

Lakes and Reservoir in Malaysia: Management and Research Challenges

Zati Sharip* & Salmah Zakaria

National Hydraulic Research Institute of Malaysia (NAHRIM), Lot 5377, Jalan Putra Permai, 43300 Seri Kembangan, Selangor Malaysia

*Corresponding author: Email: zati@nahrin.gov.my

ABSTRACT

“Lakes and reservoir are important water resources in Malaysia. Rapid pace of development surrounding many of the lake catchments has had significant effects on the quality of the water body. This paper looks into various studies on the status of lakes and reservoir that have been carried out in Malaysia. It detailed out some of the major issues and problem faced in the areas of lake research, management, governance, capacity building, information management and stakeholder participation. The paper concludes with strategies and plans to be consider as the way forward to overcome the issues.”

Keywords: Eutrophication, research, management

INTRODUCTION

This paper appraises some of the past studies that have been carried out in Malaysia and synthesise the overall findings from paper presentations and discussion in the Colloquium on Lakes and Reservoir in Malaysia held in August 2007 at Putrajaya, Malaysia.

IMPORTANCE OF LAKES

Lakes and reservoir are important sources of water in Malaysia and can have multipurpose functions. They formed part of storage basins for municipal and industrial water supply, agriculture and hydropower. Some lakes and reservoir were constructed as flood control detention storage to buffer the different flow during dry and wet season, although most of them, currently have multipurpose functions. Water bodies are also created when silt retention/detention basins are constructed in urban areas. Hydropower in Malaysia contributed about 8% of the energy requirement in year 1998 (Ministry of Energy, Water and Communication 2007). Lakes and reservoir also support important ecosystem and repository of biodiversity of rare, endemic and endangered species. Due to its economic potential, many lakes and ponds have become popular tourism and water-based recreational sites or sports- or commercial-fishing activities, expanding the water needs and creating conflicting water uses.

Generally, natural lakes are few in Malaysia and mostly form as part of swamp wetlands. A wetland of international importance, Lake Bera, was accepted as Malaysia's first RAMSAR site in 1995. At the same time a number of man-made lakes were created to fulfil the needs of the nation. Not less than 73 man-made lakes have been created for water supply, irrigation hydropower generation, flood

mitigation and others. Distribution of major lakes and reservoir in Malaysia is shown in Figure 1.

Limnological Studies of Freshwater Lakes

Limnological studies of the freshwater lakes in Malaysia was reported to have begin in the early 1970s (Ho 1995), with Lake Bera studied intensively under the International Biological Programme/Productivity of Freshwater Communities (IPB/PF) Program followed by studies of other shallow lakes such Paya Bungor and Ulu Lepar wetland. Two reviews of past studies on lakes in Malaysia (Ho 1995, NAHRIM 2005) showed most of studies that have been carried out concentrates on fisheries and aquaculture, water quality analysis and flora and fauna. Following the successful completion of the Malaysian/Japanese IBP/ PF Lake Bera Project in the late 1970s, another limnological study of a similar scale and nature has been carried out in Kenyir Reservoir in 1990s. Loagan Bunut is another lake which has been selected as one of the demonstration sites under a five-year (2002-2007) UNDP/GEF Funded Peat Swamp Forest Project which aims to promote the conservation and sustainable use of the highly significant and fragile ecosystem of tropical peat swamp forests in Malaysia.

In the NAHRIM desk top study of 2005 which covers 90 lakes and reservoir, more than 80 studies on 30 lakes and reservoir in different parts of the country, were reviewed. Main focuses of the studies were fish and aquatic fauna which include suitability of lakes for fish development and analysis of fish communities and diversity in more than 20 lakes. Water quality studies that have been looked into include water quality analysis, pollution source identification and water quality improvement techniques.

