Effectiveness of the stormwater quality devices to improve water quality at Putrajaya

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Abstract. Development of Putrajaya has changed the character of the natural landform by covering the land with impervious surfaces. Houses, office buildings, commercial place and shopping centres have provided places to live and work. The route between buildings is facilitated and encouraged by a complex network of roads and car parks. However, this change from natural landforms and vegetative cover to impervious surfaces has major effect on stormwater which are water quality (non-point source pollution). This paper describes the effectiveness of the stormwater quality devices to improve water quality at selected Putrajaya for demonstration in order to evaluate low cost storm inlet type devices in the Putrajaya Catchment. Five stormwater quality devices were installed and monitored during the study. The devices include Ultra Drain Guard Recycle model, Ultra Curb Guard Plus, Ultra Grate Guard, Absorbent Tarp and Ultra Passive Skimmer. This paper will provide information on the benefits and costs of these devices, including operations and maintenance requirements. Applicability of these devices in gas stations, small convenience stores, residential and small parking lots in the catchment are possible due to their low cost.

1. Introduction
The stormwater treatment devices are designed to reduce the level of one or more constituents of concern in stormwater drainage from a site. In-line quality devices can be categorised as storm drainage insert type devices which are used to catch sediments, filter, and absorb hydrocarbon products from the storm water runoff in the catch basin manhole/sump structure before entering the storm drainage system. These devices can be divided into three categories based on their operating principles: In-line Filtration Devices, Hydrodynamic Separators, and In-drain Filtration Devices. The first types of BMP devices namely In-line filtration devices employ some type of filtration media as the mechanism for removal of stormwater constituents in an in-line device such as StormGate, StormFilter, StormScreen, and Catch Basin StormFilter and etc [1].

Gross pollutants include naturally occurring material, like vegetation, rocks, and soil, as well as litter. High concentrations of O&G can cause toxicity in receiving waters, and most discharge regulations require that there be no discharge of oily wastes that produce sheen on the surface of the receiving water. Sources of oil and grease in storm water include O&G sorbed to trash and other debris; O&G sorbed to particulates; emulsified oils (small drops of oil suspended in storm water); free floating oil; and suspended oil. Research shows that between 83 and 98 percent of total hydrocarbons in storm water runoff are associated with particulate matter, and evidence suggests that a significant portion of these particles are settleable solids, such as sediments [2]. Therefore, storm water Best...
Management Practices (BMPs) designed to remove sediments may also remove some oil and grease associated with the sediments. Typically, only free-floating oil concentrations are measured and reported in storm water studies [3].

Sorbents can be divided into three basic categories: natural organic, natural inorganic, and synthetic. Table 1 describes the three materials and their sorbent capacities. This report focuses on synthetic sorbents; however, many BMPs can be fitted with natural organic or inorganic sorbents to help absorb oil and grease. The sorbent capacity for are measured in terms of theirs weight in oil. A study shows that synthetic sorbent can absorb up to 70 times of their weight in oil, compared to organic and inorganic with sorbent capacity up to 15 to 20 times of their weight respectively [4].

This Putrajaya pilot BMP was selected for demonstration in order to evaluate low cost storm inlet type devices in the Putrajaya Catchment. This Pilot Study was conducted to evaluate the performance of selected proprietary devices that can capture gross pollutant, silt, sediments, oil & grease and that can be incorporated into the existing drainage system. This stormwater quality device is considered to be a simple retrofit to improve storm water quality before it enters the storm drainage system. Catch basin insert type units were targeted for this type of stormwater quality device. These devices are presently manufactured and marketed by vendors around the United States and Canada. Most of vendors for these devices were located in Florida and Washington State due to the interest of these municipalities with this type of water quality improvement devices.

The study area located at Putrajaya which is situated 25km south of Kuala Lumpur and 20km north of Kuala Lumpur International Airport (KLIA). Rapid development has been ongoing in Putrajaya catchment since the formation of Putrajaya from year 1995 to date. Post development of Putrajaya has resulted in increased sediment leadings into the Putrajaya Wetland and Lake. Controlling sediment from entering drainage systems is a great challenge, since development of Putrajaya is still ongoing. The selected sites by for the installations of GPTs are Persiaran Utara, Precint 12, Putrajaya Sentral, Precint 7 and Jalan P9C1, Precint 9. Figure 1 shows the actual condition of the Putrajaya Sentral polluted with oil and grease from the buses. Meanwhile, Figure 2 shows typical view of silt and sediments entering the drainage and catch pit from the nearby bareland area at Precint 9. This study will focus on few pollution control devices which are expected to assist in oil & grease and sediment control of the GPTs installed at these 3 selected areas.

2. Methodology
Generally all the collected water samples will be analysed for 6 major parameters which includes DO, BOD, COD, AN, SS and pH to determine the water quality index (WQI). The sieve analysis was also conducted to classify the TSS grain size distribution captured in the study area. The effectiveness of the stormwater quality devices in terms of pollutant removal efficiency and O&M cost has been investigated.

The water sampling was conducted during the rain events. Water sample was collected using 1.5 litre liquid bottles and two bottles of water samples were collected at each sampling points where one
plastic bottle for other parameters and another one glass bottle for oil and grease. These samples were sent to certified laboratory for analysis. While the sediment samples were collected by scooping the sediment traps at the pollution control devices installed and were sent to the laboratory for sediment particle size distribution analysis according to BS 1377: Part 2:1990.

