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A Study on the Efficiency of Sediment Basin

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Abstract: A healthy ecosystem, which include soil, water, and plant life is critical for human survival and wellbeing. However, the earth eco-system has been disrupted in the past as a result of excessive exploration of nature in order to meet demand caused by urbanization. As a result of the development, soil on land surfaces was exposed to rain directly causes sedimentation. The determination to minimize sediment is important as we can stop it. The main focus of this study is to control water quality pollution at construction site. This study was introducing three design of sediment basin that could minimize sedimentation problem. Parameter such as Total suspended solids was focused in this study. Sediment basin is developed by using baffle and vegetation. The sediment basin was prepared with polystyrene box, pvc pipe, cow grass, aggregates and geotextile fabric. The concentration site water has 598.0 mg/L of TSS value however the result decrease after the water flow through sediment basin. The site water past through sediment basin without baffle have reduce to 75.3mg/L. Site water flow through sediment basin with vegetation baffle have reduce 36mg/L and 33.3mg/L in geotextile baffle. We can conclude that the water sample collected from sediment basin have turn from class IV to Class II.

Keywords: Soil Erosion, Sedimentation, Sediment Basin

1. Introduction

Water quality is defined as a measure water use for different purpose such as drinking recreational agricultural industrial, agricultural and habitat using [1]. The process of soil detachment from the soil surface and transport by rainfall and runoff is known as erosion. Based on study by Nainar [2] forest area gradually decreasing in Malaysia mainly due to the conservation action such as urban development activities. Contribution of rainforest to the preservation of water quality and reduced erosion. According to Robert [3] sediment is coming from the erosion of soil and give huge impact in water quality and environment. He also mentions that, having sediment basin will ensure sediment is moved by natural forces and it will not leave our site and pollute streams. In this study, a physical sediment trap was built to test the efficiency of the sediment trap with several settings to test the best approaches basin that could reduce sedimentation problem.

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The construction site has to manage the sedimentation problem by implementing this basin. Sediment basin will ensure sediment is moved by natural forces and it will not leave our site to pollute the streams. Total suspended solids are main pollutant that generated from construction activity so this study focused on parameter total suspended solids (TSS), dissolved oxygen (DO) and pH. To justify which design approach could be the best design to reduce sediment concentration, the Interim National Water Quality Standards (INWQS) referred to determine water quality status.

2. Literature review

Based on study by Pimentel [5] erosion occurs when soil is exposed to wind energy or rain drops. The greater intensity and duration of a rainstorm increases the risk for erosion. The impact of rainfall on the soil surface can disperse aggregate material and break down soil aggregates [6]. Construction activity such as land clearing causes soil erosion and wind erosion occur. According to Jim Ritter [7] vegetation is the most effective way to cover soil and intercept all falling raindrops on the surface effective in reducing soil erosion. Sediment deposition in rivers increases water turbidity and causes degradation of environment. Wind erosion causes erosion by moving the dirt around and but it can also cause air pollution.

Best management practices (BMPs) describe ways to manage your land activities to mitigate pollution. Best management practices (BMPs) categorized into erosion control, runoff control management and sediment control. Based on study by Juan Rodriguez [8] seeding, diversion channel and silt fencing are ways to manage your sedimentation. In truth, much of the silt fence used is shoddy and frequently poorly maintained. Detention basin is introduced to control storm water runoff temporarily and to remove total suspended solids (TSS). Vegetation on the basin can maintain and possibly improve infiltration, prevent erosion and remove soluble particles from site water. Implementing sediment basin improving water quality and lower contaminant loadings. According to Huang [9] the Department of Environment (DOE) uses Water Quality Index (WQI) and National Water Quality Standards for Malaysia (NWQS) to determine the situation of the water quality

3. Materials and Methods

Water quality analyses were conduct in the laboratory according to the methodology. In order to strategize the works to achieve the main objective of this study.