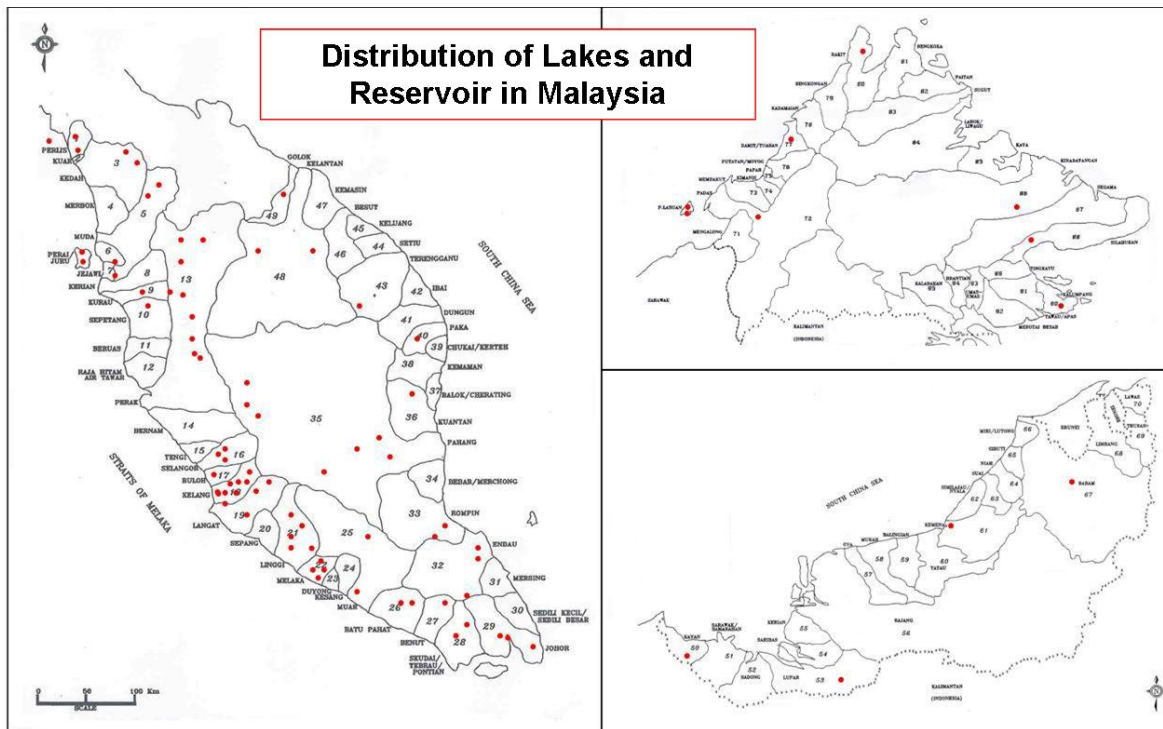


Figure 1: Distribution of Major Lakes and Reservoir in Malaysia

A comparison between reviews by Ho (1995) & NAHRIM (2005) showed studies on lakes has diversified from taxonomic and basic identification of the flora, fauna and fishes community and water quality analysis to application of technique to improve lake quality as well as development of model to understand the relationship between pollution source and ecosystem.

Status of Lakes and Reservoir in Malaysia

Lakes and reservoir all over the world experience different problem. Common problems include eutrophication, sedimentation and weed infestation. Eutrophication of lakes, which is known as a prevalent global concern in lakes and reservoir, is also a critical issue in Malaysia. The preliminary desk top study on the current status of eutrophication of Lakes in Malaysia indicated that more than 60% of the 90 lakes reviewed in the country, is experiencing eutrophication (NAHRIM 2005, Zati & Zulkifli 2007). Different lakes show different symptom of eutrophication. Phytoplankton blooms were not widely reported but macrophyte blooms are common occurrence in some lakes and ponds. Majority of lakes encounter threats arising from within lake drainage basins as well as in-lakes problems. Degradation threats from within lake drainage basin include excess sediment and non-point sources inputs associated to rapid development and changes in land use as well as pollution from agrochemical and sewage effluent. In-lakes problems

reported were weed infestation, and nutrients from fish cages.

Detail studies on a few major lakes in Malaysia show different level of degradation. Deterioration of water quality and water quantity was reported in all three biggest natural lakes in Malaysia; the Lake Bera (Chong 2007), Lake Chini (Mushrifah 2007) and Loagan Bunut Lake (Rahim Nik et al 2007). The main source of degradation includes surface run off containing nutrient-rich water from nearby plantations, sewage from communities living around the lake, logging activities and oil discharges from motorboats. Changes in land use within the three lakes catchment were widespread where part of the watershed consisted of secondary and primary forests were converted to agriculture areas specifically the oil palm plantation. Decreasing amount of water levels was also reported in Lake Bera and Lake Chini affecting transportation and natural resources.

