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CONCEPTUAL APPROACHES TO IMPROVING WATER QUALITY OF RIVERS IN CAMERON HIGHLANDS, MALAYSIA

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Abstract: Water quality of rivers in Cameron Highlands has deteriorated significantly mainly due to input from non-point pollution sources such as land clearing for agriculture, excessive usage of pesticides and fertilisers, construction activities and urbanisation. It is caused by the mismanagement and lack of policy enforcement. Unlike point-source discharges, non-point source discharges are relatively complex systems to measure and control. As a result, the current regulatory methods, such as water-quality standards and allowable-discharge permits that are commonly practised as a gauge to measure and manage point-source pollution are found to be inadequate techniques and generally impracticable for controlling non-point source pollution. Therefore, this study has suggested conceptual non-structural Best Management Practice (BMP) to improving water quality of rivers in Cameron Highlands. Greater emphasis has been given to agricultural activities as the main contributor to water-quality reduction in the area. Authorities' and public communication as well as awareness via community education were recommended as the most influential approaches followed by the implementation of good agricultural practices, performance of sustainable land management practices and the enhancement of controls on development approval, site planning and construction.

KEYWORDS: Good agricultural practices, Sustainable land management practices, Water quality

Introduction

The Cameron Highlands is a region located about 214 km north of Kuala Lumpur, in Pahang, Malaysia. At 1500 m above sea level it is the highest area on the mainland. It enjoys a cool climate, with temperatures no higher than 25 °C and which rarely fall below 12 °C year round. The rivers and small streams of the Cameron Highlands can be categorised as fast-flowing, cool, clean, and clear waters with high oxygen content and supporting sensitive aquatic invertebrates (Kumaran and Ainuddin, 2004). While the Cameron Highlands are categorised by undisturbed nature with virgin and unique mountain forest streams of (ecological and chemical) outstanding quality, intensive agriculture and tourism activities as well as urbanisations have been causing problems in this most vulnerable part of the catchment. Not much attention has been given to agricultural runoff which contains pesticides and fertilisers and urban-area sewage (not treated thoroughly or in places not at all) entering the river system; causing severe water pollution (Van der Ent and Termeer, 2005). Earlier it has been found that the water quality of rivers in Cameron Highlands deteriorated as a result of the huge increase in suspended solids and the high concentrations of nitrogen and phosphorus compounds (including COD), which cause significant eutrophication, and also the presence of *E.coli* which causes severe microbiological contamination (Eisakhani *et al*., 2009). Also, major source of sediment that enters the rivers system originates from direct runoff of agricultural lands (Eisakhani *et al*., 2008). In addition, it was ascertained that water pollution is increasing in the rivers of the Cameron Highlands, especially during and in the post-monsoon period, which indicates a higher contribution of non-point sources (such as agricultural and construction runoff) compared to point sources for this pollution rise (Eisakhani *et al*., 2012).

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While non-point source discharges are difficult to measure and control, the current regulatory methods such as water-quality standards and allowable-discharge permits, that are commonly used as the benchmark to measure and manage point-source pollution are found to be inadequate techniques that are generally impracticable for controlling non-point source pollution (Hashim, 2005).

Integrated water-resource management (IWRM) is defined as a process which promotes the coordinated development and management of water, land and related resources, in order to maximise the resulting economic and social welfare in a reasonable manner and without compromising the sustainability of vital ecosystems (D'Cruz, 2008; Castelletti and Soncini-Sessa, 2007). Catchment and basin-level management is not only important as a means of integrating land use and water issues, but is also critical in managing the relationships between quantity and quality and between upstream and downstream water interests (Matondo, 2002). Therefore, the objective of this study was to identify the Best Non-structural Management Practices that could be implemented to improve the water quality and pollution prevention of rivers in the Cameron Highlands. The main attention was given to non-point sources, especially agricultural runoff, as the main contributor to pollution in the area of study.

