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NON-WOVEN GEOTEXTILE TO IMPROVE CHEMICAL PROPERTIES OF WATER QUALITY

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Abstract: Aquatic life will be greatly impacted by clean and high-quality of river water. In Kuala Lumpur the Penchala River is a tributary that flows into the main river which is the Klang River. The problem affecting the upstream area of the Penchala River was the high level of total suspended solids, resulting in greater turbidity in the Taman Persekutuan Bukit Kiara Kuala Lumpur (TPBKKL) Pond, simultaneously affected the chemical properties. The cause is the erosion of river banks following severe rains. When there are significant rains, the river's flow intensifies, causing erosion of the riverbank. Additionally, the TPBKKL Pond's turbidity stems from surface runoff from neighboring forests, where surface runoff enters the river unfiltered. Chemical parameters such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are two of the primary measures used in water quality indicator. This study employs non-woven geotextile (NWG) as a filter media in order to reduce the concentration of BOD and COD. Other parameters such as total suspended solid (TSS), turbidity (NTU), dissolved oxygen (DO), pH and ammoniacal nitrogen (NH3-N) were also taken into account to determine the quality of Penchala River. Performance of NWG was assessed based on water quality. NWG properties used are 100% polypropylene materials, with properties design of 190µm (0.19mm) AOS, 2.2mm thickness and permittivity 2S-1. Results showed that the NWG has proven to improve COD by 17% and BOD by 8.68% of average improvement. Therefore, also improved the river classification from Class II to Class I. Other parameters that showed improvement was TSS, with average percentage improvement of 69.7% and Turbidity improvement by 68.5%. Meanwhile data such as pH and NH3-N remained unchanged throughout the study period. Overall, the WQI for Penchala River during prior time of study was in range 83.78 – 86.70 (Class II).

Keywords: Non-Woven Geotextile, BOD, COD, TSS, Turbidity, Water Quality

1. Introduction

BOD is one of the most common measures of pollutant organic material in water. BOD indicates the amount of organic matter present in water. Therefore, a low BOD is an indicator of good quality water, while a high BOD indicates polluted water [12]. BOD, or biological oxygen needs to break waste material in water by microorganisms and COD stands for Chemical Oxygen Demand, or chemical oxygen requirements for oxidation reactions to materials discharge in water [13]. They may also lower the DO of lakes and rivers. Water with high levels of COD and BOD can be produced by industrial processes and municipal wastewater discharge; Therefore, waterways must be carefully treated before being released. The best method to manage BOD and COD is to identify its sources. This includes reducing stormwater run-off, restoring eroding stream and lake shorelines, and applying industry-specific best management practices (BMPs) [1]. One of the new approaches is the application of NWG filtration media. Geotextiles are materials that improve the workability of hard soil and enable construction in regions that would not be feasible without them. Many infrastructure projects, such as highways, ports, landfills, drainage systems, and other civil projects use of geotextiles [2]. Further, in geotechnical and structural applications, involving earthworks, drainage and filtration systems, hydraulic works, roadways, and railroads, among many other applications. This study aims to enhancing water quality using NWG as filtration media to reduced chemical parameters of BOD and COD. No river yet in Malaysia has been provided with non-woven geotextiles as filter media facilities for reducing BOD and COD in river. Therefore, this study will be helpful to engineers and academics who are interested to find out more about the applications of non-woven geotextile materials in water quality. With regard to their good hydraulic conductivity, geotextiles have been used as drainage channels. Water in the geotextiles' soil structure can be stored and gradually released along the geotextiles [3]. Geotextiles are often used alongside

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with systems that have either vertical or horizontal water flow in filtering applications.