Indicators suggesting water degradation in Lake Bera includes higher presence of nutrients; phosphorous, nitrogen and ammonia in the water (Chong 2007). High coliform and faecal coliform were of concern in Lake Chini. Preliminary findings in 2003 showed the total coliform counts and faecal coliform counts exceeded the Malaysia's Interim National Water Quality Standards for recreational activities subsequently indicated the unsuitability of the lake for recreational purposes (Mushrifah 2007). Sedimentation by surface run-off is a major problem for Loagan Bunut lake. Rapid land development activities upstream were reported to contribute substantial sediment to the lake bottom, threatening

to fill up the lake within 60 years (Abdul Rahim et al, 2007). The level of heavy metal such as lead in the lake sediment was relatively high due to discharge by motorised boat that navigate in the lake and the adjacent waterways.

All three natural lakes also experience fish and phytoplankton diversity change and shift in species composition. Phytoplankton species that are more tolerant to pollution, such as *Euglenophyta* and *Pyrrophyta*, are found in areas of high human disturbance (Chong 2007). Studies on the diversity of fish in Lake Chini indicated that only 28 species have been recorded, compared to actual recorded species at 84 species (Mushrifah 2007). A number of freshwater fish species native to the lake such as *Scleropagus formosus* was no longer in the existing list of Lake Chini. Diversity issues was also reported in Loagan Bunut, with an increase in “trash” species such as the kissing gourami (*Helostoma temminckii*), and carnivorous species such as the snakehead (*Channa sp.*). Sedimentation, which robs the spawning grounds of many species and contributes to the anoxic levels of the lake during low flows were suggested by Abdul Rahim et al (2007) as part of the reason for the decrease in the fish population. Other suggestion to the changes in fish diversity in Loagan Bunut was partly due to over fishing by the local to meet the increasing market need as well as growing fishing community. The changes in water quality in Lake Chini were suggested to have encouraged the foreign species *Camboba furcata* to flourish in the lake (Mushrifah 2007).

Deep man-made lakes especially created for hydropower generation are experiencing stratification problem. In Lake Kenyir, strong thermal stratification was reported with an anoxic hypolimnion during both dry and wet seasons (Fatimah et al 2002). Despite limited aerobic condition with availability of oxygen between 10-15 m layers above the metalimnion, Lake Kenyir is known to having diverse of high commercial value of fish stock. Lake Kenyir is popular with sport-fishing and intensive cage aquaculture activities. Such activities provide nutrient rich environment which encourage localised eutrophication within the lake. Infection of fish species were also reported (Molnar et al 2003) in Lake Kenyir. Decrease in biodiversity due to over-fishing, eutrophication due to nutrient-rich water from ecotourism and agriculture activities and siltation as a result of logging in the upstream areas are some of the threats for Lake Kenyir. The relatively anoxic environment of the large portion of waters in Lake Kenyir will hasten eutrophication of the reservoir if there is no effective control of nutrient loading into the reservoir (Fatimah 2007).

Other artificial lakes created for irrigation and water supply also experience similar threat. Pilot caged aquaculture projects are a big threat for Muda and Pedu dam. Muda Dam is also subjected to eco-tourism activities by Ulu Muda tourism development

which promotes nature tours, recreation and outdoor activities, education and rural tourism. Sedimentation study for Muda Dam showed sedimentation is not likely to reduce the active storage of the reservoir (Chiang 2007). High soil erosion and turbidity was reported in Pedu Dam in 1993-2003 due to underwater logging activities. Anthropogenic activities especially agricultural and urbanization within the upstream catchment was the biggest threat for Timah Tasoh Reservoir (Wan Ruslan 2007). Sedimentation rate was reported to be relatively high during the dry year. Availability of wetlands and riparian plants, however, has contributed in controlling the water quality of Timah Tasoh by diminishing the amount of suspended solid and nutrients downstream.

Lakes surrounded with intact natural forest vegetation such as Ahning Reservoir have good water quality and suitable for water supply for domestic and industrial use (Chiang 2007). At present, there is no threat due to none development except only small scale fishing activities by local fishermen. Most lakes and reservoir in Malaysia, however, has no record on soil erosion as soil erosion study was not yet been carried out.

