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MALAYSIAN MEGA SCIENCE FRAMEWORK: THE NEED FOR SOCIAL IMPACT AND SUSTAINABILITY ASSESSMENT

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ABSTRACT

This review focuses on issues surrounding wastewater management as part of the National Sustainable Development (2013-2050) under the Malaysian Mega Science Framework. In line with the national priority area of water security, this review will highlight the technical reports compiled by the Academy of Sciences Malaysia (ASM) on the challenges of water resource development and wastewater management and treatment. The discussion will dwell on the social impact of pollution in water and wastewater and mitigation plans that need to be put in place to ensure sustainable national development and making water as a National Key Economic Area (NKEA).

Key Words: Mega Science Framework, Wastewater Management, Water Resources Development, Sustainable Development, Social Impact, Sustainability Assessment.

INTRODUCTION

The Malaysian Mega Science Framework was initiated by the Academy of Sciences Malaysia in 2011 with the objective of identifying Science, Technology, and Innovation (STI) opportunities and prepare recommendations and roadmap for short, medium and long-term (2011-2050). The aspiration of the Framework is the maximum use of STI in sustaining the country's development for a prosperous, peaceful and progressive country and its people in the next 50 years (Academy of Sciences Malaysia, 2014). One of the key rationales underlying this framework is that whereas science, engineering and innovation are increasingly central to sustainable development, elements of STI must be integrated into the national sustainable development plan in order to introduce rational policies that reflect better understanding of complex technical, economic, social, cultural and ethical issues concerning the society, the earth, and its environment. In 2011, the first phase Mega Science 1.0 focused on Water, Energy, Health, Agriculture, and Biodiversity and in 2013, the second phase Mega Science 2.0focused on Infrastructure, Housing, Transportation, Environment, Electrical and Electronics. The Academy hosted a series of stakeholder engagement workshops with scientists, practitioners, academics, government agencies, parliamentarians, and the general public to discuss issues and challenges (opportunities, benefits, barriers, problems) on current sustainable practices in order to generate recommendations for policy makers and responsible parties. Water pollution was one of the key issues raised for Water agenda in Mega Science I.0 as it was increasing parallel with the rapid development in Malaysia. This was further explored under Environment in Mega Science 2.0.Therefore, this paper explores the challenges of water resource development and wastewater management and treatment and the social impact of the recommended mitigation plans.

LITERATURE REVIEW

Water Resources Development

Comprising over 70 per cent of the Earth's surface, water is undeniably the most valuable natural resource existing on our planet. For Malaysia, the Water agenda of the Mega Science 2.0 highlights various challenges, specifically water pollution management within the context of water resources development. Water resources can be developed through water recycling, groundwater, rainwater harvesting, flood/runoff storage, desalination and atmospheric capture as shown in Table 1. Sim (2014) raised several concerns for sustaining the water resources, namely pollutants in wastewater through sewer mining and storm water recovery. Pollution of water resources is a common incident (Han and Wei, 2009; Li et al., 2010). Whereas many regulations such as the Environmental Quality Act (1974) are in place, Sim (2014) questioned whether they are effective in addressing water pollution either direct (point source pollution) or indirect (non-point source pollution) in Malaysia.

