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A Study on the Selection of Suitable Sites for Integrated Smart Trapper System Installation (InSmarts)

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ABSTRACT

Rapid expansion in major towns in Malaysia results in the construction of new drainage system mainly open monsoon or storm drains to cater the increase in surface runoff. This research are to study the suitability of selected sites to implement InSmarts and propose at selected sites based on the optimum results. InSmarts is a floatable trapper that was being synchronized with the effective and better communication tools. This product mainly consists of a fibre reinforced plastic tube that acts as floatable rubbish trapper. Acoustic Doppler Current Profiler (ADCP) was used to get water velocity and river profile at sites. The data was acquired at three different points along the river at each sites to know the best position to implement InSmarts. These tests were done to find out the attributes of different rubbish materials and weights in the flowy medium such as river or drainage. From the test that has been done, the optimum condition to install at sites are the velocities of the river must be around 0.1 m/s to 0.6 m/s and the trapper must be set up at 45° angle to accumulate the trash at one side of the trapper.

1. Introduction

Rapid growth in major towns in Malaysia results in the construction of new drainage system mainly open monsoon or storm drains to cater the increase in surface runoff [1]. Plastic production has increased rapidly in recent years from 5 million tons in 1950s to 280 million tons in 2011 [2]. With its unique properties and multifaceted applications plastic has become an indispensable part of modern life. The reduction and removal of urban litter is a complex and difficult problem, particularly for developing countries. Ultimately, the solution depends on each local authority developing an integrated catchment litter management strategy that includes planning controls, source controls, and structural controls [3].

Chittripolu [4] explained floatable trapper works as the obstacle for the floating debris travel through storm water. Trapper is constructed by PVC or UPVC pipes in inclined direction to the direction of flow. Trash of different size were captured by the trash trapper. High litter loads together with rainfall intensities and unreliable maintenance programs frequently lead to blockages and the associated risks of flooding. Removal of litter from a storm water is possible when the pollutants were obstructed by the trapper.

Allison et, al. [5] stated in Melbourne, Australia noted that urban areas contribute about 20-40 kg (dry mass) of gross pollutants per hectare per year to storm water, equivalent to approximately 60,000 tonnes or 230,000 cubic metres of gross pollutants and about two billions litter annually. Jang et, al. [6] in his research states the discharged from the Nakdong River affect the movement and accumulation of floating debris along the northeast shore of Geoje Island, South Korea. A total of 3267 people worked to collect 3400 tons of debris for 20 days and a worker must collect 52 kg of waste per day to prevent the dumping of gross pollutants. A method introduced by Khan et, al. [7] can save time and energy for a worker to clean up the river or drain that are filled with debris by trapped all the debris at one certain point.

At the same time, the maintenance cost has been reduced and less manpower is needed. Due to its buoyancy, the trapper can float according to any water level. Next, supervisor can supervise more wisely through smart phone when the debris level is fully trapped on the trapper.

2. Material & Methods

A suitable site need to determine before the InSmarts can be tested. Fig. 1 and Fig. 2 shown selected sites to represent sub-urban river and urban river respectively.This decision is made because both river has accessible areas that make data collecting convenient and both rivers criteria seems fit to study InSmarts. Majlis Pembandaran Pulau Pinang (MPPP) data showed that the per capita waste generation in Penang is now approaching that of developed nations and solid waste generation in Pulau Pinang has growth rate 3.03 % per 2 years for Sungai Derhaka.

Fig. 1: Sungai Derhaka, Seberang Jaya

Fig. 2: Sungai Pinang, George Town

A floatable trapper consist of a 12 metre polyvinyl chloride (PVC) pipe with 2.5 inches diameter and steel rods was installed at sites to record the flow pattern of the rubbish based on their certain classification. The equipment that involved were Acoustic Doppler current profiler (ADCP), FP211 Global Water Flow Probes (GWFP) and GPS. Mueller et, al [8] and Gotvald et, al. [9] stated ADCPs contain piezoelectric transducers to transmit and receive sound signals. Thus, current profile of the river from bank to bank can be measured. GWFP is a highly accurate water velocity instrument for measuring flows in open channels and partially filled pipes. The water velocity probe consists of a protected water turbo prop positive displacement sensor coupled with an expandable probe handle ending in a digital readout display. GWFP incorporates the unique propeller sensor, which uses the most accurate positive displacement technique for velocity sensing. The velocities and depth are measured using a GWFP at various points along cross sections of the river as shown in Fig. 3. Then ADCP is used to take the readings at the same cross sections line Fig. 4. ADCP and flow probes reading is taken along the same fixed line 3 times to get average readings. Discharge, Q or the river is calculated using Eq. 1.