Climate change or global warming is another threat seen as to be affecting the lakes and reservoir problems in Malaysia. Changes in the rainfall pattern and intensity provide challenges for the functioning of the lakes in controlling the flood and drought, as been experienced in different part of the country.

Issues and Challenges

Focusing on the current lake problems in the country, the main issues and challenges is discussed under the sub-headings of lake research, lake management, governance, stakeholder participation, capacity building and information management.

Lake Research

Limnological studies on lakes or the lentic system have been carried out in many lakes in Malaysia but the publications of these studies were very limited. Majority of the studies appear to have been carried out in universities and government institutions mostly on individual basis and confined to their objectives and interests (NAHRIM 2005). Research on man-made aquatic ecosystem were reported to be sporadic and rudimentary (Ho 1980). There is also no national body for coordinating lakes research (Ho 1995, NAHRIM 2005). Most of the current research focuses on aquatic pollution and water quality, water resource development and management and biodiversity. Main environmental issues concerning lakes include eutrophication, inorganic pollution, sedimentation and siltation, over-exploitation, loss of biodiversity, habitat change, aquatic plant infestation and introduced species.

There is a need to identify gaps in terms of research and management. The preliminary studies have shown a large gap in information and understanding of tropical lakes in comparison to temperate lakes (NAHRIM 2005). There is also a need to identify focus areas. Areas of concern include physical limnology, lake modelling, biodiversity and effects of exotics fauna and flora. There is also a need to study the carrying capacity of the lakes.

There are still gaps in terms of nutrient budget and trophic relationships amongst food-web organism in almost all lakes in the country (Ho 1995). Assessment on knowledge gaps between lakes and reservoirs in Malaysia and those in developed countries indicate further research needs in the areas of physical characteristics of lakes and pattern of stratification, improvement of monitoring and assessment methods and development of mathematical models for lakes and reservoir (Zati & Zulkifli 2007).

There is a need for comprehensive planning and coordination for development of long-term integrated multidisciplinary lake research programs. A holistic approach is needed to achieve specific targets. Adequate technologies and financing is also essential for the success of any restoration and conservation effort. There are few sources of funding available in terms of lake research in Malaysia which includes government funding through 5-year Malaysian Plan, Intensification of Research in Priority Areas (IRPA); E-science, Fundamental Research Grant Scheme (FRGS), National Biotechnology Directorate Development Grant (NBD) as well as private and International funding such as Global Environment Facility (GEF), European Union, Japan Society for the Promotion of Science (JSPS) and Japan International Cooperation Agency (JICA).

Lake Management

Proper management of lakes depends on the uses of the lakes. Lakes which were designed for different recreational and tourism activities require good quality of water and ecosystem. Majority of lakes in Malaysia lack adequate mechanism for managing lakes. Development of wetland parks enable nature to be introduced into urban fabric. Wetland acts as natural filter, improving the water quality and providing a sustaining environment for flora and fauna. Management measure on lakes and reservoir requires understanding of key processes that drive the ecosystem. Management of lakes and lacustrine wetlands requires preserving the health of aquatic life, protection of rare and endangered flora and fauna and habitat enhancement for birds and fishes. Development of an integrated system of the wetlands and lake management will ensure sustainability of management measures.

A good management practices requires development of vision and comprehensive strategic plan and formulation of a long term lakes or reservoir catchment development and management plan. Active participation of all stakeholders within the catchment is also crucial to ensure proper implementation of the catchments management recommended programs. There must be mechanisms to control the use of fertilizer, detergent and sewage inputs. There is a need for comprehensive monitoring program which includes water quality and habitat of flora and fauna either in the form of scientific physical and biological monitoring programme.

Currently, there is no comprehensive monitoring program carried out in majority of lakes in Malaysia. Catchment development plans are yet to be formulated for most lakes within the country. Only Putrajaya Lake Catchment has a comprehensive Catchment Development and Management Guidelines, which defines the land-use, drainage and sewerage master plans, comprehensive monitoring program as well as integrated regulatory control for areas outside Putrajaya integrating to the pertinent master plans for Putrajaya (Zaharah 2007, Akashah 2005).

