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CHALLENGES IN THE REHABILITATION OF THE PUSU RIVER

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Abstract

River rehabilitation efforts in the world are increasing to conserve the ecosystem. These efforts, generally, face challenges from various sources. Major constraints which can turn such a program into a failed project have been discussed explicitly in the first part of this research. In the second part of the paper, focus has been given on the problems of rehabilitation of the Pusu Rive at Gombak District in Malaysia. Water sampling from the river and its catchment has been done in different periods and events. Pollution loadings into the river have been calculated for different parameters. Based on analysis, sand mining activities, point source pollution and catchment landuse was identified as the major impediments of Pusu River rehabilitation. These problems must be addressed before the rehabilitation of the river in order to ensure that this activity is successful.

Keywords: *River rehabilitation; Pollution; Targets; Impediments; Failure reasons.*

Introduction

Rivers and wetlands are the most common ecosystems that are either endangered, heavily degraded or in poor condition [1-3]. At present, around 60% of the rivers of our planet are degraded or being modified heavily because of human activities. In 2002, more than 80% of the lengths of the Australian streams were considered to be affected by catchment disturbances [4]. Now it is essential for all of us to conserve this vital, life-sustaining natural resource for our own existence and for the future generation by restoration or more precisely by rehabilitation efforts. The term restoration refers to the returning of an ecosystem to its pre-disturbed natural condition. Rehabilitation means a motion to the same path of restoration, where total restoration is not performed. *P. Roni et al*. (2002) [5] remarks that reinstating an ecosystem to its' undisturbed natural state refers to restoration in which activities like improvement, enhancement, creation of habitats and mitigation of natural disasters are included. It is argued that these actions are more accurately meant as rehabilitation since majorities of them do not restore an ecosystem totally. However, well documented design of river rehabilitation schemes is rare despite its soaring public support and popularity [6]. A clear realization of the problem of a river system, specific statement of rehabilitation targets and evaluation of the completed job is essential to successfully rehabilitate a river system [7] and facilitate information for the future.

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Otherwise, such rehabilitation schemes will either deviate from its intended purpose significantly or even it may turn into a futile project.

The Pusu River in Malaysia is currently a polluted river and needs to be rehabilitated. This river runs through the International Islamic University (IIUM), which has an international reputation. The polluted river is giving bad impression to the staffs, students, visitors. The river seems to be unable to support healthy aquatic lives due to point and diffuse pollution source. The main objective of this paper is to highlight the problems in relation to the rehabilitation of the Pusu River. However, in the first part of the paper, focus has also been given on the general problems of a typical river rehabilitation program.

Background

G. Brierly and K. Fryirs (2009) [8] has onsidered three geomorphic conditions in connection with planning catchment scale river rehabilitation. The first one appreciate the diversity of the river system which is inherent in it. Then they discussed on river behaviour changes over time and finally they highlighted the geomorphic potential of river rehabilitation. Rehabilitation efforts were made to the North Gunnison River in Colorado assuming that the river's braided pattern is an effect of land use in the 20th century. The importance of project monitoring after its completion has explicitly been focused by *P.W. Downs et al*. (2002) [9]. They highlighted four case studies where one of the projects did not have any previous data and monitoring was also not done. In another case there were data records, but Post Project Appraisal (PPA) was limited. They compared these cases with the other two cases which underwent PPA and concluded that PPAs can give complex solutions to river rehabilitation programs.

B.S. Caruso and P.W. Downs [10] have demonstrated the integration of flood management and river rehabilitation planning by a study on an urban catchment in the coastal area of New Zealand and the river was a boulder bedded steep river, which is very rogue. Their study included hydrology of catchment, modelling and analysis, water quality evaluation, hydraulic modelling, flood risk assessment and analysis of aquatic ecology. They showed that all these works are essential to integrate river rehabilitation and flood mitigation. They concluded that opportunities like recreational facilities, ecological health and aesthetics can be improved even if in this challenging environment if all these analyses are performed. *M.G. Del Tanago et al*. [11] analysed the practical and theoretical approaches of river rehabilitation in Spain in the context of the Water Framework Directive (WFD) of the EU. They focused on the problems of Spanish rivers for which achieving good ecological success is hindered. According to them, water deficiency both in quality and quantity is the main constraint for Spanish rivers and also regulation of rivers is another vital threat to river ecology. They also discussed about the impediments on 60 rehabilitated river sites. *Y. Wang et al*. [12] investigated the effect of rehabilitation of inland river basins of Northwest China and remarked that its sustainability is hugely dependent on several socio-economic factors. After performing questionnaire survey work they found three critical issues among which one was that the livelihood of the local herdsman was dependent on the compensation provided by the project. Secondly, the project did not improve the water resource utilization rate undermining its own target. Finally, public benefit and externalities were neglected in the project, which is a major threat for a project's sustenance. Therefore, they also gave some recommendations for the adaptation of the project with local socio-economic, environmental and economic conditions.

