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Use of Natural Sorbent for Stormwater Treatment

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Abstract. Stormwater runoff is an important avenue for pollutant transport from impermeable surfaces to surface waters. Consequently, stormwater pollutions require additional treatment processes to achieve water quality goals. Natural sorbents have been demanded and studied for using in water treatment because of their low cost and safety. In this study the use of *Acorus Calamus*, *row Hemp*, and *procedure Hemp* in stormwater treatment was investigated. Results of study in all sorbents with different concentrations and dosage indicated high efficiency to reduce pH. The use of Acorus Calamus for Turbidity, Phosphorus, conductivity and colour resulted increasing amount in different Dosage. In another experiments, using row Hemp, procedure Hemp and Linseed as natural sorbents indicated high efficiency to reduce turbidity of stormwater. Also it is obtained that procedure Hemp has high efficiency to reduce conductivity of stormwater.

Keywords: Hemp, stormwater, natural sorbent, water quality.

Introduction

Urban rainwater runoff contains many pollutants generated by human activities and natural processes stormwater runoff can contain pollutants from fertilizers and pet and yard waste. Surface water and rain water are often the major sources of water availability in a community (Ernest et al., 2017). During periods of heavy rainfall some wastewater systems are designed to occasionally overflow and discharge excess untreated sewage directly to nearby streams (Pearson et al., 2018), rivers or other water bodies that it has become a non-point source pollution problem commonly existing in various countries across the world (Fu, 2015; Mangale et al., 2012).

The clean water for our need is obtained mostly from river so a proper wastewater treatment is to be needed before being released to the river. Different processes need a different kind of water treatment Through leaching and transport processes, however, excess phosphorus can endanger the quality of surface waters (Mahmood & Zaki, 2019). Phosphorus inputs to water bodies are under close scrutiny because of the contribution of phosphorus to water eutrophication and algal blooms (Yu et al., 2019), which result in the depletion of dissolved oxygen and high turbidity levels in aquatic ecosystem (Hsieh et al., 2007) High turbidity in water not only will reduce the quality of water itself (Abidin et al., 2013; Choy et al., 2014) but it can give impact to the ecosystem as well (Ernest et al., 2017). It indicates the presence of TSS (Total Suspended Solids) like clay, silt, organic matter which can be harmful for mankind, biologically as well as chemically (Lopez & Postila, 2018). In fact Turbidity refers to the cloudiness of a solution and its characteristics that are imparted by the suspended solid particles limiting the passing of light through water. The history of the use of sorption process to remove turbidity in water is long (Okuda & Ali, 2019) series of sorption experiment were conducted to establish the reduction of turbidity (Sahu et al., 2019). Depending on the application, chemical reagents are dosed into the water stream to increase coagulation and formation of flocs and effectiveness of settling before filtration (Javid et al., 2015) Biosorption is an emerging technique for water treatment utilizing abundantly available biomaterials there has been considerable interests in the development of natural sorbent (Iqbal et al., 2019; Kainth, 2015) which are safe for human health and biodegradable (Ata et al., 2012; Iqbal et al., 2019; Kainth, 2015; Shan et al., 2017). The sorbents with high sorption capacity, easy separation from aqueous solution, low cost, and recycling use are promising materials in the future. Sorption is a method that is preferable when compared with separations like membrane separation and coagulation or flocculation processes Mangalea et al. in 2012 evaluate the efficiency of a natural absorbent from Moringa oleifera seeds in treating river water. Various doses of Moringa seed powder viz. 50, 100 and 150 mg/l were taken and checked for the efficiency dose on raw water. After treatment of seed powder with water samples were analysed for different parameter like pH, Turbidity. All parameters were reduced with increasing dose of 50, 100 and 150 mg/l seed powder respectively. Šćiban and co-workers in 2009 were experimented ability of