Governance

Governance of inland water in Malaysia involves many sectors and thus forms the biggest challenge to ensure sustainability. Under the Federal Constitution (revised 1998), land and water resources are under the state jurisdiction thus there is segmentation in terms of ownership and management of water resources and water supply (Salmah & Zati 2007). There is also separation of powers in terms of management of lakes of different types of uses. Lakes that fall into natural water courses are under the responsibility of Drainage and Irrigation Department while wetland are either under the management of Wildlife Department, state government, Non-Governmental Organisations (NGOs) or RAMSAR. Dams and reservoir created for water supply are governed by the various water supply departments, authorities or private concessionaires while dams and reservoir created for generation of electricity is being managed by the National Electricity Board.

Major governance problems include pollution issues, eutrophication (agriculture, sewage, wastewater), Stakeholders' conflicts, invasive species, development within Lake Basin and increased of water demand.

In terms of legislations, development and management of lakes are subjected to various water and environmental laws. Some of these laws were formulated before independence and need to be revised or supported with sufficient enforcement capabilities. The laws that are indirectly related to lakes and its catchment include the Environment

Quality Act 1974 and Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987, National Forestry Act 1984, Fisheries Act 1985 (Fisheries Maritime Regulations 1967: Amended 1987 and Fisheries: Marine Culture System Regulation), Town and Country Planning Act 1976, Land Conservation Act 1960, Water Act 1920 (Revised 1989), National Land Code 1965 and National Parks Act 1980.

The National Physical Plan (NPP) coordinating land development throughout the Peninsular of Malaysia in more sustainable manner was introduced in 2006. Important measures promoted include the establishment of environmental sensitive areas and central forest spine that protect water catchment, minimise pollution and preserve biological diversity. Environment-related policies having impact on lakes include the National Forestry Policy (1978), National Energy Policy (1979), National Policy on Biological Diversity (1998), National Policy on the Environment (2002) and Third National Agricultural Policy (1998-2010). EIA Guidelines for Dams and/or Reservoir Projects published in 1995 provides information on procedural requirements for the planning, development and maintenance of man-made lakes.

In general, there are insufficient governance and accountability systems for lakes in Malaysia. Specific laws on lakes are currently not available. There is also no specific national water quality standard which requires stringent control of parameters such as nutrient, formulated for lakes. Only Putrajaya Lake has its own specific water quality standard. It is recommended that a national policy to be formulated to consolidate the various laws, regulations and enactments that govern water resources (NAHRIM 2005).

Stakeholder Participation

The success of any lake management depends on the participation of the stakeholder. Every individual and organisation either in the public or private sector contributes to the release of pollutants which affects water bodies through generation of waste and alteration of natural environment. Conversions of forest and development within the catchment area for urban and agriculture practice creates conflict to the sustainability of pristine environment. The role of managing and preserving the whole lake catchment requires awareness and participation of every stakeholder. Level of awareness and participation of public in conservation efforts especially for lakes are generally still very low.

Many Non-Governmental Organisations (NGOs) are actively involved in various environmental issues and protection and conservation efforts as well as creating awareness among the public. This includes Malaysian Nature Society, Environmental Protection Society of Malaysia,

Sustainable Development Network Malaysia, Sahabat Alam Malaysia, Wetland International and Water Watch Penang. Major activities of NGOs includes awareness raising, community development, capacity building, fund raising and campaigning on a broad spectrum of issues and initiatives, ranging from environment, community, health, governance, ecotourism and sustainable livelihood. Efforts that are being conducted by various NGOs in Malaysia include Saves Lake Campaign in Lake Chini, Save the Belum Temengor Forest Complex, and setting up of various Community Information and Education Centre.

Despite increasing involvement by NGOs in the environmental awareness and conservation effort, there is a need to establish platform or committee integrating all stakeholder of a lake basin to participate and to foster good framework of relationship in monitoring and enforcement among agencies, organisations and sectors (NAHRIM 2005).

Capacity Building

Rapid degradation or eutrophication of lakes and reservoirs in Malaysia which cause short lifespan of lakes is major prevalent issue. There is also issue in terms of availability of knowledge and understanding on lake processes based on tropical lakes. Most management strategies that are available are based on temperate knowledge of lake processes. There is insufficient in-depth knowledge of limnology for Malaysian lakes. There is also no integrated, multidisciplinary approach. Participation of stakeholders in conservation efforts and availability of management tools and technologies is needed to enable sustainable management of lakes and reservoir.