Non-Structural Best Management Practices

A proper management plan involves both natural and human systems. After understanding the sources and causes of the challenges in the watershed, it is important to understand the various management alternatives that exist to address them. In the field of watershed management, these management alternatives are called Best Management Practices (BMPs). BMPs offer both "non-structural" and "structural" approaches to water-quality protection. Non-structural BMPs may include practices such as minimising impervious areas for site development, providing vegetative buffers along all streams and waterways, promoting natural infiltration of runoff before it enters a receiving stream, pollution prevention practices and public environmental outreach programmes. Structural BMPs are permanent devices, which are designed, constructed, and maintained to remove pollutants from runoff. Non-structural BMPs should be identified and integrated into any water-management programme. As with any long-term program, the effective implementation of these BMPs may require establishing specific criteria and standard procedures for various types of facilities or operations, and personnel training. The EPA (1983) recognises the potential water-quality benefits of non-structural BMPs. Non-structural BMPs can be proposed and integrated within Cameron Highlands' rivers catchment management programme, not only to complement the structural measures taken, but also because they are comparatively less costly to implement.

Source Control of Pollution

In order to achieve efficient, equitable and sustainable water management within the integrated water-resource management (IWRM) approach, a major institutional change is needed. Both top-down and bottom-up participation of all stakeholders should be promoted, from national level down to the level of a village or a municipality, or from the level of a catchment or watershed up to the level of a river basin. As all the organisations and agencies have an important role to play in enhancing the access to water, in bringing about a balance between conservation and development, and making water an economic and social good, they have to be brought into the picture and considered. At-source control is acknowledged to be the most effective, viable and sustainable non-structural pollution-prevention approach so as to minimise if not completely stop pollutants from reaching the water bodies and thus contributes towards the improvement of the water quality. Therefore, source control of pollution was considered in management approaches, which generally involves a technique aimed at changing human behaviour, including instilling voluntary compliance through education and awareness enhancement, as well as increased commitment by the relevant stakeholders.

Defining Strategies

Implement Communication and Community Education Awareness Strategies

Provision of information and educational material and opportunities about the effects of activities and methods of mitigating such effects may substantially influence land users' behaviour. Local authorities and other agencies are required to monitor the state of the environment, including the effects of activities. The information gathered by these authorities/agencies can be used to provide land users with information about the state of their environment, including the effects of their activities on water quality. Institutional framework as marked by the World Bank (2004) can include the definition and establishment of laws, rights and licenses at levels ranging from local watershed-management institutions to international basin agencies. Clear roles and responsibilities of different sectors in water quality and service provision, environment, land-use management and construction and management of infrastructure affects the quantity and quality of water resources. It has been highlighted by UNISDR (2009) that policies and laws, public awareness raising, training and education are non-structural measures which do not involve physical construction but use knowledge, practice or agreement to reduce risks and impacts.

Provide formal training sessions for farmers and contractors: Farmers should be trained to adopt and implement sustainable agricultural practices on their land. The agricultural BMPs, and Erosion and Sediment Control Plan (ESCP) can be part of the subject matter. Formal training modules should be developed by the Department of Agriculture (DOA) in association with other related departments.

Guidelines: The preparation and use of guidelines by local authorities can be part of a wider information/education programme. The purpose of guidelines is to provide information to assist users to make informed decisions about the environmental consequences of their actions. Guidelines can be a useful means to explain the objectives of the local authority in readily-understandable terms, and to suggest practical solutions for implementation on a day-to day basis. It has been found that these guidelines may be more effective if prepared by or in conjunction with other organisations, such as sector representative bodies or those with technical authority (Woodard and Curran Inc., (2006).

Implementation of Good Agricultural Practices

The main task in minimising the agricultural impacts on water quality is to encourage farmers to adopt and adapt practices that minimise contamination by agricultural runoff. The details of these practices are likely to be relatively site-specific, depending on the particular problems and opportunities of the farming situation (Manuel *et al*., 2008). Earlier case study indicates GAPs have improved water quality in headwater of the Harpeth river, Tennessee, USA. By the GAPs installed (fence, heavy-use area protection, riparian forest buffer, stream channel stabilisation, watering facility and controlled stream access for livestock watering) in the Harpeth river watershed, considerable annual nitrogen, phosphorous and sediment load reductions have been achieved (US EPA, 2008). Good Agricultural Practices (GAPs) are methods and practices or combinations of practices for preventing or reducing non-point source pollution to a level compatible with water-quality goals. When selecting GAPs it is important that the pollutants and the forms in which they are transported is known (D'Arcy and Frost, 2001). GAPs can be basically selected in two ways: to control a known or suspected type of pollution from a particular source, or to prevent pollution from a category of land-use activity. In a fashion similar to urban practices, GAPs can be divided into source controls, hydrologic modifications, reduction of delivery, and storage and treatment. The following are suggested to be practiced with regards to GAPs in the Cameron Highlands:

Encourage the adoption of good cropping practices: It includes conservation tillage, cover crops and crop rotation. These three types of cropping systems maintain vegetative cover during critical times, and their primary objective is to reduce erosion and hence soil loss. Conservation tillage is any tillage method that leaves at least 30% of the soil surface covered with crop residue after planting. NRCS (2012) reports that, while

irrigated wheat yields in Clovis are comparable between conventional and conservation tillage, production costs for conservation tillage are lower by as much as $50 per acre. It also reduces machinery wear as less machinery means fewer pieces need to be replaced. The soil is only tilled to the extent needed to prepare a seedbed. Cover crops are close-growing grasses, legumes, or small-grain crops that cover the soil during the critical erosion period for the area. Crop rotation is a system of periodically changing the crops grown on a particular field. It has been identified by TamilNadu Farmers Association (2008) that crop rotation is a best management practice for vegetable growers. It will address loss of organic matter, disease, weed and insect pressures, soil nutrition, compaction and erosion.

Increase the efficiency of irrigation water management: Irrigation accounts for 70% of global water withdrawals, industry for 20%, and municipal use for 10% (Gourbesville, 2008). Therefore, an appropriate framework is necessary to manage this shortage. Irrigation Water Management (IWM) is a combination of practices that control irrigation water to prevent pollution and reduce water loss. It also applies to the proper application of chemicals (pesticides or fertilisers) through the irrigation system. IWM also includes proper scheduling, efficient application, efficient transport systems, utilisation and reuse of tail water and runoff, and management of drainage water. Seepage-control practices (lining ditches with concrete or converting to pipe conveyances) greatly reduces leaching losses and decreases the availability of salts in canals for application (and runoff) from fields. The extent of irrigation development has major implications for other water uses, including water needs for cities, industries, and hydropower, as well as for national parks, wetlands, instream uses, and estuaries.

Implement agricultural drainage management within agricultural areas: Agricultural lands on hilly/sloped terrains are subject to soil erosion, especially during heavy rain. The soil erosion process can be properly managed by installing a suitable agricultural drainage system. It can appropriately guide the runoff in agricultural farms by providing a proper drainage system, lining the channel at in sloped areas, and paving the agricultural access corridor acting as a drainage system and installing sediment traps before the flow discharges to the river. Drainage developments generally are intended to improve agricultural productivity, but can have significant environmental effects, including both benefits - such as control of salinisation and water logging - and costs - such as reduction in water quality for downstream uses (Gourbesville, 2008). Agricultural drainage effluent has been reported to cause the problems of nutrient, pesticide and bacterial contamination of rivers and lakes (Madramootoo *et al.* 2007).

Create rural riparian buffer zones along the river: Vegetative strips along rivers, know as riparian buffer zones, can trap a large proportion of bacteria, nutrients, and sediment that would otherwise flow from agricultural fields. Gray (2005) has mentioned that creating 2 m to 5 m rural riparian buffer zones along the main river system can intercept sediments from farm catchments. Vegetated areas along a body of water containing a complex assemblage of organisms and their environment are typically part of a riparian system. It can be a complete ecosystem or function as an ecozone between aquatic and terrestrial ecosystems, but maintains a distinct set of vegetation and soil characteristics. The area is maintained in its native state at widths sufficient for pollution-control functions. Alternatively, Mille (2001) in a study about farmer participation in riparian buffer zone programmes, has found that lack of direct marketing of the programmes, concerns about ultimately losing control over part of the farm, and the management burden of maintaining riverside fencing can cause low participation rate of farmers to programme.

