Journal of ENVIRONMENTAL Treatment Techniques

J. Environ. Treat. Tech.
ISSN: 2309-1185

Journal weblink: http://www.jett.dormaj.com

Green Highway Development Features to Control Stormwater Runoff Pollution

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Received: 11/010/2015 Accepted: 28/11/2015 Published: 30/12/2015

Extended Abstract

Beside buildings, highways and roads construction interfere with Stormwater runoff (SWR). They have two main impacts. They generate more runoff and pollutants while they contribute to the increase in impervious surfaces in the watershed and intensify activities. Regarding the increase of impervious surfaces, United States Environmental Protection Agency [1] states that roads occupy one third to two third of the land portion of the city (mostly impervious surfaces).

The resulting effects of the hydro modification are increased volume of the runoff, change in sediment loading. From undeveloped area to developed zone with 30 to 50% of road impervious surface, the storm runoff rate increases from an average of 10% to 30% of the rain fall [2]. Kansas Department of Health and Environment exhaustively listed water pollution indicators as ammonia, total suspended solids (TSS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD), chlorophyll, dissolved solids, heavy metals, minerals, nitrates, pesticides, pH, phosphorus, temperature, and turbidity. Barrett et al. [3] state highway pollutants are from three categories: organic, inorganic and microbial pollutants. Inorganic Pollutants (most common heavy metals) and the group of nutrients (herbicides, pesticides)) are toxic in high concentration and tend to amass into the tissue of aquatic flora and fauna [4,5]. Coliform bacteria are ordinary microbial pollutants encountered in storm runoff. They are of meticulous interest due to their easy access into the runoff either through anthropogenic sources or illicit connections to stormwater sewer system. Waterborne diseases originating from non-point sources (NPS) pollution are alleged to be more detrimental than sedimentation issues in developing countries [6]. Additionally, erosion and sedimentation process contribute to Stormwater runoff pollution. Sediment sources from roadways include road sanding, runoff from unpaved roads and areas where soil has been exposed during construction.

Malaysia is a country with an objective of being a fully developed country by 2020. Among the objectives stated in Malaysian's 10th Master Plan (2010-2020) increasing water resources pollution and providing quality water which is expected to grow over 70% of the total population [7]. Controlling water pollution, water resource management is a priority in Malaysia where more than 90% of water supply if from rivers and lakes [8]. As a matter of fact, highway/roads have been identified, and developed countries are moving forward in curbing highway-related water pollution through the establishment of highway assessment framework. The current study aimed to identify criteria and sub-criteria in Green Highway development towards controlling Stormwater runoff pollution in Malaysia.

A questionnaire form was designed for data collection. The scaling range was 1: strongly disagree, to 5: strongly agree, to obtain the agreement level of respondents from 22 companies and 109 consultants in highway engineering. The research has applied the Average Index method (was developed by Abd Majid and McCaffer [9]) which provides means to ascertain respondents validation of a criterion. The Average or the Mean Index of a criterion is evaluated using the following Equation:

$$\text{Average/Mean Index} = \frac{\sum a_i X_i}{\sum X_i}$$

Where, a = constant, weighing factor for i, {i = 1, 2, 3.........n}; Xi = frequency of respondent. According to result analysis presented in Table 1, the most significant sub-criteria are Confirm wastewater treatment with the local authority, and Equip to control and monitor pollutant loads of stormwater and wastewater runoff to comply with regulatory requirements that scored the same average of 3.833. Applying the LID best management practices of sand filters, dry/wet swales, and bio retention, and other structural BMPs to treat 90 percentile of annual rain fall, provide and preserve existing buffer zones, determine and reduce pollutant loads to maintain water resources using Best Management Practices followed the most significant criteria while scoring respectively 3.77, 3.73 and 3.71. The lowest score, 3.58 is taken by the less significant criteria

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namely in contrast, prepare control practices of sediments and erosion to shield soils, and protect the construction and demolition materials throwing to waterways have been scored as the lowest average index amongst other sub-criteria.

