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Research paper

Assessment of Storm Water Quality in Grass Swale by Using Sand Filter Media: a Case Study at UTHM Campus

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Abstract

Urbanization in Malaysia has contributed to the increased of volume runoff to the drainage system. SUDS (Sustainable Urban Drainage System) / MSMA (Manual Saliran Mesra Alam) has been implement in Malaysia within several of components. Hence, swale is one of the designed and suggested by SUDS or MSMA in order to control the quantity and quality storm water runoff. The present study aimed to determine the quality of storm water runoff in swale and to analyse storm water runoff treatment using sand column as a part of filtration process. Water quality parameters tested included COD, BOD_5, DO and TSS. The samples was test with sand column on D30, D60, D90 and DMIX. The results revealed that sand column improved the water quality by 4% to 80%. In conclusion, the sand column can be used to improve the storm water quality and can enhance the natural habitat.

Keywords: *Grass Swale; Sand Filtration Media; Storm Water Quality.*

1. Introduction

Development and urbanization of watersheds typically increases impervious land cover (e.g. roads, parking lots, buildings) and thus leads to an increase in storm water runoff peak flow rates, total runoff volume, and degradation of runoff water quality. Storm water management focused on flood prevention through mitigation of the increase in peak flow rate by routing the runoff through a detention pond or some other system. As a result, storm water management has shifted to include techniques that reduce runoff volumes and improve runoff water quality in addition to reducing the peak flow rate. Such techniques are called Sustainable Urban Drainage System (SUDS) practices and are typically designed to reduce runoff through infiltration as well as improve storm water runoff quality. The implementation of (SUDS) storm water management is to control storm water and treated storm water runoff. Hence, storm water runoff carrying the pollutant will flow to the watersheds. The urban storm water can be heavily contaminated with range of polluting substances [1]. Storm water contains a complex mixture of natural organic and inorganic materials, with a small proportion of man-made substances derived from transport, commercial and industrial practice [1]. Therefore, the storm water need to improve in order to achieved health and safety of environment and community. Storm water that passed by the swale will through sub surface drainage by infiltration process for treatment purpose which the pollutant will be removed. Therefore, the new design of filter media will suggest to improved storm water quality. The filter will be used two material which is sand and coconut coir. The effectiveness of sand is depends on the size of particle which use in filter. Sands with too many fines have a greater chance of hydraulically failing (clogging) than sand with an effective particle size 0.3-0.5 mm, assuming similar loading rates [2]. Furthermore, the coconut coir helps in heavy metal removal and increase pH value. Coconut coir, compost and sludge are able to achieve high metal removal rates [3]. Coconut coir and compost contain humic substances, cellulose, lignin and carboxyl groups that have a high tendency to bind metals especially between pH range 6-8 via surface complexation and ion exchange processes [4].

Swale is one of the components that design to control the volume of storm water runoff and treated the storm water by infiltration process. Usually, swales use the permeable soil as the subsurface drainage. There are many types of swale such as grass swale, bio swale, dry swale, wet swale and others. Pollutant removal can occur by sedimentation of solid particles onto the soil surface, filtration of solid particles by vegetation, or infiltration of dissolved pollutants (with storm water) into the soil [5]. The performance of a swale depends on many factors including the health and abundance of the vegetation within the swale. The several causes of poor vegetative cover in swales including standing water in the swale for prolonged periods of time, high flow velocities, large fluctuations in surface water depth and soil moisture, excessive shade, and improper installation [6]. Improper installation could be the result of poor design or poor construction practices.

Filter media is a material that are used as a layer for filtering process such as gravel, soil, waste material, sand, peat, crushed granite and other. Usually, the application that used filter media such swimming pool, storm water management, industrial and especially for water drinking. As we know, the filter media can improve the water quality but it depends on the material. Hence, filter media as pretreatment is one in the SUDS practice, which the storm water will through the filter media before directly flow to downstream. The performed a study which showed that sand filters provide little (i.e. 20 - 50 % total, 5-30% soluble) capacity for phosphorus removal compared to other SMPs [7]. Their results also concur that a pure sand-filter media provides “only limited removal of phosphorus” [8]. The researcher observed larger

breakthroughs of unoxidized matter due to short retention times and instantaneous lack of oxygen when applying relatively large hydraulic loads to filter media with coarse grain size, especially above 1 mm [9]. The present study aim to determine the quality of storm water runoff in swale and analyze storm water runoff treatment using sand column as a part of filtration process.

