FRESHWATER ECOSYSTEM: A SHORT REVIEW OF THREATS AND MITIGATIONS IN MALAYSIA

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Abstract

Freshwater ecosystem is an important ecosystem which provides humans and other organisms with basic necessities, such as water and food. However, due to increasing human population and demands, human exploitation has significantly changed the freshwater ecosystem, with changes affecting their physical, chemical, and biological characteristics. The freshwater ecosystem has been mismanaged for such a long time, leading to threats towards the ecosystem. In Malaysia, the emergence of harmful algal blooms, infectious disease, freshwater salinization, as well as climate change have threatened the freshwater ecosystem which consequently affect water quality and biodiversity surrounding the freshwater habitat. Increasing urban, industrial, and agricultural areas have significant effects on freshwater ecosystem, especially through soil leaching. Thus, mitigation steps are needed to reduce the effects of freshwater degradation, such as through education and awareness, research and monitoring, making polluters pay, and integrated holistic environmental management. These mitigations should be carried out by the responsible authorities, as well as all industries involved. Continuous monitoring involving technologies is recommended to monitor the current condition of freshwater ecosystem for further interventions.

Keyword: Aquatic, Lake, River, Stream, Water Supply, Water Management

Introduction

The Earth's aquatic ecosystems are a subunit of freshwater ecosystems which contain lakes, ponds, rivers, springs, bogs, and wetlands. They can be compared to marine environments, which have higher content of salt (Carpenter et al., 2011). Freshwater is spread around the globe unevenly. The 21 largest lakes on Earth contain two thirds of the entire global freshwater sources and engaged various ecological and social environments (Sterner et al., 2020). Freshwater habitats apply to all fresh or saline inland water bodies, including rivers, streams, wetlands, subsurface waters, and estuaries. The term 'inland water ecosystems' sometimes referred to as 'freshwater ecosystems' because they exclude saline ecosystems. (Driver et al., 2011). For global biodiversity, freshwater habitats are vital because they provide critical services to the environment. Studies revealed that freshwater environments are vulnerable due to the impacts of environmental change (Pinceel et al., 2018; Reid et al., 2019), which contribute to irreversible changes in the regime, through which biodiversity and ecological services can be lost (Hossain et al., 2018; Jarić et al., 2019).

The freshwater ecosystem can be separated into lentic (standing water) and lotic (flowing water). The lentic lake system is closely connected to the land surrounding it in its drainage basin and chemical ingredients carried to the lake by lotic river system. Freshwater ecosystem plays a fundamental ecological role and provide goods and services that are economically relevant. They provide aquatic plants, fish, reptiles, amphibians, birds, and mammals with important habitats to live and reproduce. Freshwater habitats provide tourist attraction areas, such as water sports and bird watching. Malaysia is well equipped with aquatic ecosystems, such as rivers, lakes, wetlands, swamps, mangroves, estuaries, lagoons, and seas. The aquatic environments and their services in Malaysia provide domestic purposes, agricultural irrigation, industrial food and water, medicine, energy, and transportation (Yusoff et al., 2006).

Increasing human exploitation has significantly changed the aquatic environments, with changes affecting their physical, chemical, and biological characteristics. Over time, freshwater environments have undergone significant transformations that have influenced their characteristics (Carpenter et al., 2011). Present-day human impacts to freshwater habitats include quick growth of substructures and changes in land use, wasteful use and over-abstraction of water, and contaminants. Combined with rising demand for water supplies, these risks intensify the problem of sustainable growth (Matthews, 2016). Most natural freshwaters are in flux, but there are also extremely large existing modifications on the freshwater ecosystem. The primary factors contributed to freshwater changes are climate, human modifications of water flows, land use and land use modifications, chemical inputs, aquatic invasive species, and human harvesting, including aquacultures (Carpenter et al., 2011). The freshwater ecosystem has been mismanaged for such a long time. Various ecosystem mismanagements exist, such as intentionally manipulating the structure of the freshwater ecosystem and adjusting human needs. Freshwater ecosystem is frequently contaminated due to various human activities, such as wide scale farming and industrial revolutions. Freshwater contamination is the defilement of non-coastal streams by materials which make them incompatible with their natural or purposeful use. Freshwater pollution may involve fecal wastes, chemicals, pesticides, petroleum, precipitates, or even warmed trashes (Li et al., 2016). Streams and rivers are obstructed because of highly toxic industrial discharges. Pesticides and composts used in cultivations, on golf courses, and residential yards contribute to an incredibly huge percentage of non-point source pollution (NPS). The NPS pollution is typically the outcome of land runoffs, rainfalls, atmospheric depositions, ventilations, leakages, or hydrological alterations (Vaughn et al., 2015). The NPS pollution is usually caused by rainfall or snowmelt during leaching process through the ground.