By employing drainage geotextiles, fluids are able to drain with minimum of pressure loss [4]. Geotextile additionally prevent fine particles from passing between soil layers in a drainage system. NWG has been proven in many studies to enhance water quality [5][6]. Improving the level of water quality depends on several factors. The apparent opening size (AOS), thickness, permittivity/permeability, and the NWG capability to withstand external resistance like weather or chemicals are only some of the considerations [7]. Shown in that study the effectiveness of NWG are at reducing nutrients and suspended particles to enhance lake water quality. Malaysia's Department of Irrigation and Drainage (DID) introduced One State One River (1S1R) in year 2005. The program's objectives are to enhance river water quality and assist state DID in planning river conservation initiatives. Penchala River had been chosen by the DID State of Selangor for the aforementioned programme due to contributed to the pollution problems in the river. Furthermore, Penchala River is one of Klang River's tributaries, and in 2005, Penchala River was the most polluted river, according to [8]. Among the reasons of pollution in the Penchala River consist of the discharge of domestic trash from neighboring houses, thick silt at the river's bottom, and restaurants that drain food waste without first filtering. As a result, the WQI at that moment dropped into Class IV, which the range between of 31 to 51.9. Water quality fell into Class III in 2018 and remained there through 2019 [9]. For that reason, this study was carried.

2. **Material & Method**

2.1 Material

Many civil engineering projects applied geosynthetics, specialized nonwovens. Nonwoven fabrics are permeable and typically utilized for filtration and drainage applications, such as slope and highway construction, because of the wide range of properties that they may be made to take on that other materials just cannot match. Due to their ability to meet the requirements of these circumstances, nonwovens are in great demand in water conservation, highway, railway, maritime, and airport projects due to the rapid improvements in infrastructure. Nonwoven materials offer dynamic and valuable substitute for conventional materials. These geotextiles have great filtration qualities and aid in keeping debris and dirt out of drains, prolonging their useful life and improving performance. Non-woven polypropylene geotextile has exceptional physical and hydraulic qualities, as well as strong tensile strength.

Nonwoven filters provide several advantages over woven filters, including higher permeability, less blinding tendency, no yarn slippage compared to woven media, no thickness limitations, high production rates, and continuous process lines. Compared to woven or knit materials, the pore diameters are substantially smaller. Because of the overlaying of yarns, the size of the pore, or opening between the yarns, is quite enormous, as evidenced by holding up a piece of these filter fabrics to the light. Woven and knit fabrics are two-dimensional filter bag media with yarns overlapping.

NWG's were used as filter media for this study due to their efficient filtration properties. Additionally, it is frequently used as separator or filter in civil engineering projects, such as drainage systems, rehabilitation and stability of slopes, building of highways, and landfill covers. NWG used in this study was developed and manufactured in Malaysia. UV-stabilized, 100% polypropylene is the material used in NWG. The NWG apparent opening diameter and thickness are 0.09 and 2.2 mm, respectively. 20 filters (8.4 m^2) total cut in the shape of a rectangle measuring 700 mm by 600 mm were used in this study. This filter is set up in three rows, across perpendicular the river's flow, in order to ensure its efficacy. These filter sheets are suspended across the river on iron rods with a diameter of 50mm. A weight is positioned at the bottom of each filter sheet to provide stability and support, preventing the filter sheet from ripples caused by changes in velocity. The spacing between the centers of each of these filter sheets is 750mm. Figure 1-(a) and (b) shows the NWG filters and their placement on-site.

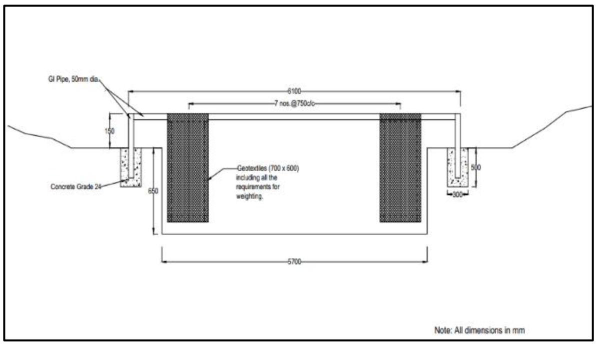

Fig.1- (a) NWG dimensions and setting.