2. Materials and Method

2.1. Materials tested

The filter media materials used in this study were chosen using the coconut coir and sand. The size particle of sand was taken uniformly from sieve analysis test which are D30, D60 and D90. The coconut coir consists of coconut husk chopped into different sizes, producing a highly porous and heterogeneous mix. Sand was dried in the laboratory and sieve into relatively uniform sand-sized particles to obtain a texture similar to mix with the coconut coir. In this case study, four filter media will be prepared with different size particle of sand and coconut coir will be added to all filter media.

2.2 Column setup and experimental procedures

The laboratory experiments were divided into two sets. For the first set, the sample which is taken from swale and pond was tested with four parameters which is BOD_5, DO, COD, and tested to determine the quality of storm water. The second set involved four filter media with different materials that show in Figure 1 that tested with sample by four parameters to analyze storm water runoff treatment using sand column as a part of filtration process.

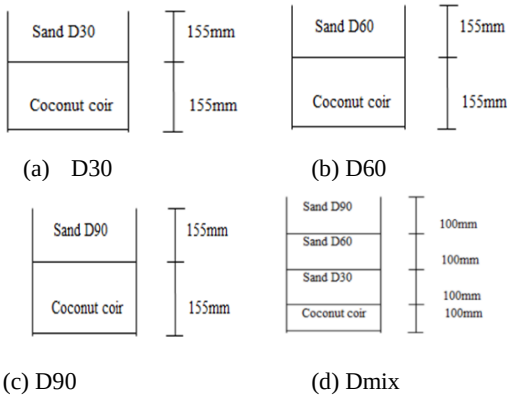

Fig. 1: Filter media design

3. Results and Discussion

3.1. Characteristics of untreated and treated samples

The characteristics of untreated and treated samples by using different filter media in infiltration system are illustrated in Table 1 and 2.

Table 1: Characteristics of untreated sample

Type of Parameter	Untreated Sample	
	Swale	Pond
COD (mg/l)	62.5	87.5
BOD5 (mg/l)	14.12	60.59
DO (mg/l)	3.94	3.5
TSS (mg/l)	4	6

Table 2: Characteristics of treated sample by using 4 different types of filter media

Type of Parameter	Treated Sample							
	swale D30	pond D30	swale D60	pond D60	swale D90	pond D90	swale DMIX	pond DMIX
COD (mg/l)	37.5	50	43.75	68.75	56.25	75	25	31.25
BOD5 (mg/l)	9.41	37.65	10.59	43.52	12.4	54.12	5.29	28.82
DO (mg/l)	4.86	4.55	4.45	4.26	4.18	3.93	5.36	5.1
TSS (mg/l)	2	4	3	5	3	5	1	2

The results in Table 1 shows that the pond recorded the highest reading of COD 87.5 mg/l, followed by the swale 62.5 mg/l. The parameter tested in BOD_5, pond recorded of 60.59 mg/l and swale 14.12 mg/l. It clearly shows the highest readings recorded by pond because it is the biological high in BOD_5. DO of the swale and pond was 3.94 mg/l and 3.5 mg/l. While for TSS is 4mg/l for the swale and 6 mg/l for the pond.

The COD parameter for treated sample by 4 types of filter media recorded the highest number which is swale DMIX 25 mg/l and pond DMIX 31.25 mg/l. The untreated samples show that the result of COD is higher than treated sample. The treated sample of swale D30 is lower than sample of pond D30 which are 37.5 mg/l, 50 mg/l, respectively from swale D60, pond D60, swale D90, pond D90, swale DMIX and pond DMIX. BOD test, the untreated sample for pond appeared the highest reading of 60.59 mg/l, followed by the swale 14.12 mg/l. There is a reduction in BOD parameter for treated sample using DMIX and noticeable after filtering process. The value reduces of pond and swale is reduces to 28.82 mg/l and 5.29 mg/l respectively. In addition, DO test for untreated swale and pond are 3.94 mg/l and 3.5 mg/l. However, the value of treated sample with four types of filter media increased to 5.36 and 5.1 for DMIX for the samples from swale and pond. The test for TSS parameters untreated sample showed that the sample of swale is low which is 4 mg/l compared to pond is 6 mg/l. Each sample untreated has reduction in each type of filter media. Furthermore, the highest reduction value for the suggested filter media that show the swale treated is 1 mg/l and pond 2mg/l compared to untreated are 4 mg/l for swale, followed by pond 6 mg/l**.**

3.2. The effectiveness of filter media

Each percentages of parameter are based on types of filter media with two sources either before and after treatment were determined. The percentage of removal pollutant in swale and pond that were treated with 4 different types of filter media for each parameter were also specified. The highest percentages of removal recorded that suggestion filter media efficient to treat the storm water runoff. Figure 2 shows the percentage removal of COD by swale and pond that are treated with suggested filter media.