The mismanagement of the freshwater ecosystem should be restrained. Although freshwater ecosystem takes a long time to recover, it is crucial to conserve this ecosystem as it provides water supply, source of economy, and biodiversity. Striving for solutions that could assist the conservation of freshwater habitats and at the same time providing important human necessities are significant (Matthews, 2016).

Emerging Threats

Climate Change

Climate change is the biggest challenge to nature and humanity on the 21st century. Temperature record analysis in Malaysia indicates a warming trend. The temperature changes vary from +0.7° to +2.6°C for Malaysia, while precipitation changes from +0.7°C to +2.6°C. The relative humidity range is from -30% to +30%. This phenomenon has been shown to have a negative impact on ecosystems in Malaysia, including freshwater ecosystem (Rahman, 2009).

Around 50% of the world's freshwater fish species are endangered by climate change (Darwall and Freyhof, 2016). According to Gallardo et al., (2018), the current and future drivers and rate of freshwater biodiversity loss are poorly understood. Out of the 31 ecological structures that direct the production of the freshwater ecosystem from genes to

populations, 23 are influenced by the environment, including decreases in body size, changes in distribution and improvements in phenology, algae growth and desynchronization of inter-specific interactions (Scheffers et al., 2016).
Climate change, if combined with other human-related impacts could cause alteration in species distributions, population declines, and local extinctions (Jarić et al., 2018). For example, deforestation with climate change could further reduce oxygen level in freshwater habitat, connectivity loss that affects the presence of fish hosts, and in extreme cases could cause desiccation of freshwater ecosystem (Hastie et al. 2003). Different species have different threat level, thus it is important to identify research and management priorities in deterring effects of climate change on biodiversity (Jarić et al., 2018).
The presence of invasive species further threatened the native species in freshwater ecosystem in the occurrence of climate change (Gallardo et al., 2018). These invasive species do not only compete, but also threaten the native species to obtain food and habitat.

Infectious Disease

Freshwater is also a source of transmission for human and animal pathogens (Johnson and Paull, 2011). In regard to the significant of water to the sustainability of most life forms, freshwater habitats often serve as healthy yet localized as multi-species hub interactions. The freshwater environment also encourages the production of several parasite infectious stages, either directly or indirectly through ingestion, as well as the potential for interaction with potential hosts (Marcogliese, 2008; Johnson and Paull, 2011).
In certain cases, freshwater biodiversity may be significantly impacted by infectious events. There are several diseases that threaten the freshwater habitats in Malaysia. Virus related diseases, such as *Iridovirus* disease, *Betanodavirus* disease, *Ictalurid herpesvirus 1* (channel catfish virus), *Cyprinid herpesvirus 3* (Koi herpesvirus), herpesvirus diseases, and Tilapia Lake Virus Disease affect freshwater fishes; while white spot syndrome, white tail disease, infectious hypodermal and haematopoietic necrosis disease affect crustaceans. Meanwhile, bacterial related diseases recorded in Malaysia are, such as viriosis, acute hepatopancreatic necrosis disease, streptococcosis, edwardsiellosis, piscine tuberculosis, and motile Aeromonas Septicemia (Chiew et al., 2019).