3.1 Sediment basin

In this study three (3) types of sediment basin arrangement with various settings were tested to investigate the best sediment basin design to reduce the sedimentation problem.:

- Sediment basin without baffle (1)
- Sediment basin with vegetation baffle (2)
- Sediment basin with vegetation, aggregates and geotextile fabric baffle (3)

3.1.1 Basin test

Concentration water was collected from construction site runoff after heavy rainfall. Water quality based on parameter such as (TSS), (DO) and pH was conducted in the laboratory to analyses the concentration of water. To develop this study, the water sample was emitted in sediment basin without baffle. After one week the particle in the water was settle down at the bottom of the basin. The basin has played its role to minimize suspended solids in water. Then the water is collected from riser valve to conduct laboratory test. The same idea was developed in sediment basin with vegetation, aggregates and geotextile fabric baffle to archive the objective of this study.

3.2 Methods to construct physical basin

A polystyrene box is prepared with the dimension of 60cm length, 30cm height and 44cm width. After that a pipe with closure valve fixed at the level of 17cm depth from bottom of the basin to allow the water flow through the basin. Overflow pipe the runoff must also construct in this basin at the height above the normal exit which is 25cm and connect at the outlet of this basin. The length of the overflow pipe is 30cm. The pipe use in this basin was polyvinyl chloride (PVC) pipe with 20mm diameter. The basin the pipe is lengthen 4cm to allow riser pipe and overflow connected at basin exits. Another polystyrene board was added at the top of the basin with slope height 45cm and 30cm width to allow the site water runoff. The total length of this sediment basin area was 152.4 cm length and 60.70 cm width. In vegetation basin cow grass was used in this study to trap the sediment particles, the dimension was 60 cm length and 30 cm width. An aggregate with size of 20 mm were added on the geotextiles mat at the outlet of the sediment basin to test the efficiency basin.

3.3 Equations

Total suspended equation is used to develop result from the particle retain on filter.

$$Total\ suspended\ solid = \frac{(\mathrm{A} - \mathrm{B})\mathrm{x}10^{6}}{Volume\ of\ sample(ml)} \qquad Eq.1$$

4. Results and Discussion

4.1 Results

The findings of the investigation carried out were discussed on the basis of data collected from (TSS), (DO) and pH. The data obtained to assess the class in the water according to water quality index and to prove that the method of constructed sediment basin is the best way to trap the sediment from water. From the result it shows the sediment basin is very efficiency to solve sedimentation problem. Thus, basin with vegetation, aggregates and geotextile fabric baffle was very effective basin in these study Table 4.1 shows the result the concentration of TSS, DO and pH were measured for these three-sediment basins.

Table 4.1: Average results from sediment basin

Parameter	Site water	Basin (1)	Basin (2)	Basin (3)	Standard deviation σ
TSS	598 (mg/L)	75.3 (mg/L)	36.0 (mg/L)	33.3 (mg/L)	23.50
DO	6.6 (mg/L)	6.8 (mg/L)	7.4 (mg/L)	8.0 (mg/L)	0.6
pH	6.2	6.2	7.4	7.4	0.42

4.2 Total suspended solids (TSS)

The TSS are the most parameters that need to be reduce by introducing the sediment basin which also the main culprit in polluting the water quality at the construction site. The concentration of TSS were measured for these three-sediment basins. Figure 4.1 shows the chart of TSS concentration results for each sediment basin.