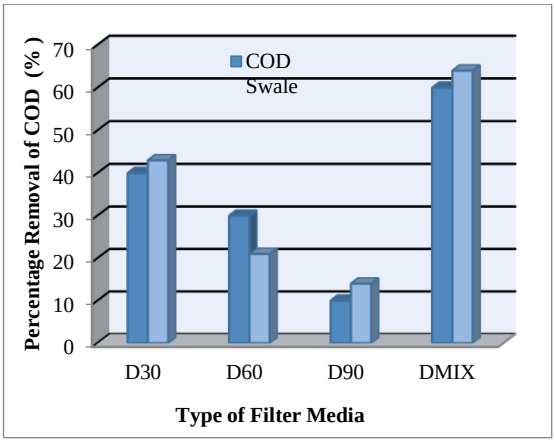

Fig. 2: Bar chart of the percentage removal of COD against types of filter media.

The results show that the percentage removal of COD, for the suggested filter media is 64% for pond and 60% for swale compared with D90 are 14% for pond and 10% for swale. Moreover, the second highest record is sand filter media D30 where these two different samples from swale and pond showed that are the value 40% and 43% respectively while results of D60 type of filter media for swale and pond are 30% and 21%. Result by the filter DMIX showed the higher readings than the percentage of removal COD of other types of filter media. However, High levels of COD can have eco-toxic effects on aquatic organisms and consists of potentially harmful substances such as heavy metal, and organic matter. Hence, the reduction removal of COD due to that the organic wastes that was oxidized.
Figure 3 shows the percentages of removal BOD5 for treated swale and pond with four types of filter media. The lowest percentage is D90 which swale and pond with 4.3 % and 20 % compared others filter media. While for D60 swale and pond is 29% and 34%, followed by D30 for swale and pond is 46% and 47%. The percentage of reduction using DMIX filter media is 57% and 53% respectively. Table 4.5 Show the comparison of result of the test. It can be seen that the highest percentage of removal for BOD_5 is to use DMIX filter media. The maximum percentages reduction of BOD_5 due to lowering the temperature, which minimize the bacterial population by produce the temperature that not encourage with low uptake of oxygen due to their retention in the sand bed.

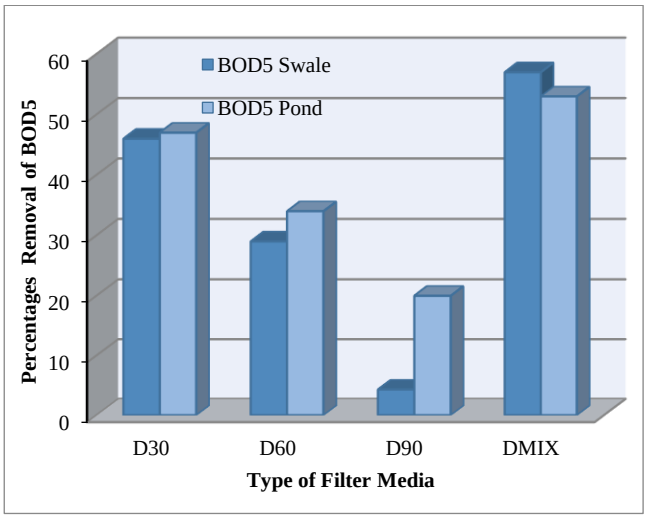

Fig. 3: Bar chart of the percentage removal of BOD_5 against types of filter media.

Figure 4 demonstrate the percentage of removal for three types of sample which are swale, pond inlet and pond outlet treated by different types of filter media. Percentage removal of total suspended solid parameter shows that the highest percentages of sample from swale, pond inlet and pond outlet are using DMIX filter media, which recorded 75%, 67% and 80% respectively. Percentages removal of D30 filter media for three samples are high, with 50%, 33% and 40% of reduction compared to D90 filter media. The result for D60 filter media from swale, pond inlet and pond outlet are 25%, 17%, and 20% which show the same readings with D90 filter media. It can be conclude that DMIX filter media are the most efficient in terms of percentage removal of total suspended solid. It is because of the mixed of different size particle of sand, that encourage the suspended solid to clog within void space of each layer. D90 filter media recorded the lowest percentage removal of total suspended solid due to the size of sand particle that is bigger than the other types of filter media.