Harmful Algal Blooms

Harmful algae blooms (HABs) are a natural occurrence caused by an increase in the abundance of microalgae in aquatic environments. HABs combined with global climate change could cause acidifying, warming, and deoxygenating of freshwater ecosystem (Griffith and Gobler, 2020).
HABs have increased in frequency and severity in Malaysia, involving more species that were previously unknown. Factors contributing to increasing algal blooms are industrialization, urbanization, and commercial agricultures which have caused nutrient run-offs and nutrient enrichment in freshwater environment (Teen et al., 2012). High effluents from domestic wastes have changed the concentration and composition of nutrients in the freshwater ecosystem, triggering blooms of some tolerant algae species (Adam et al., 2011). As a result of the decomposition process of these blooms, massive fish kills had occurred in Malaysia since 2002. Thus, HABs cause uncertainty risk which can give an unforeseen loss if problem arises (Mohyedin et al., 2019).
The blossoming event in Penang, Malaysia from 2005-2006 was an example to be learned for several aquaculture operators. Most of the finfish farming in the region was intended for export purposes. Increasing finfish aquacultures for domestic consumption and export demand have been identified in playing a significant cause of increasing HABs in Malaysia. Tremendous fish kills have been recorded from the region with losses estimated at no less

than RM 20 million (Teen et al., 2012). About RM 700 thousand loss was reported by the Johor Fisheries Department. In South China Sea, flowers of *Noctiluca scintillans* are associated with enormous kills of fish and marine invertebrates (Huang and Qi 1997), and the presence of this species on the Malacca Straits is a regular occurrence (Razali et al., 2015). Inadequate research on this specific species in our waters has not been able to link this species to massive fish kills in the straits. Thus, responsible authorities, as well as the industries involved should treat HABs seriously. Besides, HABs are not the only factors that pose adverse effects on the natural environment. Shellfish contamination from several types of neurotoxins could also cause seafood poisoning, in which severe cases of hospitalisation were reported (Teen et al., 2012).

Freshwater salinization

Freshwater salinization is a process of salty runoff into the freshwater ecosystem. There are two sources of freshwater salinization, namely natural factors (primary salinization) and anthropogenic activities (secondary salinization). This process is recognized as a significant land degradation process (Hashim, 2003). Freshwater salinization could decrease species diversity, thus dramatically change trophic processes by reducing consumer food sources (Finlayson et al., 2013). Salinization can cause density stratification, anoxifying surface sediments, and changes in freshwater plant communities (Davis et al., 2010). Biodiversity living in high salinity freshwater patches is predicted to decrease gradually (Mausbach and Dzialowski, 2020).

Freshwater salinization is detected by measuring electrical connectivity (EC) in any changes related to plants' appearance, vigor, and crop yield planted in land that is prone to salinity problems (Hashim, 2003). In Malaysia, areas that have high salinization are along the coastal areas, especially in west Peninsular Malaysia, the east coast of Sabah, the deltas and coast of Sarawak. For inland water, Cameron Highland, Pahang located in central Peninsular Malaysia is identified to be the active area of salinization. Intensive cropping, high rate of fertilizer and manure applications for vegetables and flowers in Cameron Highlands have contributed to saline soils which are further deposited into freshwater bodies. The use of plastic protective structures commonly known as 'rain-shelters' has intensively lead to salinization process in Cameron Highlands because salts accumulated in soils without leaching due to total exclusion of natural rainfalls (Hashim, 2003). Besides, high intensity of land use is the main reason of saline soils in inland waters.

Local salinization relief can be done by managing the extraction of salts from point sources or pumping groundwater into lower water tables. Strategic release of freshwater may be successful at a more localized level. However, other substantial costs may appear, such as the cost of not using the freshwater release for environmental or consumer purposes (Herbert et al., 2015).

Mitigation steps

Integrated and holistic environmental management

Integrated environmental management (IEM) is a comprehensive administration strategy that has evolved to tackle complex terrain and water management issues in many countries. The IEM aims to integrate management activities through stakeholder panels consisting of members of the government and non-government agencies (Margerum and Hooper, 2001). Currently, with intentions for protection and conservation of natural ecosystems, aquatic ecosystems are controlled by different agencies. The fisheries sector is managed by the Department of Fisheries, the State Department of Water Works for water supply, and the Department of Forestry for the forestry sector. In addition, land issues are under the control of the authorities of the state. The water scarcity for domestic and industrial purposes has primarily led to insufficient watershed management. For instance, the drying up of the Durian Tunggal Reservoir in Malacca in 1991 and water pollution at the Hulu Langat reservoir were examples of bad water management. A desegregate and systematic approach to environmental regulation should be practiced to protect water resources and to increase aquatic ecosystem productions, while resolving problems composed by competing functions and priorities of various sectors within the country (Yusoff et al., 2006).