Methodology

In order to identify the problems related to Pusu River rehabilitation program, at first the point pollution sources of the river were identified. Water samples were taken from the point and non-point pollution sources and tested according to the American Public Health Association (APHA) standard methods. Flow rate of the pollution sources were measured by Area-Velocity method using a current meter and measuring tape. Sand mining activities was being conducted at the upstream of the river which was the cause of murky appearance of the river water. Therefore, in order to quantify the impact of sand mining water samples were collected and tested during sand mining and no sand mining period.

The catchment of Pusu River was delineated based on the available topographic map. Different landuses in the catchment were identified from Google Earth map. The map was digitized to determine the total area and proportions of different landuses within the catchment. Grab sampling was performed during dry weather. Water samples were taken during storm events at an interval of 10 minutes to determine the Event Mean Concentration (EMC) values from the areas of particular landuse.

Major constraints of river rehabilitation

In this section, discussion has been made on those major restraints of a river rehabilitation project, which can result in the overall failure of such kind of projects. The reason for this discussion is that to rehabilitate a particular river, we cannot ignore the common problems of a rehabilitation scheme. Therefore, this initial discussion is mainly for the mangers and decision makers who are in control of such programs.

Funding

One basic driving factor for a rehabilitation program is funding for which a running project may come to an end without being completed and potentially undermining the improvements made [13, 14]. The river rehabilitation program at Lane Cove Valley, Sydney suffered from this problem during the 1990's, leaving many rehabilitated portions fragile to weeds [13].

Uncertainty

Many times, it happens that potential uncertainties are ignored. And the problem gets more severe when uncertainties are barely assessed and are almost not reported to the public as well as to the stakeholders. Many authors have described the reasons of uncertainty as ambiguous and insufficiently specific rehabilitation objectives [15, 16]. It is comprehensive that choosing the general rehabilitation purposes as objectives in a careless manner may lead to darkness. Natural diversities, historical and spatial contingencies are also conducive to uncertainty [17].

Ignoring watershed behaviour

There are cases where the watershed behaviour of the river was ignored in rehabilitating a river. The reach specific strategies to rehabilitate rivers are generally adopted neglecting the temporal and broader context [18, 19]. Piecemeal efforts are not efficient and economical to achieve ultimate rehabilitation success [20]. Implemented measures may result in failure to achieve their intended objectives as long as a pragmatic catchment (watershed) scale rehabilitation vision is not adopted by the concerned authorities [8]. Site specific rehabilitation, which is often opportunistic in a sense that it can show improvement almost instantly but tends not to sustain in the long run due to their scopes lie beyond the strategic actions needed [21].

Small scale rehabilitation schemes

Large scale rehabilitation efforts are far more successful than small scale site specific schemes even if large scale projects may consume much time to show the success. Having the pressure of demand from the funding authorities, resource managers are reluctant to go for such kind of slow rate and time consuming rehabilitation projects [22]. Rehabilitation of the habitat patches (riparian and instream) of a small scale project are vulnerable to large floods [23]. The Statistics of a study by *G.G. Alexander and J.D. Allan* [24], as shown in Figure 1, shows that large scale projects (projects ≥ 1.5km length) in the USA are decreasing over the time, which is not a good news for sustainability. The percentage of large scale river rehabilitation projects in the USA was the lowest during 1991-1995 period since 1970s.

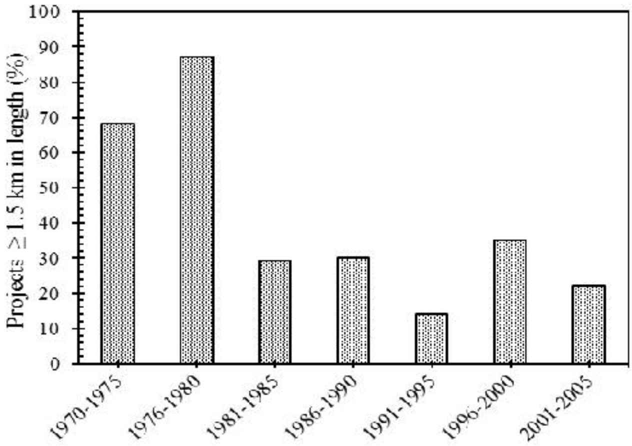

Fig. 1. Percentage of large scale projects in the USA (Adapted from Alexandar and Allan 2006)