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seed extracts of several species of chestnut and acorn to act as a natural coagulants using a synthetic turbid water. Active components were extracted from ground seeds of Horse chestnut and acorns of some species of family Fagaceae: Common oak, Turkey oak, Northern red oak and European chestnut. All investigated extracts had coagulation capabilities and their amounts depended on pH values and initial turbidities. The seed extracts from European chestnut and common oak acorn were the most efficient expressing the highest coagulation activities, about 80% and 70%, respectively, in both low and medium investigated water turbidities at the lowest coagulant dose 0.5 ml/L. In other case Baptista et al. in 2015 were used Moringa oleifera seed to obtain a natural coagulant that was able to reduce the colour and turbidity of surface water with initial turbidity of 75 NTU without increasing the organic material in the water treated. The results indicated that saline coagulant had a better performance in the removal of colour (89.15%) and turbidity (88.75%). Ramavandi in 2014 were extracted a bio coagulant from Plantago ovata by using a FeCl3-induced crude extract (FCE). The potential of FCE to act as a natural coagulant was tested for clarification using the turbid water of a river. Experimental tests were performed to evaluate the effects of turbidity concentration, coagulant quantity, water pH, and humic acid concentration on the coagulation of water turbidity by FCE. The maximum turbidity removal was occurred at water pH 8. At the optimum dosage of FCE, only 0.8 mg/L of dissolved organic carbon was released to the treated water. An increase in the humic acid led to the promotion of the water turbidity removal. Results demonstrated that the FCE removed more than 95.6% of all initial turbidity concentrations. Mahmood and Zaki in 2019, were measured the effectiveness of Artocarpus Heterophyllus seed as natural coagulant. There are two types the natural coagulant from Artocarpus Heterophyllus were considered in this study such as raw and dried seed. The result showed dried Artocarpus Heterophyllus seed (1M NaCl) at 20 mg/L achieved the optimum dosage of coagulant compared to dried Artocarpus Heterophyllus seed (distilled water), raw Artocarpus Heterophyllus seed (distilled water) and raw Artocarpus Heterophyllus seed (1M NaCl) in removing turbidity. It reduced up to 50% turbidity, and 70% suspended solid after the treatment process. Kamel and co-workers in 2018 conducted a research to compare the effectiveness of natural based coagulant made from *Psophocarpus tetragonolobus* and chemical coagulant in improving the quality of raw water. Findings from this study showed *P tetragonolobus* can remove turbidity up to 60 percent with 40 ml, 1% solution. Therefore, *P. tetragonolobus* can be considered as a potential resource for natural coagulant. Rak and Islami in 2012 used *Cassia alata* leaves to test coagulant rate and dose. The turbidity and other physico-chemicals of surface water sample were measured before and after the jar-test by using portable instruments. The results have shown that Cassia alata leaves can remove turbidity up to 93.33% at the optimal dosage of 1.0 mL/L. In this study, we focused our attention on evaluation of *Acorus Calamus*, Row Hemp, Linseed and procedure Hemp efficiency as bio-sorbent to decrease Phosphorus, pH, Conductivity, colour and Turbidity in the stormwater. The main aim of this study is evaluation of sorption characterization for these Natural sorbents. This bio-sorbents were obtained from *Acorus Calamus*, *Linseed*, procedure *Hemp* and *row Hemp* which are abundantly available in Lithuania, as well as in many other countries worldwide like Iran.

1. Material and methods

Stormwater

Samples were collected from VGTU university parking plots located in Vilnius, Lithuania from September 20 till December 14. Table 1 shows the main characteristic of stormwater and snow melted water. According to the results shown in Table 1, Phosphorous, Turbidity and Conductivity of stormwater are in higher level than standards.

Table 1. Characteristics of used stormwater (Vilnius, Lithuania)

Parameters	Units	min	max	Standard
Phosphorus	mg/l	1.8	9.8	1 mg/l
pH	–	7.2	7.84	6.5–8.5
Conductivity	µS/cm	107	547	<500
Color	pt scale mg/l	1.12	5.3	5
Turbidity	mg/l	12.7	723	20

Preparation of used sorbents

To obtain Acorus Calamus powder as an sorbent, the Acorus Calamus were previously Cleaned, washed with tap water, dried in 120 °C for one day, ground and then finally sieved by an impact laboratory test sieve with an aperture of 300 mm to obtain a solid powder with a diameter less of 0.3 mm (Adesina et al., 2019; Jonesn & Bridgeman, 2019; Zaidi, 2019). The employed Acorus Calamus was composed of six units, each containing 0.5 L of stormwater and different amount of fine powder to achieve different concentrations (2, 4, 6, 8, 10 mg/l). The first step of Jar test consisted of stirring the stock solution at 120 rotations per minute (rpm) for roughly 30 minutes. After 30 minutes, the solution was filtered through a Whatman paper (0.45 micron) (Shan et al., 2017; Zaidi, 2019) to obtain filtrated water.