(Width of river = 5.7m, Depth of river = 0.65m and 7 nos {0.7m x 0.6m @ 750c/c})

(b) NWG were arranged in 3 rows across the river at TPBKKL intake pond.

2.2 Method

This study focuses on the Penchala River upstream from the TPBKKL intake pond. The goal is to estimate the concentration of chemical parameters such as BOD and COD that influence the water quality of the Penchala River. This study used both, on-site and laboratory test using the Lamotte and Partech 7450 Model sensors, respectively, and following the methods from [11], the parameters for BOD and COD were calculated for the baseline data. Before applying the NWG filter media, a baseline value starting from November 2019 for both values was recorded first. Baseline data or benchmarks are critical for determining the effectiveness of a system by comparing events before and after its adoption. Aside from BOD and COD, five (5) standard parameters for water quality were also recorded, including Turbidity, TSS, pH, DO, and NH_3-N. Except for dissolved oxygen (DO), which was done on-site, all of the experiments were carried out at the Department of Chemistry Malaysia.

For a year, river water is sampled once a month during clear weather and at normal flows. The collected data was evaluated and compared to Malaysia's National Water Quality Standards (NWQS). The baseline data was compared to thirteen (13) data samples obtained between December 2019 and December 2020 for this study's analyses. The river was classified using a National Water Quality Standard (NWQS) guideline and DOE's Water Quality Index (WQI) to determine the efficacy of the filters. Tables 1 and 2 represent the Water WQI and the Water Quality Classification Based on WQI, DOE standard, respectively. DOE also established water classifications and methods for categorizing water conditions based on WQI results.

Table 1 - Water Quality Index (DOE, 2019)

Parameters	Unit	Classes				
		I	II	III	IV	V
NH_3-N	mg/l	< 0.1	0.1 - 0.3	0.3 - 0.9	0.9 - 2.7	> 2.7
BOD5	mg/l	< 1	1 - 3	3 - 6	6 - 12	> 12
COD	mg/l	< 10	10 - 25	25 - 50	50 - 100	> 100
DO	mg/l	> 7	5 - 7	3 - 5	1 - 3	< 1
pH		> 7	6 - 7	5 - 6	< 5	> 5
TSS	mg/l	< 25	25 - 50	50 - 150	150 - 300	> 300
***Turbidity**	NTU	5	50	-	-	-
WQI	mg/l	> 92.7	76.5 - 92.7	51.9 - 76.5	31.0 - 51.9	< 31.0

*Note/Source: National Water Quality Standard, (DOE, 2019)

Table 2 - Water Quality Classification Based on Water Quality Index (DOE,2019)

Parameters	Index Range		
	Clean	Slightly Polluted	Polluted
SIBOD	91 - 100	80 - 90	0 - 79
SIAN	92 - 100	71 - 91	0 - 70
SISS	76 - 100	70 - 75	0 - 69
WQI	81 - 100	60 - 80	0 - 59

3. Result and Discussion

3.1 Physical & Chemical Characteristics

In this study, all parameters if the results after implementation exceeded the baseline data it will be considered as a negative (failed) or vice versa. The baseline for TSS and turbidity is 150 mg/l and 154 NTU respectively. The TSS and turbidity, meanwhile baseline for BOD and COD are 0.68mg/l and 29mg/l. When referring to this baseline data was in Class III for TSS and SIss 53.60 was in Polluted category. Turbidity, on the other hand, the baseline results showed that it was not either in Class I or Class II but in highly turbid. This is because, in the NWQS, the value that can be measured are starting from 0 -5 (Class I) and 6 - 50 (Class IIA or IIB). For BOD and COD the value was in Class I and Class III with SIBOD 97.72 and SICOD 64.17. With the baseline data obtained, it showed that it has strengthened the evidence that the condition of Penchala River is contaminated with high physical and chemical parameters.