Discharge, Q = Area, A × Velocities, V (Eq. 1)

This calibration has to be done for maintaining the quality of measurement as well as to ensure the proper working of particular instrument as make sure whether result from ADCP is valid and can be used we need to record the data manually. Both results from manual way current meter and using device ADCP is later then compared. R^2 graph is produced to show the accurateness of ADCP compared to GWFP. The calibration was done at Sungai Kurau, Perak.

Fig. 3: Taking manual measurement using current meter rod (GWFP)

Fig. 4: Moving ADCP from side to side to take readings

3. Results & Discussion

The R^2 coefficient of determination is a statistical measure of how well the regression line approximates the real data points. An R^2 of 1 indicates that the regression line perfectly fits the data. In Fig. 5, the value of R^2 is 0.8334 which just less 0.1666 from 1.This indicates the readings from ADCP is close enough with manual method which is current meter. Thus, the data from ADCP is validated and can be used.

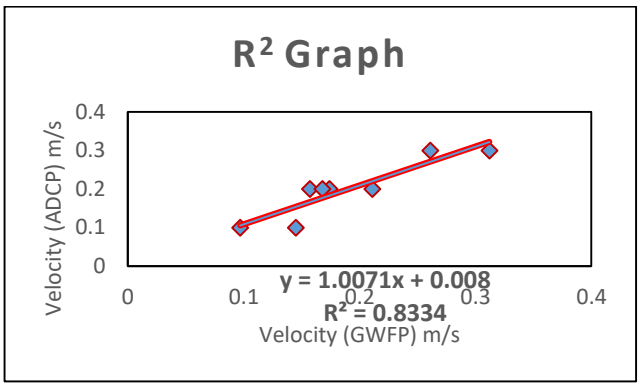

Fig. 5: R^2 graph [velocity (ADCP) vs velocity (GPWF)]

3.1 Sungai Derhaka

The max depth at Sungai Derhaka (POINT 1) is 0.59m and the maximum velocity is 0.10 m/s. River cross profiles show the cross profile of a river changes as it moves from the upstream to downstream direction. The red arrow in Fig. 6 shows the direction of water flow at sites. The water flow as shown in the Fig. 6 are from 0.01 to 0.10 m/s. Fig. 7 shows the river section vary in width from 0.2 m to 0.6 m which has the least sedimentation compared to other 2 points as it flow faster toward downstream. Observation at site also recorded smooth unobstructed water flow.

Fig. 6: Sungai Derhaka (Point 1) 5°23'36.44"N 100°23'38.47"E (Source: Google Maps)

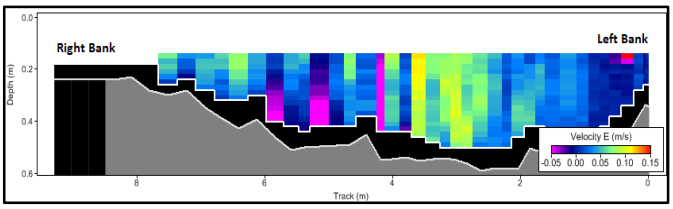

Fig. 7: River Profile at Sungai Derhaka (Point 1)

The max depth at Sungai Derhaka (POINT 2) is 0.49m and the maximum velocity is 0.07 m/s. The red arrow in Fig. 8 shows the direction of water flow at sites. River cross profiles in Fig. 9 shows sedimentation has occurred in the middle course and this point has uneven river bed. ADCP unable to get reading at river depth less than 0.3m besides. Water flow also slower here although not much difference compared to point 1. InSmarts seems not suitable to install here as it is too shallow to install trapper.Rubbish might stuck at the shallow region of the river.