Finally the pH, Turbidity, Phosphorus, conductivity and colour of filtered sorbent was measured. All the steps of jar test filtration water are shown in Figure 1.

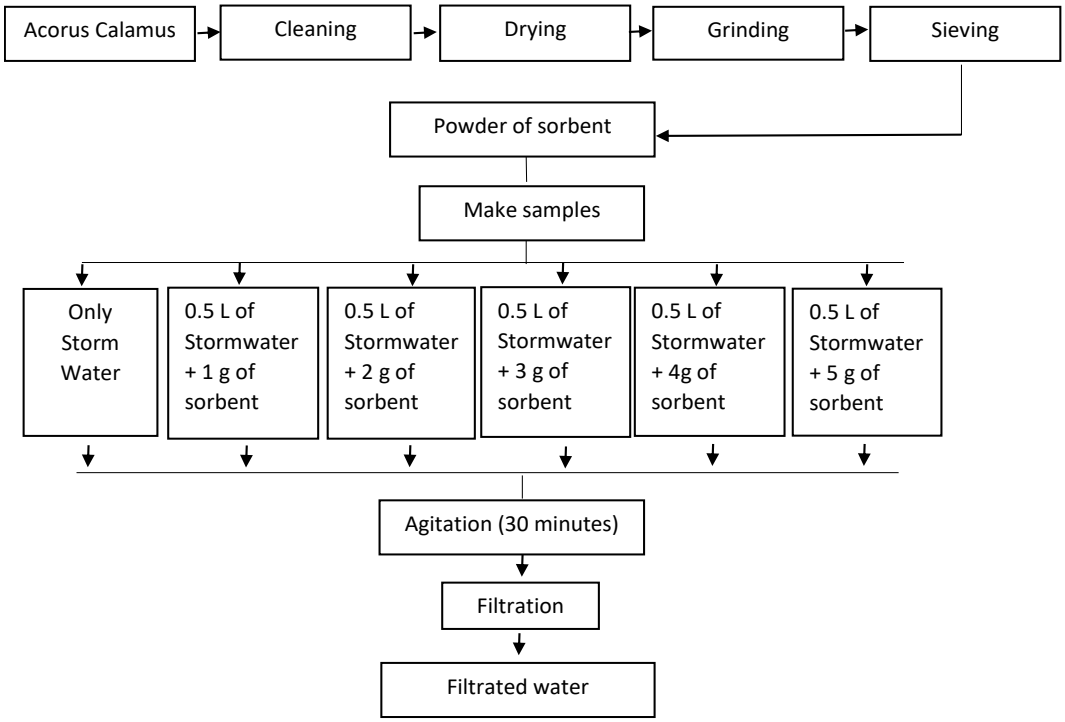


Figure 1. Jar test steps of A. Calamus to obtain filtrated water

In the next experimental research the prepared Row hemp was filled into the filter column and washed to clean. Furthermore 0.5 L of stormwater was added to the filter column (40 cm height and 5 cm Diameter) for 30 minutes settling to accomplish treated water. After 30 minutes, the solvent was filtered through a Whatman paper (0.45 micron) to obtain samples (Zaidi, 2019). This research repeated in different rainy days. Finally PH, Turbidity, Phosphorus, conductivity and colour of filtered sorbent was measured to obtain efficiency of Row Hemp as a sorbent. All steps of the column test are shown in Figure 2.