Capacity building should be carried out at various levels. At present, there is an increasing development of capacity building in universities. Most public Institute of Higher Learning offer courses in aquatic sciences and engineering as subjects in environmental, ecological or engineering based programmes. Various training programmes are available at a few universities such as Universiti Malaya, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia and Universiti Sains Malaysia (Ho 1980). However, there are not that many courses which are developed as an entire programme. Most of the approach taken in the public universities is too academic and theoretical with insufficient application taught and no hands-on training in industry. Private universities and colleges, in contrast, rarely seen to undertake such programmes due to high course to run the course while graduates were seen as not marketable.

Major recommendation to address the issue is the need to redesign the curriculum towards multidisciplinary and integrated approach. There is also a need to encourage life-long learning and

capacity building at all levels and awareness programmes to local communities as well as sustainable utilization of water bodies.

Information Management on Lakes

Information management on lakes in Malaysia is very limited. No lake has been studied extensively on integrated approach to enable the database of the lakes and reservoirs in Malaysia to be properly developed (NAHRIM 2005). At present, there is no systematic effort to compile and share information on all lakes in Malaysia. Comparative analysis of trends is not able to be carried out as there is no agreed template of information to be collected. Thus it is difficult to gain new insights of the major problem. There is also no central, national repository for information on lakes in Malaysia. Dissemination of knowledge to suit the layperson is also limited due to unavailability of suitable materials.

The Way Forward

Many efforts are being pursued to address the lake eutrophication issues. One of the efforts that have been carried out is the organising of a national lake colloquium with the support of the Ministry of Natural Resources and Environment. The colloquium aims to foster greater awareness on the status and issues pertaining to lakes and reservoir in Malaysia through sharing the findings of past and current research activities and lake management practices. The colloquium's stakeholder discussion has resulted in the setting up of Lake Technical Committee which formed as a platform to develop a framework for sound lake management and to move forward the related research agenda. A series of workshops will be organised to develop strategies and action plan involving various stakeholders to enable integrated governance and management of lakes and its catchment based on the basin concept.

In addition, the colloquium provide a reference material on the subject through development of proceeding which subsequently form a practical information in planning further actions and programmes towards sound management of lakes and reservoirs in the country. A coffee Table book on lakes is being pursued and targeted to increase awareness among public and various stakeholders on the importance and value of lakes in Malaysia. It covers selected natural lakes and man-made reservoirs.

In-line with the need to develop strategic information and knowledge management including development of a database; a Lake Data Repository which includes development of booklet is being pursued by National Hydraulic Research Institute of Malaysia. The repository will be based on the 90 lakes inventoried in the preliminary study on the status of eutrophication of lakes by NAHRIM. The

information from Lake Data Repository will be used for monitoring purposes as well as to guide management effort and measures needed to restore and conserve lakes sustainably. It will also steer further researches needed to look into the various issues on lakes in the country.

One of the reasons for the setting up of the National Hydraulics Research Institute of Malaysia (NAHRIM), in 1995 was the impact of global warming looming in the background. The effect of global warming and rapid economic development has an impact to the growth and lake water quality. To meet the need to establish a centre to coordinate research in lakes, the government has established a Lake Research Unit within National Hydraulic Research Institute of Malaysia, to act as the focal point in coordinating lake research in Malaysia. Results from integrated research programmes will be instrumental in guiding the governance and management efforts.

CONCLUSION

A preliminary study on lakes in Malaysian has shown that eutrophication is a major problem of lakes in Malaysia. Rapid development through conversion of catchment area to agricultural and urbanization has a great effect to the quality and quantity of water. Different lakes experience different level of degradation and eutrophication. Awareness on the eutrophication issues is still very limited despite increasing threat to the water bodies. Barrier and large gap existed in terms of lake research, management, governance, information management, stakeholder participation and capacity building. Measures that are being carried out to address some of the threat include increase awareness through development of reference materials for both technical and public besides improve information management on lakes through development of data repository to enable collection of data which can be used for monitoring purposes. A specific research unit on lakes has been set up to coordinate research efforts among the various institutions of higher learning, research institutes and government departments subsequently assist lake management efforts through dissemination of research findings.

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