Fig. 8: Sungai Derhaka (Point 2) 5°23'16.43"N 100°24'20.93"E (Source: Google Maps)

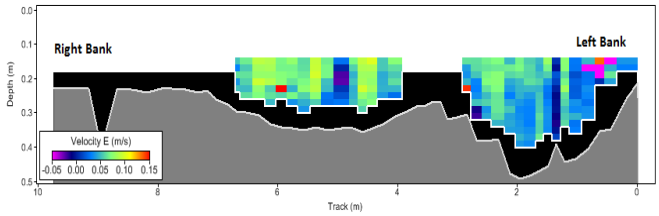

Fig. 9: River Profile at Sungai Derhaka (Point 2)

The max depth at Sungai Derhaka (POINT 3) is 0.45m and the maximum velocity is 0.12 m/s. The red arrow in Fig. 10 shows the direction of water flow at sites. This point location is in the most upper course compared to the point 1 and point 2. River cross profiles shows, the valley and channel are narrow and shallow. River cross profile in Fig. 11 shows "V-Shaped Valley" since they look like a letter V. This is certainly not suitable at all to install InSmarts as this part of the river also very shallow. However the water at the 'deep' region of the river is recorded quite high water velocities. If trapper is installed here, floating trash most probably will flow at this direction only and shorten trapper lifespan. Further research about rubbish flow pattern will be elaborated.

Fig. 10: Site 1 (Point 3) 5°23'16.05"N 100°24'35.58"E (Source: Google Maps)

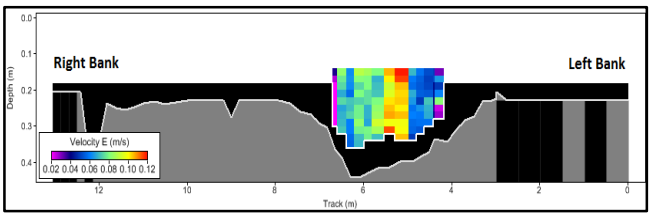

Fig. 11: River Profile at Sungai Derhaka (Point 3)

3.2 Sungai Pinang

The max depth at Sungai Pinang (POINT 1) is 0.57 m and the maximum velocity is 0.33 m/s. The red arrow in Fig. 12 shows the direction of water flow at sites. A cross section of a meander would show that on the outside bend, the channel is very deep and concave. This is because the outside bend is where the river flows fastest and is most energetic as shows in Fig. 13 where section at outside bend recorded higher water velocities compared to the shallow region. This is because lots of erosion by hydraulic action and corrosion takes place. River cliffs form on the outside bend as the river erodes laterally. The inside bend is shallower with a gentle slip-off slope made of sand or shingle that is brought across from the outside bend by the helicoidal flow of the river.

Fig.12: Site 2 (Point 1) 5°24'42.61"N 100°18'32.53"E (Source: Google Earth)

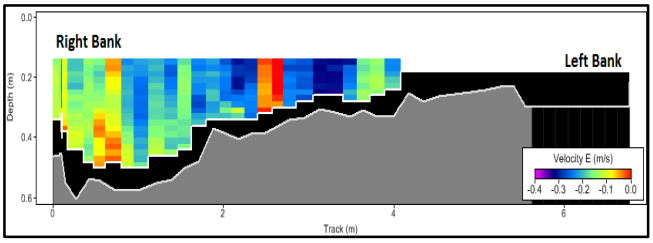

Fig. 13: River Profile at Site 2 Point 1 (Sungai Pinang)

The red arrow in Fig. 14 shows the direction of water flow at sites. The max depth at Sungai Pinang (POINT 2) is 0.47m and the maximum velocity is 0.8m/s. Fig. 15 shows the river channel is a little wider but not much deeper and the river bed is flat. This is suitable to install trapper as rubbish would be stopped by trapper instead of stuck by uneven river bed. However water Upstream ties recorded quite high in the middle of the river.

Fig. 14: Site 2 (Point 2) 5°24'39.24"N 100°18'45.68"E (Source: Google Earth)

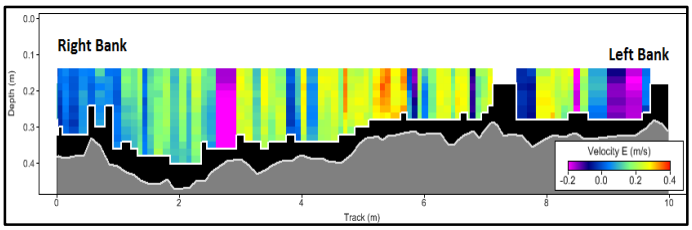

Fig. 15: River Profile at Site 2 Point 2 (Sungai Pinang)

The max depth at Sungai Pinang (POINT 3) in Fig. 16 is 0.46m and the maximum velocity is 0.04 m/s. Fig. 17 shows massive sedimentation has occurred in the middle of river. Water flow velocities also quite low at the small region. Floating trash could easily stuck in at the shallow region and also and the small opening on both side of the river at this point of location. It is also too shallow to install InSmarts.