Table 1

Water Resources Development

	Water Recycling	Groundwater	Rainwater Harvesting	Flood/Runoff storage	Desalination	Atmospheric Capture
Source	Sewer mining. Stormwater recovery.	Aquifer abstraction/ recharge.	Rainwater capture and storage.	Divest runoff from river to holding ponds.	Removal of mineral from seawater.	Water abstraction from humid ambient air.
Uses	Indirect potable reuse (e.g. NEWater). Irrigation and factory process water. Recharging of aquifer augmenting environmental flow.	Industrial supply. Augmented potable supply. Bottled water. Aquifer storage and recovery. River bank filtration.	Supplement water supply (non-potable). Emergency storage. Reduced stormwater runoff into river.	Emergency storage for water supply. Augmenting water treatment plant operations. Reduce floods by diverting flood runoff.	Industry supply. Potable water supply.	Potable water supply. Doubles as an air conditioner (potable units) Available for small to large capacity units.
Issues	Efficiency of system to remove human pathogens and biological active molecules. Public perception.	Lack of regulations and enforcement of industry. Environmental degradation. Over exploitation. Transboundary aquifer.	Cost outlay for unit. Low water pricing makes this option not attractive. Mandatory requirements but not enforced.	Pollution issues. Large land area required. High capital cost.	High infra-structure and operational costs. Requires large amounts of electricity to run. Environmental issues – salt residues.	High energy requirement for harvesters. High cost.

Source: Sim (2014).

Pollution in Water and Wastewater

Water pollution can be derived from two general categories of sources: direct and indirect contaminant sources. Direct sources or point source pollution includes sewage outfalls from refineries, industries and waste treatment plants. On the other hand, indirect sources or non-point source pollution include contaminants that enter the water supply from ground water systems and from the atmosphere by rainwater (Zhao, 2010). Further, contaminants can be arranged under two broad classes, organic and inorganic. Some organic water pollutants include manufacturing solvents, inconstant organic compounds, pesticides (Zhao, 2010), insecticides (Xu et al., 2010) and food processing wastes, and others. Inorganic water pollutants consist of metals, fertilizers and acidity caused by industrial discharges (Vijayaraghavan and Yun, 2008).

Many industries are using metals extensively, including metallurgical, mining, electroplating, electronic and metal finishing. Metals are toxic both to lower and higher organisms. Occasionally metals may accumulate to toxic levels and cause ecological damage (Jefferies and Firestone, 1984). Metals such as lead, mercury, cadmium, chromium and uranium are regarded as toxic; whereas copper, cobalt and zinc are not as toxic. However their frequent usage and increasing level in the environment becomes an important issue (Brown and Absanullah, 1971; Volesky, 1990). They are not self-degradable and can accumulate in living organisms, causing severe disorders and diseases (Tran et al., 2010).

Water pollution impacts on the society, the earth, and its environment were further explored by the Academy of Sciences Malaysia in Mega Science 2.0. Water pollution will lead to reduced water resources, demand high economic cost for cleanup, contaminated lands and habitat degradation and the social impacts include social and health issues and lower quality of life in Malaysia. The Academy was driven to conduct a comprehensive review of the technical, economic, social, cultural and ethical issues concerning water pollution and recommend mitigation plans. The rest of this review will look at the wastewater management. The Mega Science 2.0 also calls for the implementation of the National Water Resources Policy (2012) and the National Water Resources Act to protect water rights for all, but more importantly to integrate the water resources management and wastewater management which are presently under different jurisdictions at the federal and state levels.

Wastewater Management and Treatment Technology

Technologies for treating industrial wastewaters are chemical, physical, and biological methods. Chemical methods include chemical precipitation, chemical oxidation or reduction, formation of an insoluble gas followed by stripping, and other chemical reactions that involve exchanging or sharing electrons between atoms. Physical treatment methods include sedimentation, flotation, filtering, stripping, ion exchange, adsorption, and other processes that accomplish removal of dissolved and undissolved substances without necessarily changing their chemical structures. Biological methods are those that involve living organisms using organic, or in some instances, inorganic, substances for food, completely changing their chemical and physical characteristics. As a general rule, biological treatment is more economical than any other type of treatment, when reasonably complete treatment is required, and whenever it can be made to work successfully (Woodart, 2001).