Monitoring deficiency

Appropriate monitoring is done to very few number of river rehabilitation projects [25]. *C.A. Frissell and R.K. Nawa* [26] also state that a large proportion of river rehabilitation projects have been undertaken without considering any provision of monitoring. *E.S. Bernhardt et al*. [27] reported that monitoring or any form of assessment was performed to only 10% of river rehabilitation projects in the United States. Many authors have objected to the lack of monitoring [28], which affects finished and future projects. Monitoring and reporting of previous projects help to prevent costly mistakes by choosing a suitable rehabilitation approach [29]. It is evident from Figure 2 that from 1970 to 1987, the number of river rehabilitation projects recorded and documented are very negligible. Even though from 1988, there is a sharp increase in the number, many projects have gone unrecorded and affected the succeeding projects due to lack of information. Unrecorded projects could have contributed a lot by providing critical information.

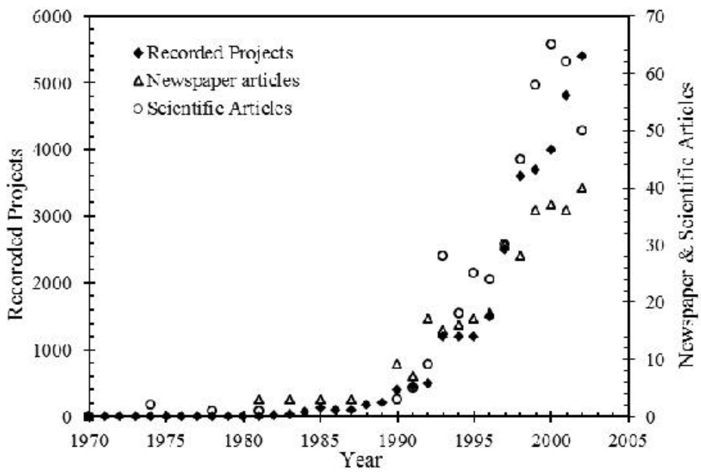

Fig. 2. Recorded River Rehabilitation Projects in ***National River Restoration Science Synthesis (***NRSS),

USA and Publications Related to Stream Rehabilitation (Adapted from *E.S. Bernhardt et al. 2005)*

The Pusu River system

Figure 3 shows the River Pusu system within its catchment. The river drains an area of 12.4km^2. The upstream of the catchment is dominated by forest and at the downstream, the river runs through International Islamic University Malaysia (IIUM). Sand mining activities go on the upstream of River Pusu and its major tributaries named Anak Pusu and Batang Pusu. Other small tributaries also join the river at the downstream of the river inside IIUM. The total length of the river is about 4.1km before it joins Gombak River. The highest elevation at the upper catchment is about 428m and the average elevation at the downstream is about 85m from mean sea level [30]. There are seven ponds along the river and its tributaries at the downstream, which are inside the IIUM campus area. The ponds are marked in figure 3 denoted as P and pond number. The river is now considered as a Class IV river according to the Malaysian standards [31]; whereas there are five classes of rivers in the classification system of which Class I is the best condition and Class is the worst condition.

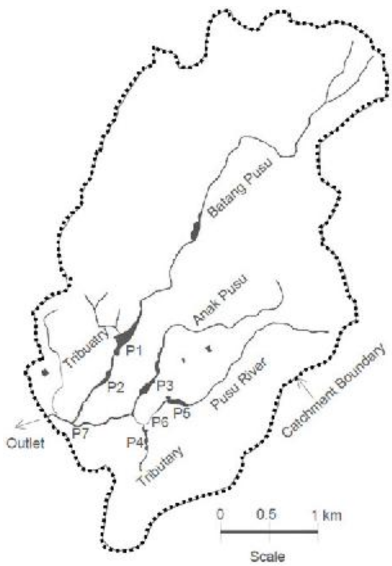

Fig. 3. The Pusu River system and catchment

Impediments to rehabilitate the Pusu river

Land clearing and sand mining

Improper land clearing activities are being carried out along the main tributaries of Pusu River. As a result of disturbed and unprotected land surfaces, huge amount of sediments are deposited in the ponds. Sand mining activities are rampant at the upstream of the Pusu river. Sand is mined and washed and the silt is released to the river causing very high suspended solids concentration and turbidity of the water. Sand mine has caused deterioration of the water quality and made it very tough for fishes to survive. It has caused siltation in the ponds along the river. These ponds were excavated several times without stopping the sand mining activities. As the sand mining was going on in its regular manner, the silt and sand deposition filled the pond again making the excavation effort futile. Therefore, improper land development activities and sand mining are the main challenges to rehabilitate the Pusu River. Figure 4 illustrates that at pond 1 (P1) siltation has occurred profusely, which is due to the improper land clearing activities for residential development and sand mining activities occurring at a few 100 meters upstream of the pond. Figure 5 shows the condition of pond 5 during disilting period and a few months after the excavation of the same pond.