Education and Public Awareness

Environmental education plays an effective role in promoting healthy awareness and preparing the required knowledge. Environmental education enables a person to understand the natural environment, which in return provides the society with spiritual, aesthetic, and ethical values. It is important to improve awareness campaigns for policy makers, government officials, and the public. Although the current high school curriculum has emphasised environmental education, more programs from the private sector should be introduced and provided to the public. Public engagement should be encouraged in the drafting and management of environments, such as marine ecosystem and resources. Non-governmental organisations, for instance the Malay Nature Society and Marine Science Society of Malaysia, should play a greater part in raising public apprehension of aquatic issues (Yusoff et al., 2006).

Make Polluters Pay

In early times, pollution was not a significant consequence in Malaysia as Malaysia was an agrarian region. However, nowadays with swift industrialization, pollution in Malaysia is now becoming a serious issue. In the late 1997, our country had experienced the worst air pollution in its history, along with the contaminations of drinking water by diesel oil which had caused public misery, costing factories, and businesses loss in millions (Yusoff et al., 2006). Simultaneously, 23 out of 27 potable water sources in Selangor was confirmed to have been contaminated by industrial and animal wastes, heavy metals, and sewages (Rajah, 1997). Therefore, it is fair enough to make polluters pay for the loss of resources to discourage pollution. Heavy sanctions would be a quick lesson. In Japan, the process of remedying environmental pollution costs about 100 times more than paying preventive steps (Yusoff et al., 2006).

Research and Monitoring

For appropriate planning and management strategies, research and monitoring of aquatic ecosystems and their reservoirs are required. In Malaysia, the Department of Environment (DOE) and the Malaysian Centre for Remote Sensing (MACRES) are two of the most crucial agencies that monitor land degradation, including freshwater salinization. The DOE regularly monitors condition of the major rivers and issues reports on the problems, such as pollution and sedimentation rate (Hashim, 2003). The DOE had a total of 927 monitoring stations on 120 major streams, 79 wells and 219 marine stations, including islands in 2002. In areas with major reservoirs and swamps, additional monitoring stations are needed.

The Bera Lake Declaration in Bera Lake, Pahang with its area of vicinity of about 260 km^2 for conservation purpose in 1994 should serve as a model for sustainable operation of wetlands in Malaysia. In addition, institutions should be encouraged to perform research on the production of affordable aquatic pollution reduction technologies (Yusoff et al., 2006). Moreover, obstructing aquatic pollution needs continuous monitoring and inventorying processes. Bio-monitoring is recommended for assessing biological and ecological components of aquatic contamination with the aid of bio-indicator species. The techniques used in bio-monitoring of aquatic ecosystem include bio-accumulation, biochemical alterations, morphological and behavioral strategies, population and community level modus operandi, and in vitro toxicity tests of aquatic species. Bio-monitoring via bio-accumulation has gained recognition compared to other bio-monitoring techniques in Malaysia. Aquatic ecotoxicological research study is scarce in Sabah and Sarawak, compared to Peninsular Malaysia (Prabhakaran et al., 2017).

Conclusion

In conclusion, the freshwater ecosystem should be continuously monitored and preserved to create a balance community, environment, and ecosphere. Although the global climate change and temperature continues to increase, the current human-based activities that threaten the freshwater ecosystem should be monitored and reduced. Significant changes might cause severe effects towards organisms, including humans. The freshwater ecosystem should be well protected and conserved by all sectors and industries as it provides sources of water, food, and income. Allocations should be provided for research and activities that contribute to sustainable use and intervention of the freshwater environment. Any problem regarding to the freshwater environment should be well treated for future uses and generations.

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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