3.2 Total Suspended Solids (TSS)

From December 2019 onward, all TSS levels fluctuated between 42 and 48 mg/l. As of January 2020, the TSS value was 45 mg/L, a small decrease from the initial finding of 46 mg/L. Following that, the TSS value increased to 48 mg/L in February 2020; however, in March and April 2020, the data dropped to 43 mg/L and stayed stable. A month later, in May 2020, the TSS value dropped to 42 mg/L, the lowest recorded value throughout the study's lifetime. In August 2020, the data was increased greatly to 48 mg/L. The results revealed a little reduction to 43 mg/L in September 2020, an increase to 47 mg/L in October 2020, and persistence until November 2020. Finally, at the end of the prior of study in December 2020, the result was 45 mg/L. Figure 2 shows the result.

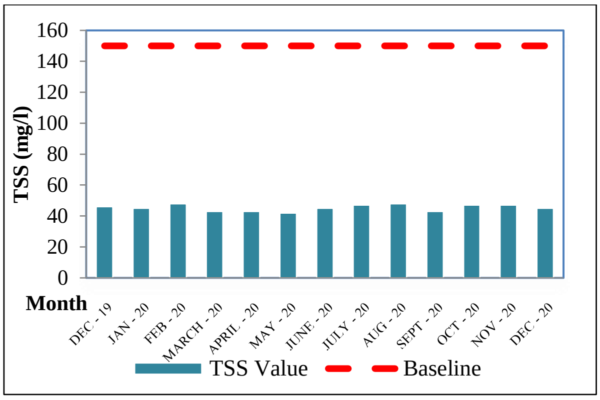

Fig. 2 - Monthly Results of TSS

3.3 Turbidity

Turbidity is a measurement of how much light is absorbed or scattered by suspended material. Figure 3 shows the turbidity levels at the TSS sample location. November 2019 saw the establishment of the baseline level, which had a turbidity level of 154 NTU. To monitor the turbidity levels, water samples were obtained once every month. Data on turbidity levels from December 2019 varied throughout the range of 45 to 50 NTU. In February, July, and August of 2020, the maximum turbidity value was measured at 50 NTU, while in September of the same year; the lowest turbidity value was measured at 45 NTU. From December 2019 to January 2020, there was no change in turbidity for 48 NTU.

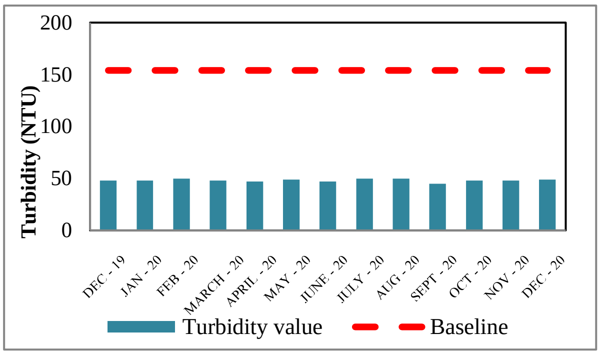

Fig. 3 - Monthly Results of Turbidity

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3.4 Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), NH_3N, DO and pH.

The line Figure 4 shows the Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) levels of upstream of Sungai Penchala just before inlet of Kolam Taman Persekutuan Bukit Kiara, Kuala Lumpur from November 2019 to December 2020. The baseline levels for COD and BOD were established in November 2019. From the next month onwards, December 2019 till December 2020, water samples were collected on a monthly basis to monitor the COD and BOD levels. BOD is a measure of the capacity of water to consume oxygen during the composition of organic matter and the oxidation of inorganic chemicals like ammonia and nitrite in a unit volume of water, whereas COD is a measure of the capacity of water to consume oxygen during the composition of organic matter and the oxidation of inorganic chemicals much like ammonia and nitrite in a unit volume of water. As a result, COD concentration is always higher than BOD concentration because COD does not distinguish between biological availability.