(a) Before sand mining (b) After sand mining

Fig. 4. Effect of improper land clearing and sand mining at Pond 1

(a) Excavated pond (b) Silted pond

Fig. 5. Effect of improper land clearing at Pond 5

Figure 6 substantiates that sand mining adversely affected the River Pusu water quality. The TSS and turbidity is very high in a dry day during the period when sand mining activities were going on compared to that of a no sand mining day.

M. Manap and A. Voulvoulis [31] state that the sand mining activities have a significant impact on the environment; whereas the degree of impact depends on the sediment properties, technology used and economic consideration. Therefore, to solve the problem, it is required to take an integrated approach incorporating ecosystem disturbance, legislative challenges and cost effectiveness.

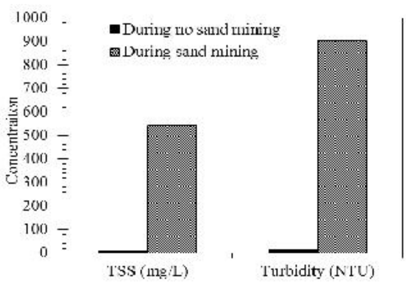

Fig. 6. Sand mining effect on water quality

Point Source Pollution

Point source pollution can have a detrimental effect on a river if the pollutant concentration and flow is high enough to impact the river [33]. A huge amount of waste water is being discharged into the Pusu River worsening the water quality condition of the river. The point source pollutions discharging waste water have been identified within the IIUM, Gombak campus area as shown in Figure 7.

The pollution loading is given in Table 1. However, at the upstream of the river, it is anticipated that there are some other waste water discharges from a village named Kampung Sungai Pusu, which are unidentified. Therefore, the pollution loading on Pusu River is actually more than shown in Table 1. The flow of the river is around 0.4 cumec in a dry day, which is quite low. Compared to the flow of the river, the pollution loading is quite high. Currently, fish species are rarely seen in the river. If this pollution sources continue to discharge into the river, it will be very much difficult to sustain a rehabilitation effort. Consequently, point source pollution is a major threat for the rehabilitation of the river.

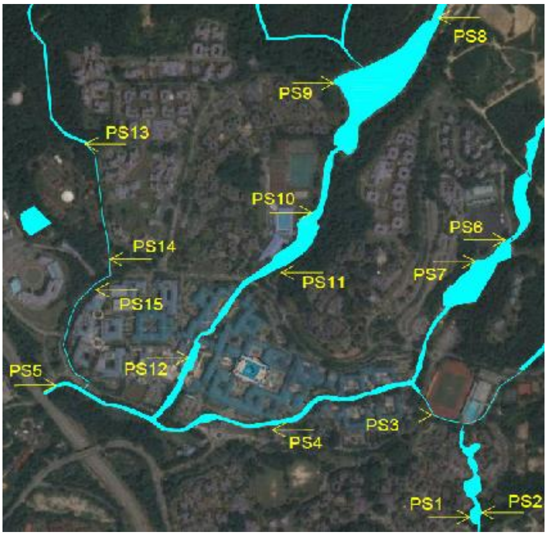

Fig. 7. Location of point source pollution discharge points within IIUM campus

Table 1. Point source pollution loading from the campus

Pollution Source ID	Source	Pollution Loading (kg/day)					
		TSS	BOD	ON	NO_3-N	AN	TP
PS1	Sullage	37.8	12.2	1.2	2.1	0.4	0.2
PS2	STP	9.8	5.2	1.3	1.1	4.9	0.3
PS3	STP	36.3	18.1	6.9	4.5	26.6	2.4
PS4	STP & Sullage	129.6	62.6	8.2	8.0	18.1	9.7
PS5	STP	20.5	12.4	3.0	2.6	15.6	1.7
PS6	STP	8.1	6.1	0.9	2.4	9.7	0.7
PS7	STP	7.0	7.0	1.9	2.0	8.9	1.7
PS8	STP	24.2	20.7	4.6	2.2	18.7	1.5
PS9	STP	18.1	11.8	5.0	1.9	15.7	1.1
PS10	STP	109.6	90.0	31.7	8.2	82.2	21.9
PS11	STP	25.8	22.5	4.5	4.0	33.9	4.9
PS12	Sullage	60.0	38.6	2.7	1.2	0.4	3.3
PS13	STP	14.9	11.9	3.3	3.1	10.7	1.8
PS14	STP	19.6	14.2	2.7	2.6	11.4	1.0
PS15	Sullage	29.0	1.0	0.3	0.6	0.1	0.0
	Total =	**550.3**	**334.3**	**78.2**	**46.5**	**257.3**	**52.2**