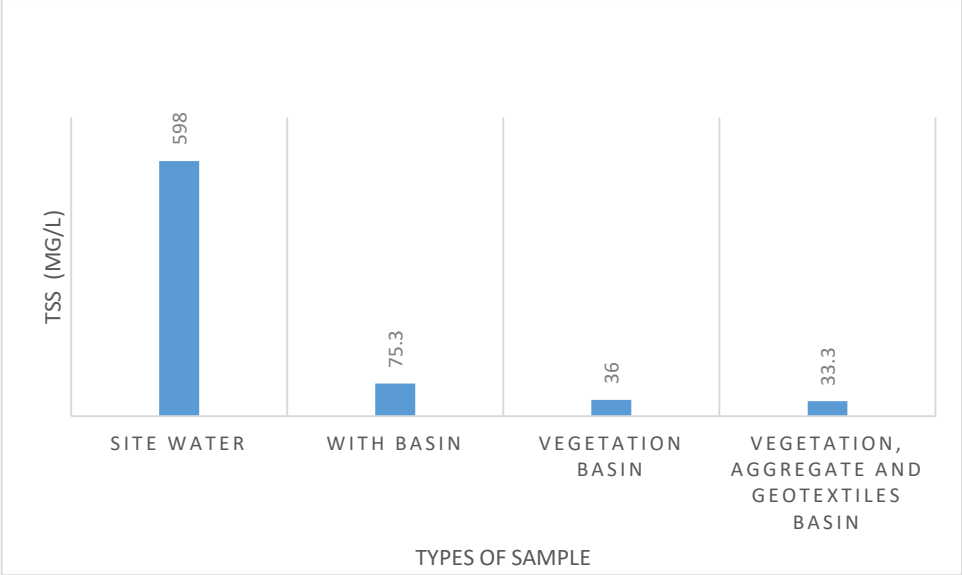

Figure 4.1: Total Suspended Solid result

The result obtained from this study total suspended solids (TSS) is more than the range of Class V requirement which is 300mg/L. Water sample was collected after the silty water flow through the sediment basin. The result shows that constructed sediment basin is very efficiency to trap sediment from the water. This basin has help to settle down the sediment from 598.0 mg/L to 75.3 mg/L in this single basin. This amount gives huge impact in result, 80 % of reduction in suspended solids have trap in this sediment basin. Based on the study by Jane Peirce [10] has indicated that the sediment basin reduces the amount of TSS concentration by 60 to 80%. The water is stored in these basins until the particles settle to the bottom. She also mentions that, sediment basin reduces flooding and pollution throughout the system. Vegetation baffle also used in this sediment basin study. In this basin, we found that this vegetation is very important because it has reduced the suspended solid from the previous sediment basin which is 75.3 mg/L to 36 mg/L. The vegetation baffle has trapped the particles in the grass and sediment basin which has result about 39 mg/L differences compare to previous basin without baffle. Based on the study by Barcelona et al., [11] has indicated that the sediment basin with vegetation has significantly reduce the amount of TSS concentration. They also mention that, the extensive of vegetation could disturb the water flow into the sediment basin because sediment particles are trapped by plant leaves. Thus, the maintenance needs to put a priority if sediment basin was designing the integration of vegetation. From sediment basin which has vegetation, aggregates and geotextiles baffle the last water sample was collected. In this basin, the result found doesn't give huge impact only 2.7mg/L difference from previous basin which is 36.0mg/L to 33.3mg/L. The water comes through riser pipe have passed through aggregates and geotextile baffle after past through the vegetation basin. However, according to Liu et al., [12] has indicated that the geotextiles baffle creates containment systems to remove suspended soil particles by intercepting site water runoff to sediment basin. Based on the study by Mekonnen [13] has indicated that the gabion fence trapped high amount of sediment. Aggregates should make into gabion fence because high flow event from sediment basin can move it. Thus, the gabion wall needs to put a priority if sediment basin was designing the integration of aggregates.

4.3 Dissolved oxygen (DO)

The DO also the parameter that need to be increase by introducing the sediment basin which also creates an imbalance in water natural DO of 6-8mg/L. The value of DO was measured for these three-sediment basins. DO is developed by using these values to differentiate the result. Figure 4.2 shows chart for DO result for each sediment basin.