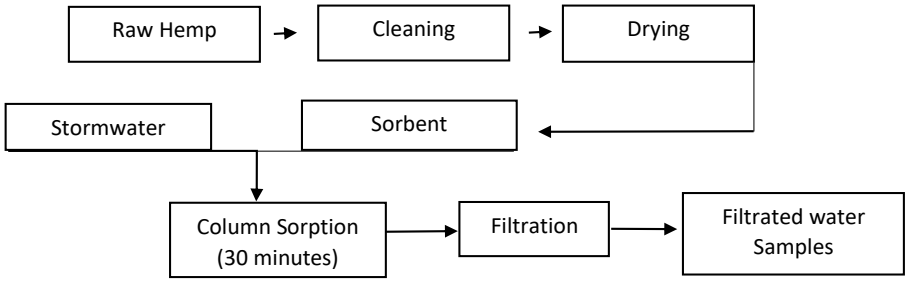


Figure 2. Column test steps of Row Hemp to obtain filtrated water

Analytical methods

Finally the residence electrical conductivity in every sample was measured by conductivity meter 315i (made in Germany). The pH was detected by a pH Meter 330i (made in Germany). The colour was determined by Spectrophotometer NOVA 60 (made in Germany) with 436 nm wavelength range and the residual turbidity with wavelength range of 550 nm. The phosphorus concentration was measured by Spectrophotometer Genesys 10 VIS (made in USA) (Carranzo, 2012).

2. Results and discussion

In this section the results of using row Hemp and procedured Hemp as sorbent in column test and A. Calamus in jar test to treat water pollution and increase water quality are presented and discussed.

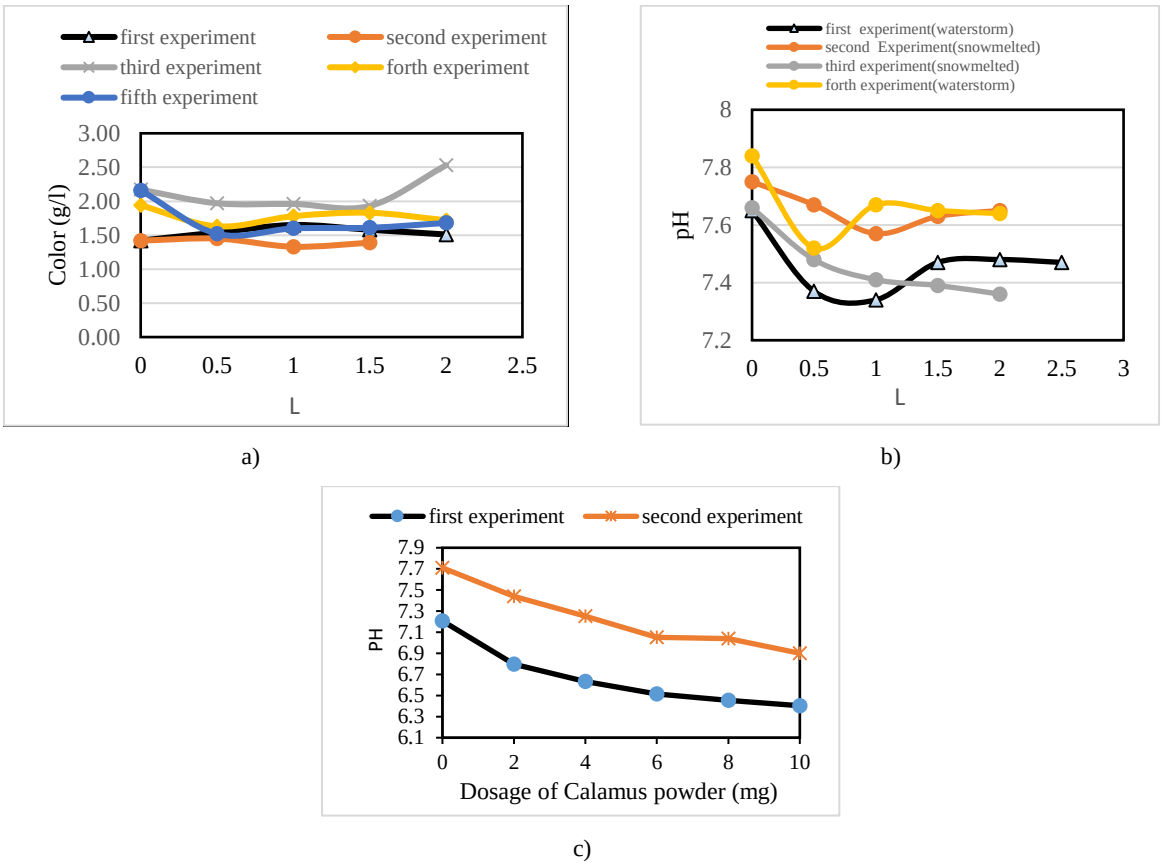


Figure 3. Effect of row Hemp, procedured Hemp and A. Calamus on pH

Results of using Row Hemp (Figure 3a) and procedured Hemp (Figure 3b) as sorbent indicated the same results with Acorus Calamus and Linseed. They have high efficiency to decrease pH of water that it can be related to the structure and nature of sorbents. Figure 3c confirm when Acorus Calamus is used as a sorbent, increasing the dosage of the sorbent, the pH of stormwater decrease to the minimum (6.4) (McDermott & Strait, 2017). This occurrence can be related to the nature of the sorbent and it would be efficient sorbent to stabilize water pH.