Implementation of Sustainable Land Management Practices

This section suggests the responses that local authorities could consider adopting when formulating policies to reduce the impacts of agriculture on water quality.

Establish and provide the Cameron Highlands technical advisory services unit: The local government or other related agencies should

establish a technical advisory services unit within the existing institutional setup that provides farmers free advice on soil-erosion control, best available management on agricultural practices, sustainable land-use practices and riparian management to avoid unnecessary discharges of excessive sediment loads into the rivers. The significant role of technical advisory committee has been highlighted by US EPA as agricultural best management practices improved water quality in headwaters of the Harpeth River in which considerable pollution load reduction has been achieved.

Develop demonstration farms in the Cameron Highlands: The DOA together with other related government agencies, such as Department of Irrigation and Drainage (DID), Department of Environment (DOE), and other local authorities should facilitate development of a **"**monitored farm**"** to demonstrate environmentally-sustainable methods of pastoral farming. The owners of the farm should work with the management committee, involving farming community representatives, and representatives of the sponsoring organisations. It was mentioned in Adroit Consulting Engineers (2004) that a specific objective of the monitored farm project is the development of practical indicators for sustainable farming systems. The project should also include an extension programme to encourage pastoral farmers to take up sustainable management practices. Information from the focus farms is to be transferred to other farmers in the area to raise awareness of sustainable management issues. ETESP Agricultural Review (2007) indicates training and technical support for farmers' groups in Indonesia have helped farmers establish their own demonstration farms, and serve as an example and model for other farmers' groups. Same report shows use of demonstration farms for rice and chili pepper production to illustrate new technology.

Provide incentives to encourage farmers to implement sustainable agricultural management practices: The government should provide a range of incentives to encourage sustainable management practices. Zalom (2001) indicated that the incentives can come in non-financial and financial approaches. The incentives should not be used to reward resource users for achieving an environmental bottom line or simply complying with legislation, they should be used to achieve positive environmental results over and above minimum acceptable standards. The main economic methods for addressing non-point source pollution from agriculture are taxes, charges and subsidies. Taxes increase the private costs of farming to reflect the true value (monetary and non-monetary) of resources to the community, including the costs of pollution on the environment (the "social costs" of the resources). Subsidies are payments to encourage behaviour that advances some public policy goal. They may be paid by an authority on behalf of the general public, or by the beneficiary of the activity.

Enhancement of Controls on Development Approval, Site Planning and Construction

The implementation of standard erosion and sediment controls on agricultural areas and construction sites will provide major improvements to the health of the basin. Likewise, greater consideration on the physical limits of land development in relation to slope stability, drainage and visual amenity in the development approval process will result in more sustainable and accepted development. Coordinated and concerted efforts are required by agencies to provide the necessary inter-government management structure, technical information and support to control land development, prepare and review Earthwork Plans, and install, monitor and enforce site controls. This comprehensive approach has to cover the main areas identified in the catchment objectives, namely land-use planning and controls, awareness, monitoring and enforcement (Spruill, 1990). Finally, it should be mentioned that it is not possible for a single agency to take responsibility for ensuring that erosion and sediment control is achieved on construction sites and from agricultural land. A number of agencies currently have regulatory and management responsibilities for approving, monitoring and/or enforcing controls, at the federal, state and local government levels. This existing system has to be built upon to substantially improve the application of controls.

Conclusion

Uncontrolled Agriculture practices, non-sustainable tourism and urbanisation activities have had a tremendous effect on the water quality of the rivers in the Cameron Highlands. A lack of enforcements, policy and mismanagement are found to be the main contributors to the above-mentioned problems. The implementation of a communication and community-education awareness strategy was proposed as being the most important approach to overcome these issues. Other than that, initiatives such as the application of good agricultural practices, performance of sustainable land-management practices and the enhancement of controls on development approval, site planning and construction could be suggested. For the water-quality improvement in the Cameron Highlands' rivers, the majority of recommended non-structural management practices take a longer time compared to structural management practices. Therefore, while the application of non-structural management will produce more fundamental approaches such as the education of farmers, public and authorities' awareness and pollution source control, for the short-term, the use of structural management such as proper sewage and river water treatment systems should be implemented.

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