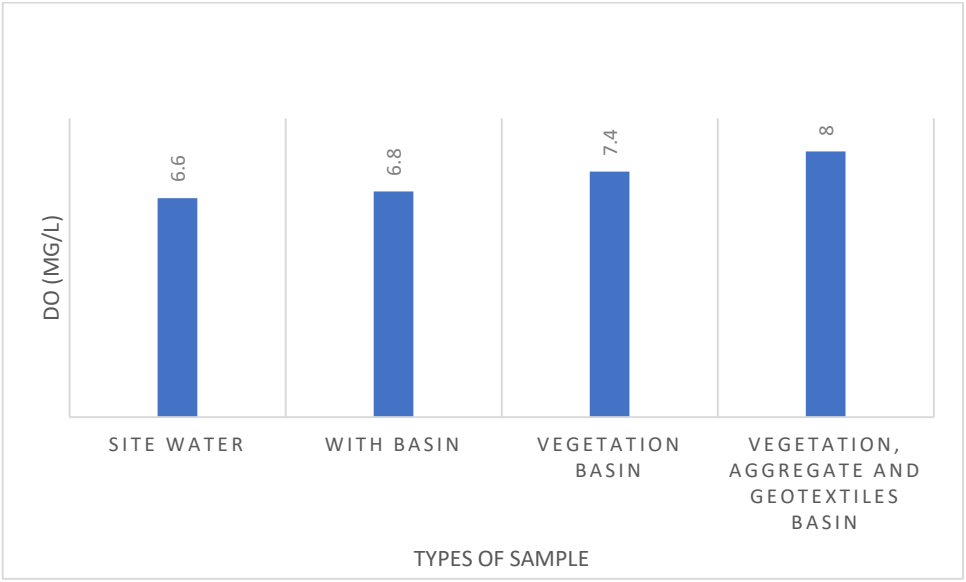

Figure 4.2: Dissolved oxygen result

In this sediment basin study, the average amount of oxygen level in site water is 6.6mg/L. Besides that, sample water in basin 1 also have average amount of oxygen which is 6.8 mg/L. The amount of oxygen slightly increases, however the water from site and sediment basin is acceptable since the DO level in water is 6.6 to 8 mg/L [13]. The water also was collected after the water flow through vegetation sediment basin. The result shows that the level of water dissolved oxygen (DO) increase compare to previous basin and the amount that rise is from 6.8 mg/L to 7.4 mg/L. Based on the study by Mohammed [14] DO can enters the water through the plant or air. They also mention that, sediment runoff causes oxygen depletion in water. Since vegetation, is useful in sediment basin it helps to increase the DO level in water inside sediment basin. The water flow through vegetation sediment basin, aggregates and geotextiles baffle shows that the level of water (DO) increase compare to previous vegetation basin and the amount that rise is from 7.4 mg/L to 8.0 mg/L. Thus, the maintenance needs to put a priority if sediment basin was designing the integration of vegetation to increase DO level.

4.4 pH

The pH is another parameter that need to be neutral by introducing the sediment basin which also creates an imbalance in water natural pH of 7. The value of pH was measured for these three-sediment basins. pH is developed by using these values to differentiate the result. Figure 4.3 shows the result of pH range for each sediment basin.