Effect of row Hemp and procedured Hemp on conductivity

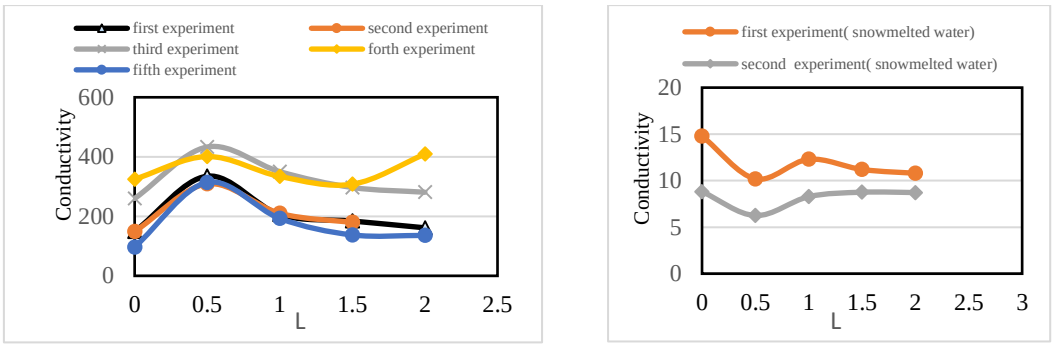
In order to see the effect of row Hemp as a sorbent on conductivity in different volume of stormwater, the Conductivity measurements were taken. It is indicated that by increasing dosage of stormwater (from 0.5 L to 2 L) at first the conductivity increased (in 0.5 L volume of stormwater) and after that it reduced and stabilized. It should be underscored that at first the dosage of row Hemp for reducing Conductivity from water storm is high because by increasing volume of stormwater the Conductivity reduced and stabilized.

Settling stormwater in row hemp sorbent indicated sudden increase in conductivity because of high dosage of row Hemp that by increasing dosage of stormwater and reducing concentration, it reduced and stabilized (Figure 4a). Effect of procedured Hemp on conductivity showed opposite results with row Hemp sorbent and at first the conductivity decreased dramatically in 0.5 L of stormwater and by increasing the stormwater it increased and stabilized (Figure 4b).

Effect of natural sorbents on Turbidity

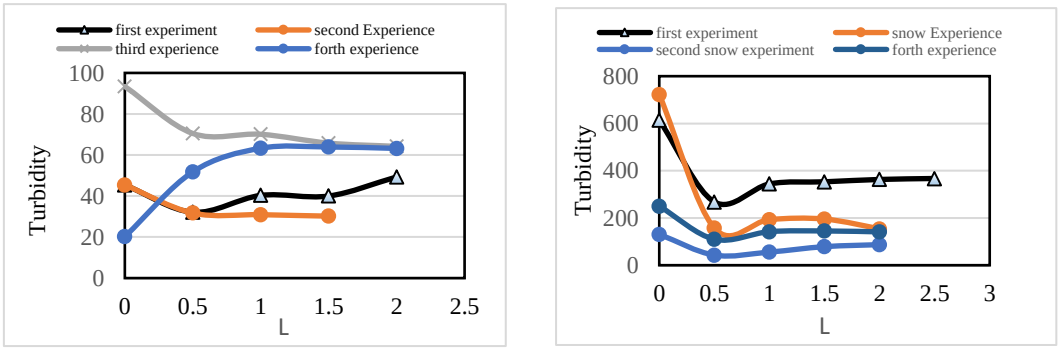
Reducing Turbidity from stormwater is very important to enhance the quality of water (Baptista et al., 2015). Figure 5 shows effect of natural sorbents on reducing turbidity from stormwater. According to the results presented in figure sorbents they have high efficiency to reduce stormwater turbidity.