STP = Sewage Treatment Plant, TSS = Total Suspended Solids, BOD = Biochemical Oxygen Demand, ON = Organic Nitrogen, AN = Ammoniacal Nitrogen, TP = Total Phosphate

Catchment landuse

The Non-Point Source (NPS) pollution is dependent basically upon the landuse pattern of a catchment, antecedent dry days, amount of rainfall etc., which contribute a huge amount of pollution to the water body [34]. The Pusu River catchment is dominated by forest land as shown in Figure 8 and Table 2. However, at the middle of the catchment, development activities are going on, which is causing indiscriminate land clearing. Table 3 shows the EMC values of pollution from various types of landuse within Pusu River catchment during a rainfall event. From the table, it can be seen that pollutant concentration from an unturfed bare land is comparatively high, especially the TSS concentration. Currently about 7% of the Pusu River catchment area is under the category unturfed bare land including developing areas. It is expected that more areas will be developed in the future and NPS pollution will continue to exacerbate the water quality during storm events. It is not suggested that to stop development activities rather measures should be taken to reduce the pollution contribution from these developing areas. Otherwise rehabilitation effort of Pusu River will be hindered.

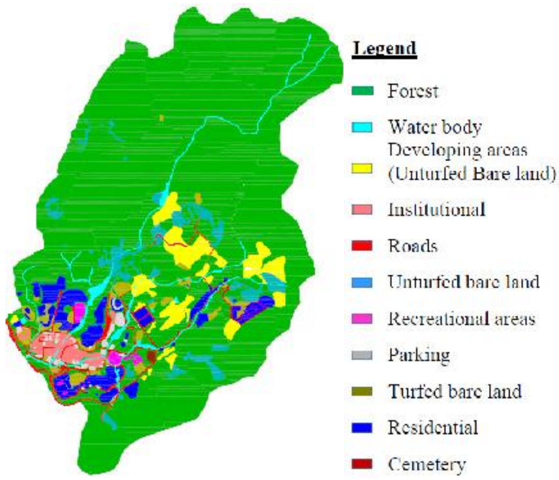

Fig. 8. Landuse within Pusu River catchment area

Table 2. Distribution of different landuse within Pusu River catchment area

Landuse	Total area (ha)	Percent (%)
Forest	1,031.11	82.31
Parking	7.02	0.56
Recreational	5.52	0.44
Residential	53.75	4.29
Roads	14.38	1.15
Turfed Open Space	21.24	1.70
Unturfed Bare land	37.41	2.99
Institutional	17.01	1.36
Developing	49.68	3.97
Cemetery	0.98	0.08
Water Body	14.62	1.17

Table 3. EMC values of pollution from different landuse in River Pusu catchment during storm event

Pollutant (in mg/L)	Landuse							
	Forest	Parking	Recreational	Residential	Roads & Parking	Turfed Land	Bare Land	Institutional
TSS	58	46	38	62	79	48	886	48
BOD	4	6	3	12	10	4	7	6
ON	0.72	0.69	0.86	0.47	0.5	0.57	1.18	0.23
AN	0.48	0.21	0.24	0.63	0.4	0.43	0.32	0.27
NO_3-N	0.8	0.3	0.4	0.9	0.8	0.6	0.6	0.4

TP	0.07	0.22	0.2	0.31	0.14	0.1	0.14	0.18

Conclusion

The major impediments of river rehabilitation program have been discussed. Before the launching of river rehabilitation program for a particular river, these impediments should be kept in mind and plan the program accordingly. The problems to rehabilitate the Pusu River in Malaysia have been identified. It has been found that sand mining poses a great threat for the rehabilitation of the river. Point source pollution is also a significant contributor of pollution to the Pusu River. The pollution loading from point and non-point sources must be reduced substantially to sustain a rehabilitation effort of the aquatic habitats. The main challenge of this small watershed is the improper development in the catchment. The landuse must be properly planned, monitored and regulated to avoid a doomed Pusu River rehabilitation program.

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