Conventional methods for removing metal ions from aqueous solution have been studied in detail, such as chemical precipitation, ion exchange, electrochemical treatment, membrane technologies, adsorption on activated carbon etc. However, chemical precipitation and electrochemical treatment are ineffective, especially when metal ion concentration in aqueous solution is as low as 1 to 100 mg/L, they also produce large amount of sludge to be treated with great difficulties. Ion exchange, membrane technologies and activated carbon adsorption process are expensive, especially when treating a large amount of water and wastewater containing heavy metal in low concentration, so they cannot be used at large scale (Wang and Chen, 2006). Much has been discussed about their downside aspects in recent years (Atkinson et al., 1998; Crini, 2006), which can be summarized as expensive, not environment friendly and usually dependent on the concentration of the waste.

Recently, research attention has been focused on biological methods for the treatment of effluents, some of which are in the process of commercialization (Anirudhan and Radhakrishnan, 2009; Bhatnagar and Sillanpaa, 2009; Dias et al. 2011). There are three principle advantages of biological technologies for the removal of pollutants; first, biological processes can be carried out *in situ* at the contaminated site; Second, bioprocess technologies are usually environmentally kind (no secondary pollution) and third, they are cost effective (Loukidou et al., 2003). In looking at waste or wastewater as resource, Sim (2014) highlighted the need to explore bio-effluent in reclamation for non-potable reuse of wastewater, or biosolids in nutrient recovery and soil amendments as well as biogas for renewable energy generation.

DISCUSSION

The preceding review highlights the challenges in water resources development and the need for further exploration of water pollution technology as mitigation plans to address the economic and social impacts of wastewater pollution. Among the many recommendations, the Mega Science 2.0 proposed several mitigation plans for the period 2013 to 2050 for Water and Wastewater Treatment System as shown in Table 2 (Sim, 2014):

Table 2

Mitigation Plans for Water and Wastewater Treatment System (2013 to 2050)

Timeline	Mitigation Plan
2013-2020	R&D for innovative watertreatment technologies, e.g. using solar enegy systems,recover useful byproducts, e.g. Methane, H2 gas. Improve efficiency andperformance of existingsewage treatment. More advance R&D onbio-solids and sludgemanagementtechnologies, e.g asfertiliser. Incentive for SME –wastewater treatment plant.
2020-2035	Pilot projects andefficiency assessment oftechnology. Combined sewer/stormwater systemsadoption – segregation fordesignated treatmenttechnologies – more efficient& economical.
2035-2050	Commercialization oftechnology and services. Industrial implementation of bioeffluent/biosolids/biogas systems. Water and EcologicalSustainability. Water and Wastewater. Treatment Systems.

Whereas these recommendations address the environmental impacts of reduced water resources, economic cost for cleanup, contaminated lands, and habitat degradation, much is left to be desired in investigating the social impacts of water pollution which give rise to social and health issues and lower quality of life. For example, there are environmental studies on the impact of pollutants on coastal areas such as the Tunku Abdul Rahman Marine Park (Md Suhaimi Elias et al., 2011). However, we need more broad-based social impact studies, for example Tran, Euan, and Isla (2002)on the impact of water pollution on the livelihood of a small coastal community whereby public perceptions of the locals were sought. They raised concerns about the need for environmental education and public awareness campaign as well as a well-planned moderate development plan. The same should be done in Malaysia through coordinated sustainability assessments and social impact assessments throughout the country. Singh et al. (2012) reviewed 41 indices from various sustainability assessment methodologies based on international efforts on measuring sustainability. However, only few of them have an integral approach of environmental, economic and social aspects. Further, Singh et al. (2012) argued that indicators of sustainable development should be selected, revisited and refined based on the appropriate communities of interest, thus the Academy will be best served by integrating sustainability assessment within the Mega Science Framework.

CONCLUSION

This review focuses on issues surrounding wastewater management under the Mega Science Framework (2013-2050) to ensure national sustainable development for Malaysia. In highlighting the issues and challenges of water resources development and wastewater management and treatment in the country, the mitigation plans recommended the Academy of Sciences Malaysia (ASM) can be further enhanced by integrating appropriate sustainability assessment methodologies and incorporate the social impacts of water and wastewater pollution to ensure sustainable national development.

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