According to the results the highest volume of reducing turbidity from water storm is occurred in 0.5 mL and after that it stabilized until passing its capacity to reduce turbidity.

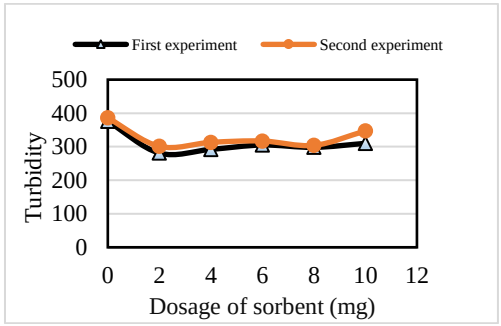


a) b)

Figure 4. Effect of row Hemp sorbent on conductivity



a) b)



c)

Figure 5. Effect of row Hemp (a), procedured Hemp (b) and linseed (c) on turbidity

In Figure 6 the results of turbidity are expressed in percentage point of turbidity removal, using the following formula (Kamel et al., 2018; Rak & Ismail, 2012):

$$\text{Turbidity removal (\%)} = \frac{(initial\ turbidity - residual\ turbidity)*100\%}{Initial\ turbidity}. \quad (1)$$

At first because of higher concentration of sorbents, more solution particles are extracted from bio-sorbents that solve in solvent, and removal efficiency is less than other steps (Hu et al., 2013). When the water storm concentration increase the turbidity removal increase and it will continue to fulfil the capacity of sorbent (Gaouar & Benguella, 2016; Mangale et al., 2012; Mehari et al., 2014; Thomson et al., 2003; Vieira et al., 2010). The turbidity may have different concentrations in different water resources, and different turbidity concentrations may have an effect on sorption (Vijayaraghavan et al., 2011). It is noticeable that the efficiency of turbidity removal by a natural sorbent is significantly influenced by the characteristics and the origin of the sorbent (Ramavandi, 2014).