3. Results Analysis and Discussion

The results of this paper include the sediment and oil and grease capture rate, as well as operation and maintenance summary and cost assessment of the trapping devices. The basic operations and maintenance (O&M) requirements for sorbent materials include periodic checks to ensure that they have not reached their sorbing capacity or become clogged. The frequency of visits and cleaning of sediment and debris from SQID using sorbent materials depends on the type of SQID and the area in which it is located. In general, all SQIDs using oil sorbent materials should be inspected at least monthly. If the material is placed in an area where it is susceptible to a high oil loading rate, the SQID should be inspected and serviced more frequently.

However, inspections of these devices are depends on the individual unit and vary from monthly to quarterly. For example, the Grate Guard and Drain Guard should be serviced quarterly to remove accumulated sediment and debris and to check the sorbent. The Passive Skimmer systems were recommended to be inspected at least once a month to check the position of the skimmer and ensure that it remains on top of the water for maximum oil removal efficiency. The devices were in operation from January 2008 to May 2008. Table 1 and Table 2 shows the results from the monitoring work on the performance of various devices.

| Device | Average Sediment Captured/ Gallon Filtered (lbs/ 1,000 gallons) |
|--------|---------------------------------------------------------------|
| Putrajaya Ultra Drainguard (Putrajaya Sentral) | 2.51 |
| Ultra Grate Guard (Precint 9 – 1 Event) | 8.86 |

| Device | Average Oil Captured/Gallon Filtered ((mg/Kg)/1,000 gallons ) |
|--------|---------------------------------------------------------------|
| Putrajaya Absorbent Tarp (Putrajaya Sentral) | 291.13 |
| Passive Skimmer (Precint 9) | 326.73 |
| Passive Skimmer (Putrajaya Sentral) | 961.69 |
| Sponge under Grate Guard (Putrajaya Sentral) | 81.37 |

There are four main categories are associated with the acquisition and operation of sediment and oil and grease trap, which are: (i) one-time structure cost; (ii) one-time installation cost; (iii) recurring maintenance costs; and (iv) recurring waste disposal cost. The capital costs depend primarily on the model and size of the stormwater quality improvement devices (SQID) purchased. Installation costs vary significantly depending upon whether the SQID is placed in a greenfield or brownfield development. Maintenance costs vary by device, site and practice, while waste disposal costs are location-specific. Table 3 shows a capital and installation cost summary for drain guard, kerb guard, grate guard, oil passive skimmer and absorbent tarp installed at Putrajaya study area.
Table 3. Capital Cost Summary for Stormwater Quality Improvement Devices (SQID)

| Device          | Drain Guard | Kerb Guard | Grate Guard | Oil Passive Skimmer | Absorbent Trap |
|-----------------|-------------|------------|-------------|---------------------|----------------|
| Structure Cost (RM) | 630         | 455        | 520         | 530                 | 430            |
| Media Replacement Interval | Every 6 months | More than 2 years | Every 6 months | Every 3 months, based on physical condition | Every 3 months, based on physical condition, applied location |
| Media           | N/A         | N/A        | 350         | N/A                 | N/A            |

*1st Year Capital Cost (RM) | 700 | 500 | 580 | 590 | 480

Annual Maintenance Cost & Disposal Cost | 7600 | 2300 | 2300 | 2300 | 2300

Total Annual Cost | 8300 | 2800 | 2880 | 2890 | 2780

In general, a typical SQID system can be expected to cost about RM 2,800 or more per year over its lifetime. Again, these costs are preliminary estimation, given their variability by site and application. Higher costs would result for large models, for brownfield retrofits.

4. Conclusions

This study investigates the performance of stormwater quality devices (SQID) in the removal of suspended particles, particularly sediment, Oil & grease and associated pollutants in stormwater. Storm event and dry weather water samples were collected entering and leaving a stormwater quality devices unit and were analysed for Total Suspended Solids (TSS), Heavy Metals and Oil and Grease concentrations. The SQID has shown previously to be an effective stormwater quality device in USA, however the performance of the SQID under tropical climates is not well understood. Therefore, the objective of the study is to investigate the effectiveness of SQID in the removal of sediments and oil & grease. This study suggests a stormwater treatment sequence involving an efficient stormwater quality device, such as the drain guard unit, pre-treatment by a constructed wetland or a bioretention zone can be expected to treat a wide spectrum of pollutants found in stormwater.

At Putrajaya Central and Precint 9, sediment are expected to be contributed from the side of the car park area and sediment from the bare land deposited to the pollution control devices installed at that place respectively. The sediment grain size distribution, mainly consist of Gravelly Sand. It is estimated (using USLE) Soil Erosion Loss at Precint 9 as much as 361.011 t/ha/yr annual. This shows that stormwater quality devices must be installed in the study area in order to remove the sediments in the stormwater based on the estimated soil erosion loss rate. The target is to control the problems at source by installing the SQID or planting vegetation at the bare land slope. The Putrajaya Stormwater Source Control Projects have provided excellent opportunities to demonstrate innovative at-source structural treatments. It is expected that the results of this trial will be valuable for stormwater managers grappling with a multiplicity of pollution issues and limited capital and maintenance budgets.

References

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