The baseline level for COD is 29 mg/L which is classified as Class III under the National Water Quality Standard. All the COD levels from December 2019 onwards were lower than the baseline level and ranged between 21 – 25 mg/L. The result shows that a COD level has improved from Class III to Class II of the National Water Quality Standard. Meanwhile the baseline level for BOD measured 0.68 mg/L which is classified as Class I under the National Water Quality Standard. The BOD levels from December 2019 onwards were observed similar to the baseline level and ranged between 0.60 – 0.68 mg/L which are classified as Class 1 of the National Water Quality Standard Class II limit.

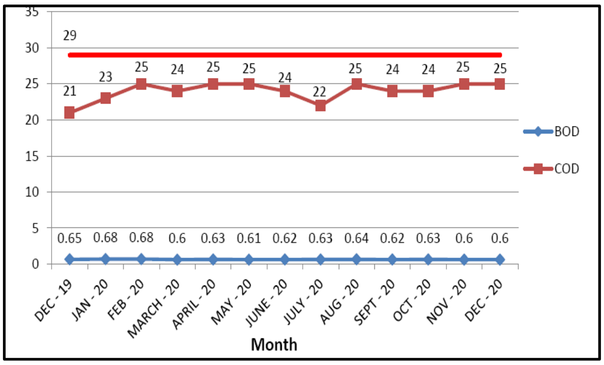

Fig. 4 - Monthly Results of BOD & COD

For the NH_3N, DO and pH values, it was recorded in a range of 0.06-0.07, 5.40-6.58 and 7.02-7.57[15].

3.5 Water Quality Index (WQI)

Figure 5 shows the WQI of the upstream of Sungai Penchala right before the inflow of Kolam Taman Persekutuan Bukit Kiara in Kuala Lumpur from November 2019 to December 2020. In November 2019, the baseline level was determined and according to the National Water Quality Standard, the WQI value of 81.36 placed it in Class II. Starting in December 2019, the WQI levels varied from 83.78 to 86.79 mg/L, which is still Class II of the National Water Quality Standard. This represents a small improvement over the baseline levels. When compared to baseline levels taken in November 2019, the WQI level generally showed improvement.

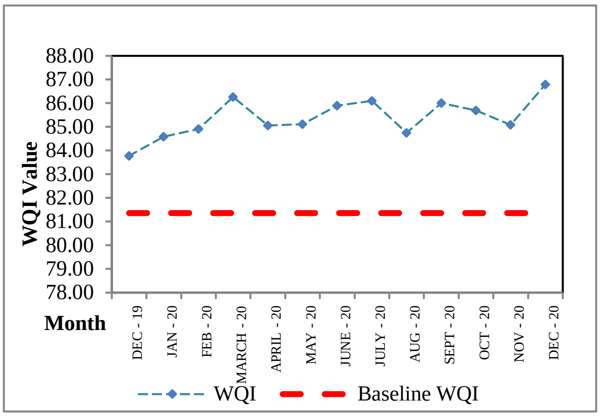

Fig. 5 - Monthly Results of WQI

4. Conclusion

Based on the findings, it shows that the average improvement of COD level is 17% and BOD level were almost remained. But for TSS and Turbidity level reduction were almost 70% after treatment with NWG filter media. It can be concluded that the high level of TSS content in that area had caused high turbidity level in the river. Meanwhile, it can also be seen that the quality of the river is increasing with an average of 4.94% almost reaching Class 1 (Class 1 needs an increase of 12% from the baseline data) based on WQI. If this study is extended for a few more months, the likelihood of achieving Class 1 is high due to fluctuating graph patents considering point source and non-point source. As conclusions, this study has achieved the aims to improved chemical properties such as COD but not for BOD because the improvement of BOD was not significant by using NGW and determination of removal the TSS and Turbidity were also accomplished. Comparison with NWQS is correspondingly performed in order to classify the river quality which showed improvement in the WQI value.

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