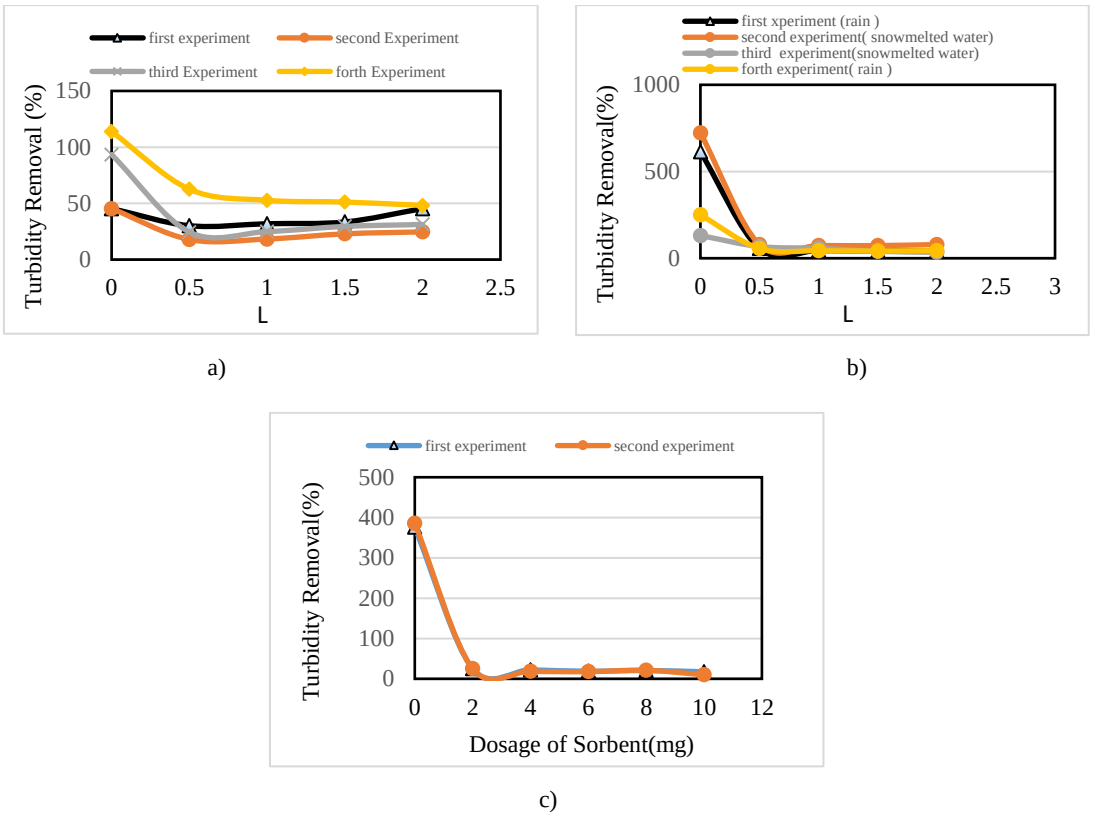


Figure 6. Effect of row Hemp (a), procedured Hemp (b) and linseed (c) on turbidity removal.
According to the results it is obtained that all sorbents have high efficiency to remove turbidity (76.4%, 56.3% and 25%)

Effect of natural sorbents on color

Colour removal from water is important to ensure contaminants are filtered out and the water is appealing for different purposes (Ernest et al., 2017). Figure 7 shows effect of natural sorbents on reducing colour from stormwater. According to the results presented in Figure 7, row Hemp and Hemp procedured have high efficiency to reduce storm-water colour.

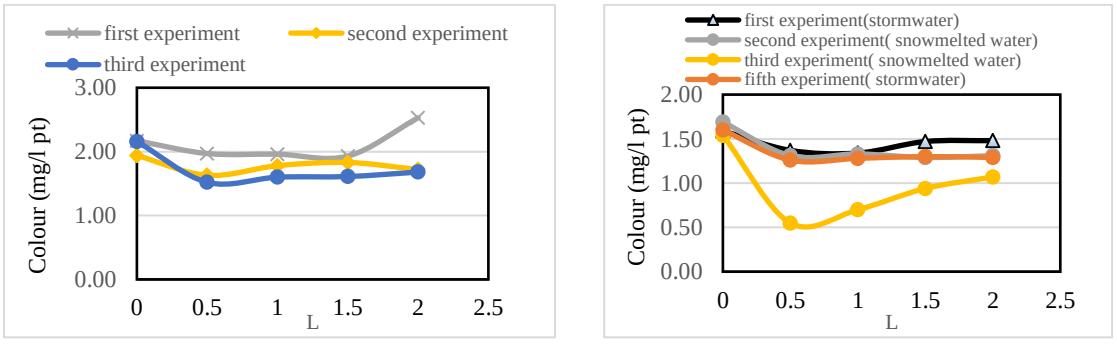


Figure 7. Effect of row Hemp (a), procedured Hemp (b) on color removal.
According to the results it is obtained that sorbents have high efficiency to remove color

It is obtained by using row Hemp (Figure 7a) and procedure Hemp (Figure 7b) the colour of stormwater at first step dramatically reduced and after that it stabilized and continued until the sorbent loose its capacity to remove colour.

Conclusions

The purpose of this study was to investigate the effectiveness of natural sorbents to treat stormwater. In order to confirm sorbent efficiency, different stormwater were collected and experimented using A. Calamus, row Hemp and procedure

Hemp sorbents showed the same results on pH and reduced pH of stormwater. Use of Acorus Calamus powder in detail reduce pH of stormwater from 7.2 to 6.4 and 7.7 to 6.9. Respectively using row Hemp, Linseeds and procedured Hemp for treating Turbidity from stormwater showed interesting results. It resulted in order 62%, 25.2% and 78.2% efficiency to remove turbidity. Settling stormwater in row hemp sorbent indicated sudden increase in conductivity because of high dosage of row Hemp that by increasing dosage of stormwater and reducing concentration, it reduced and stabilized. In other side Effect of procedured Hemp on conductivity showed opposite results with row Hemp sorbent and at first the conductivity decreased dramatically in 0.5 L of stormwater and by increasing the stormwater it increased and stabilized.

Indeed using row Hemp and procedured Hemp as sorbent to treat colour showed decrease in results at lowest concentration of stormwater that by increasing stormwater dosage the colour increased and stabilized. It is to highlight that procedure Hemp has high efficiency to treat water and reducing pH, colour, Turbidity and conductivity.

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