Fig. 16: Site 2 (Point 3) 5°24'29.60"N 100°19'21.94"E (Source: Google Earth)

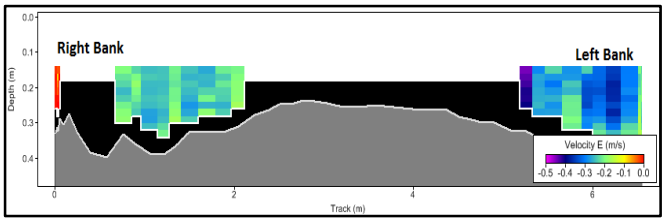

Fig. 17: River Profile at Site 2 Point 3 (Sungai Pinang)

3.3 The Most Optimum Trapper Angle

Fig. 18 and 19 shows the result of final placement of rubbish at 45° trapper. Trash accumulation is observed at one edge of the trapper with one exception. Trash weighed 400g to 1000g gathered at the cornered angle of the trapper. 200g trash end up solitarily to opposite site of the trapper. This is because of sedimentation at the middle of the river and also disturbance from the wind which made lighter trash (200g trash) swayed easily to another direction. However, regardless of the 200g trash, this will make as easy path for the management team to do clearance and do not have to consider for both parts of the trapper as trashes will accumulated together at cornered angle eventually.

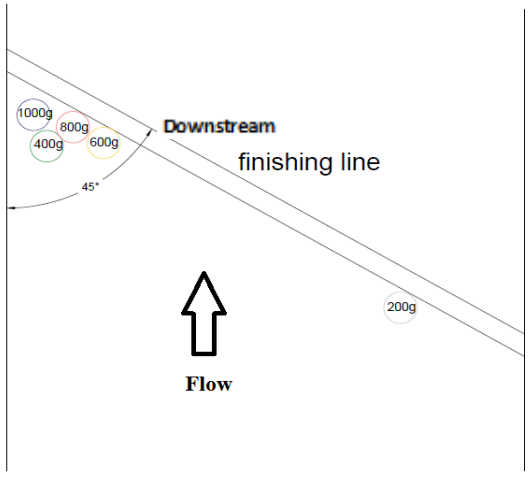

Fig. 18: Final placement of rubbish at 45° trapper

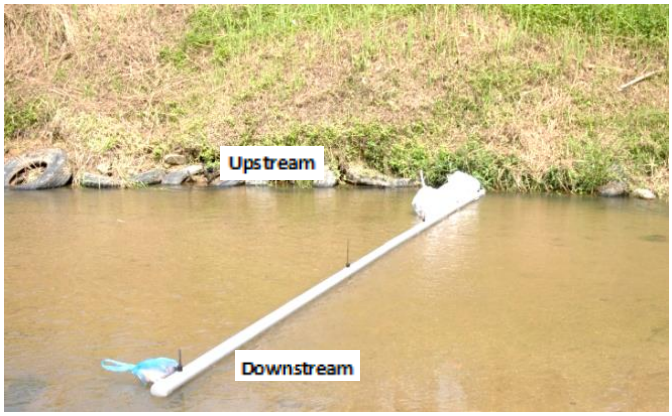

Fig. 19: Actual picture at the Sungai Kurau

4. Conclusion

Derhaka River is chosen under sub-urban river category and Pinang River is chosen under urban river category to study the suitability of both sites to install InSmarts. This decision is made because of landuse around the river. The origin and movement of land-based debris are related to landuse. Urban area is prompted to generate more trash while sub-urban generated less trash. The average percentage of material identified as trash, varied by population and land use. Variation in trash percentages are likely due to both variations in trash generation. Both selected points are in downstream region which the receiving water flow is not very high as high receiving flow velocity might dislocate the trapper. The location points also chosen because of less water level fluctuation. Trash can be easily collected at transects (trapper) in the stream channel to estimate trash delivered to the stream. Finally, sites selected are convenient to access. There is adequate areas for trucks to park to collect trapped trashes.

Based on the results, the optimum condition to install InSmart at sites are the velocities of the river must be around 0.1 m/s to 0.6 m/s which is not very high as high receiving water velocity might dislocate the trapper and allow trash to flow pass the trapper, river depth must be more than 0.3m for easy trapper installation and avoiding floating rubbish to be stuck and end up at river bed, areas that has high trash generation, river that has uniform flow so the trash does not accumulate at certain points at the trapper and finally the trapper must be set up at 45° angle to accumulate the trash at one side of the trapper to make it convenient for

the worker to collect rubbish when doing maintenance works. All the objectives are successfully accomplished to meet the requirement of the research.

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