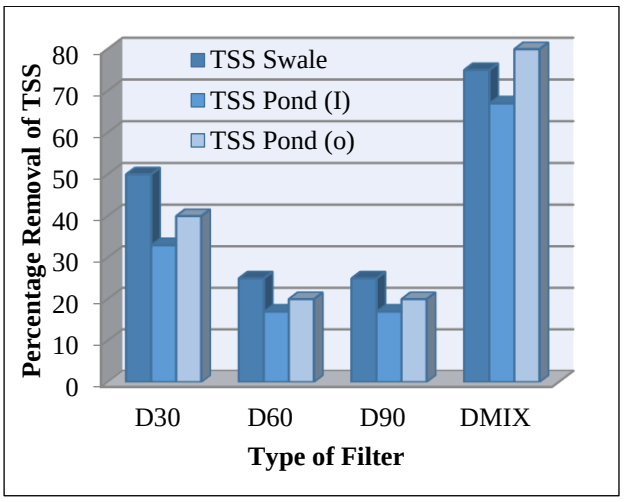

Fig. 4: Bar chart of the percentage removal of TSS against different types of filter media

The result of DO analysis for samples from swale and pond are presented in figure 4.4. The result shared that the DO value has increased after the treatment using DMIX filter media. These conditions also comply with other filter media. Additionally, the value of DO after treatment using DMIX filter media showed the highest and significant value with 5.35 mg/l and 5.1 mg/l. Figure 5 Show the comparison of result of the test. Consequently, the value after the treatment increase due to water falls over each layer of sand with minimization of organic matter and population of bacteria that retained in the each layer of sand. As we know, water with high temperature have low level of DO for example, water in the river with sand bed is better quality compared to water in the river with soil bed

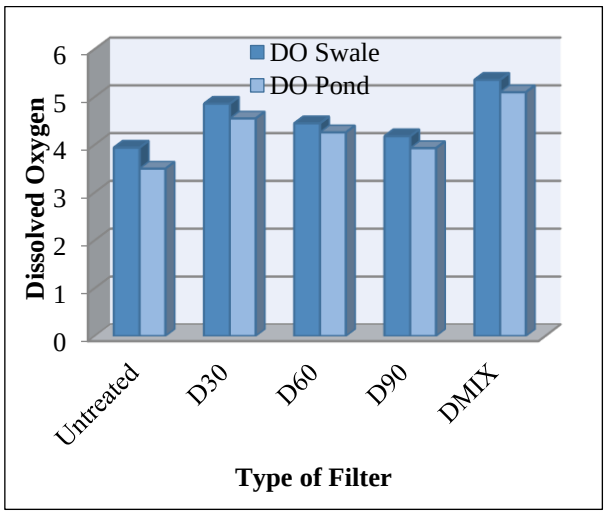

Fig. 5: Bar chart of the DO combination two types of untreated and treated sample used four different types of filter media

4. Conclusion

Based on the result it can be conclude that each filter media give positive result which is has different percentages removal. The effectiveness of both materials can be seen which the smaller size sand particle the smaller of void space that made the organic matter retained while the coconut coir is sustainable product which it is a waste product that can be used as filter media. The most effective is filter media Dmix that give the highest percentages removal compared to the other filter media.

References

[1] David B & John WD (2011), Urban Drainage 2nd Ed, pp 110.
[2] Converse MM, Converse JC & Jerry Tyler E (1999), Sand Filter Evaluation in a Northern Climate. GA. pp. 201-210.
[3] Seelsaen N, McLaughlan R, Moore S, Stuetz RM (2007), Influence of compost characteristics on heavy metal sorption from synthetic stormwater. *Water Sci. Technol*. 55, 219-226.
[4] Quek SY, Al-Duri B, Wase AJ & Forster CF (1998), Coir as a biosorbent of copper and lead. *Process Saf. Environ.* 76, 50-54.
[5] Abida H & Sabourin JF (2006), Grass swale-perforated pipe systems for stormwater management. *Journal of Irrigation and Drainage Engineering* 132(1), 55-63.
[6] Mazer G, Booth D & Ewing K (2001), Limitations to vegetation establishment and growth in biofiltration swales. *Ecological Engineering* 17(4), 429-443.
[7] Herrera Environmental Consultants. (1995). Memorandum to the City of Bellevue (Washington). Lake Sammammish phase II restoration project, Lake Park stormwater treatment facility, task 2: bench scale test results.
[8] Anderson, Damann L, Robert LS & Richard JO (1985), Technology assessment of intermittent sand filters. Municipal Environmental Research Laboratory, Office of Research and Development, USEPA, Washington, D.C.
[9] Boller M, Schwager A, Eugster J & Mottier V (1994), Dynamic Behavior of Intermittent Sand Filters. *Water Science and Technology* 28(10), 99-107.
[10] Hasany SM & Ahmad R (2006), The potential of cost-effective coconut husk for the removal of toxic metal ions for environmental protection. *Journal of environmental management* 81(3), pp.286-295.