil suspensions. Further research would determine the exact amount needed for optimal flocculation.

Curriculum Lab Extension

Treatment of Drinking Water – 8th grade students will develop a four step process of cleaning muddy water, using methods of filtering, sedimentation, flocculation, disinfecting.

References

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2. Tang, Z., Li, W., Lin, X., Miao, Q., Huang, L., Chen, L., & Wu, H. (2017). TEMPO – Oxidized Cellulose with High Degree of Oxidation. *Polymers,* doi:10.3390/polym9090421, www.mdpi.com/journal/polymers
3. Goodner, Kevin L. (2009) Estimating Turbidity (NTU) from Absorption Data. *Synergy,* Sensus Technical Note, SEN-TN-0010