Table 1: Average Index Analysis of SWRQ Sub-criteria

No.	Sub-criteria description	N Valid	N Missing	Mean	Std. Deviation	Minimum	Maximum	Score
1	Explore and remove non-stormwater released from non-hygienic sources or other commercial residential, or industrial sectors	140	0	3.69	.662	3	5	3.69
2	Explore non-stormwater released from non-hygienic sources or other commercial residential, or industrial sectors	140	0	3.60	.763	1	5	3.60
3	Confirm wastewater treatment with the local authority	140	0	3.83	.684	3	5	3.83
4	Determine and reduce pollutant loads to maintain water resources using Best Management Practices	140	0	3.71	.640	2	5	3.71
5	Equip to control and monitor pollutant loads of stormwater and wastewater runoff	140	0	3.83	.755	2	5	3.83
6	Applying the LID best management practices of sand filters, dry/wet swales, and bio retention	140	0	3.77	.710	2	5	3.77
7	Prepare control practices of sediments and erosion to shield soils	140	0	3.58	.670	2	5	3.58
8	Protect the construction and demolition materials throwing to waterways	140	0	3.58	.709	2	5	3.58
9	Restore wetlands and reduce cut and fill areas	140	0	3.65	.714	2	5	3.65
10	Provide and preserve buffer zone (Jabatan Perhutanan & Perhilitan, DOE)	140	0	3.73	.674	3	5	3.73

The sub-criteria are grouped into three major criteria which are shown in Fig. 1. Instrumentation and monitoring of highway runoff, storm runoff treatment, and pollution reduction practices represent the three group of criteria under which fall the sub-criteria. Those criteria score respectively an average of 3.77, 3.75, and 3.66. Each of the three criteria has an average index higher than 3.5, which means that they are accepted as green highway criteria. Furthermore, instrumentation and monitoring, and Stormwater runoff treatment criteria are more significant as they score an average index of the same range which is higher than that of the pollution reduction practices criterion. In fact, highway runoff constituents and loadings are still under exploration. Monitoring of the SWRQ is the only way to provide such understanding.

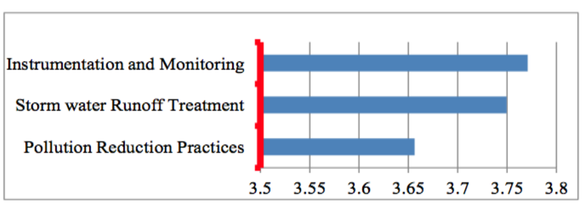

Fig. 1: Average Index Analysis of Stormwater Runoff Quality Control Criteria

Consequently the study provides means to construct highway development toward more sustainable practices. The study identifies green highway SWRQ control criteria and sub-criteria to achieve better control of water pollution;

i. Green highway SWRQ control criteria are Instrumentation and Monitoring of SWRQ, Stormwater Runoff Treatment, and Pollution Reduction Practices. These criteria are composed of sub-criteria among which providing and preserving existing buffer zones are the most significant sub-criteria.

ii. Stormwater runoff pollution control criteria represent 30% in the group of water and environment protection. Three main sub-criteria are identified: pollution reduction practices, storm water treatment, and instrumentation and monitoring of runoff. Each individual criteria scored three points.

As the future study, the specific needs from water resources of various watershed can be explored in order to design appropriate stormwater plan for various zones.

Acknowledgements

The authors would like to thank the PAS grants vote no. Q.J130000.2709.01K40 and Q.J130000.2709.01K41, and GUP grants vote no. Q.J130000.2609.11J04 and Q.J130000.2609.10J8, and MOSTI grant vote no. 4S123. Also, the authors appreciate these organizations for their supports and contributions, TNCPI, and Research Management Center at Universiti Teknologi Malaysia.

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