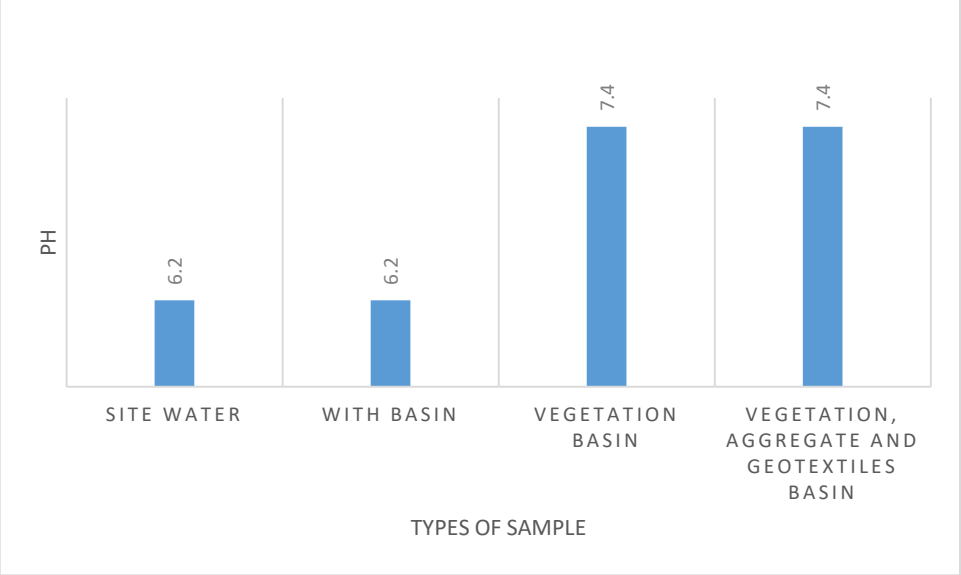

Figure 4.3: pH result

Based on the study by Dave Jones [15] carbon dioxide is soluble in water and reacts with it to generate carbonic acid. Because the acid dissociates into carbonate ions and hydrogen ions, eventually forming H_30+ ions, an increase in CO_2 will result in decrease in pH as the solution becomes more acidic. They also mention that, the increase of the dissolved oxygen in water tackle the pH value. Site water and water sample from sediment basin remain the same pH value of 6.2 while water sample collected from vegetation basin and vegetation aggregates and geotextiles baffle has increase to 7.4. Thus, the adding vegetation in sediment basin helps to change the pH level from acidic to neutral.

5. Conclusion

From the result it shows the sediment basin is very efficiency to solve sedimentation problem. Based on this study sediment basin and baffle has traps the suspended solids from the concentration water sample. Based on the result, the concentration of site water reduced from 598 mg/L to 75.3 mg/l on sediment basin without baffle, 36.0 mg/L on sediment basin with vegetation baffle and 33.3mg/L on sediment basin with vegetation, aggregates and geotextile fabric. Hence, this design could be implemented at construction site as sediment basin because it can reduce sedimentation problem and may change to landscape pond which helps to control flood.

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References

[1] Giri, S., & Qiu, Z. (2016). Understanding the relationship of land uses and water quality in twenty first century: a review. Journal of environmental management, 173, 41-48.

[2] Nainar, A., Bidin, K., Walsh, R. P., Ewers, R. M., & Reynolds, G. (2017). Effects of different land-use on suspended sediment dynamics in Sabah (Malaysian Borneo)–a view at the event and annual timescales. Hydrological Research Letters, 11(1), 79-84.

[3] Robert M. Engler. (2019). Sedimentation. Pollution issues.

[4] Liu, Y. (2016). Landscape connectivity in Soil Erosion Research: concepts, implication, quantification. Geographical Research, 1, 195-202.

[5] Pimentel, D., & Burgess, M. (2013). Soil erosion threatens food production. Agriculture, 3(3), 443-463.

[6] Lal,R. (2017). Soil erosion by wind and water: problems and prospects. In Soil Erosion Research Methods (Pp. 1–10). Routledge.

[7] A. Jim Ritter. (2012). Ministry of Agriculture, Food and Rural Affairs. Soil Erosion – Causes and Effects.

[8] Rodriguez, Juan. (2019). Erosion control methods for construction projects. The Balance Small Business.

[9] Huang, Y. F., Ang, S. Y., Lee, K. M., & Lee, T. S. (2015). Quality of water resources in Malaysia.

[10] Jane Peirce. (2020). Extended detention basin. megamanualgeosyntec.

[11] Barcelona, A., Oldham, C., Colomer, J., Garcia-Orellana, J., & Serra, T. (2021). Particle capture by seagrass canopies under an oscillatory flow. Coastal Engineering, 169, 103972

[12] Liu, L., Perez, M. A., Whitman, J. B., Donald, W. N., & Zech, W. C. (2021). SILTspread: Performance-Based Approach for the Design and Installation of Silt Fence Sediment Barriers. Journal of Irrigation and Drainage Engineering, 147(10), 04021041.)

[13] Bozorg-Haddad, O., Delpasand, M., & Loáiciga, H. A. (2021). Water quality, hygiene, and health. Economical, Political, and Social Issues in Water Resources.

[14] Mohammed, N. Y., & Abdulrazzaq, K. A. (2021). Evaluation of Drinking Water Quality in Al Wahda Treatment Plant in Baghdad City-Iraq. Journal of Engineering, 27(9), 38-50.

[15] Dave Jones. (2021). Does increased atmospheric carbon dioxide change the ph of water ocean acidification in the polar regions. PolarTREC,