Sustainability in Water Resources Management in Putrajaya Wetland: Impact Assessment on New Emerging Pollutants

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Abstract. Putrajaya Wetlands in Putrajaya which is the first man-made wetland in Malaysia is believed to be the largest constructed freshwater wetlands in the tropics. Nowadays, the wetlands around the world continue to decrease and being destroyed. Human activities cause wetland degradation and loss by changing water quality, quantity, and flow rates; increasing pollutant inputs and disturbance from construction within the area. A degraded wetland is less able to effectively perform with its normal functions. For this reasons, wetland degradation is as big a problem and need to be overcome systematically. Therefore, it is very important to implement certain changes within the water resource management regarding the problem of water quantity and water quality. This researchwill be conducted by sketching the existing water management in Putrajaya Wetland, analysing based on sustainability concept and modify the existing water management due to new emergent pollutant. The effectiveness of the water management can be assessed by implementing interview, data collection, lab analysis, and duplication of technologies used by other countries in dealing with any potential threat towards the lake and wetland. Based on the information gathered, we can identify whether the existing water management can be sustained in dealing with potential threat of different pollutant sources thus considering new emerging pollutants. The survival of the water management in the future depends on the ability of PPJ to obey with the pillars of the sustainability concept and consider potential threats from new emerging pollutants such as PAH.

Introduction

Presently, the area of Putrajaya Wetland consist of about 30% area of catchment managed by the authority meanwhile the other 70% is controlled by the existing land owner there [1]. Due to rapid development in Putrajaya, it can be found that there are potential threat such as increasing pollutants inputs and disturbance from construction within the area that needs to be addressed by PPJ. It is very important to implement studies regarding the Putrajaya Lake and Wetland due to the fact that it depends on how the water resource management is applied to develop the water resources and protect them. With the occurrence of new emerging pollutants, the water management should have the ability to quickly adapt to this potential threat considering sustainability concept.

Problem Statement

It can be found that there 4 major issues that are now affecting the Putrajaya Lake and Wetland:

Water Quantity – Non Suitable Water Level

Changes to the flow regime may have significant negative impacts where a reduction in the natural flow together with a discharge of lower quality drainage water can have severe impacts on downstream users. This change of flows of about 20% may also alter the micro-habitat due to the restrictive ecological requirement of the species. Moreover, certain activities such as water motor sport may also be affected due to the unsuitable water level requirement. If such activities cannot be implemented, it can cause a huge impact on the tourism that mostly contributed to the economic within Putrajaya.

High Discharge Suspended Solids

Usually, the discharge of suspended solids is due to the construction sites within the area surrounding the Putrajaya Lake and Wetland. The movement of these suspended solids may settle out at various points which depend on their size and the rate of flow. Too much settling of suspended solids in one point can cause the water to be cloudier and more turbid. This causes the amount of light entering water may be reduced thus reducing the rate of photosynthesis. Turbidity is the essential aspect in determining the suspended solids in water which consider the water clarity of the affected area.

Increment of Nutrition/Fertilizer-pesticide in Water Body

Pesticide. The upstream and middle area which consists of palm oil plantation and parks may be exposed with the usage of pesticides by farmers to enhance the growth of plants in controlling pests. Contribution of pesticides may contribute to the high concentration of nitrate and phosphate which causes the algae to grow and multiply rapidly that can lead to eutrophication events. As algae die, they are broken by bacteria which use all oxygen in water that may cause death to many aquatic animals. Network of pesticides sampling sites in urban and agriculture areas in Putrajaya Wetland is essential for pesticide management plan to detect the contamination in early stages.

*Fertilizers.*Certain fertilizers may contain other nutrients such as zinc and iron which can be very harmful and toxic if it flows to the surface area depends on the concentration. Impact of the chemical fertilizers could be dangerous that can lead to water pollution problem due to the storm water containing high loading of nutrient reaching Putrajaya Lake and Wetland. Extra loading of the nutrient can cause eutrophication that supports luxuriant growth of macrophytes harming the water stream.

Consideration on New Pollutants

Synthesis of new chemicals or changes in usage and disposal of existing chemicals can produce new source of emerging pollutants which may directly discharge in water streams causing different sort of environmental problems referring to the aquatic system in the Putrajaya lake and wetland.

Oil Content within the Water Body. Due to the impervious surfaces constructed during the land development surrounding the Putrajaya, water running off these impervious surfaces tends to pick up gasoline, motor oil, trash and other pollutants which contribute to the major source of polycyclic aromatic hydrocarbon (PAHs). Majority elements in PAH are created by combustion by products of gasoline and other fossil fuels.

Chemicals from buildings. To prevent growth of fungi within the buildings, specific chemical was used through the paintings. The exposure of these buildings towards the rainwater causes these chemicals from the paint to be washed out by rain that could later be transmitted to the water body. This could bring huge impacts to the water ecosystem due to harmful properties of chemicals used in the paints.

Objectives

The objectives of this study are:

1. To sketch existing water management within the Putrajaya Wetland.
2. To analyse these water resource management based on the sustainability concept.
3. To modify the existing water management for the Putrajaya Wetland due to new emerging pollutant.

Research Outline

The research will outlined three important elements such as the quantity, quality, and management of the Putrajaya Lake and Wetland. Since all the problems are related to the three elements mentioned, this research consists of literature study, water sampling, and analysis.

Literature Review

Growing pressure on water resource from population and economic growth, climate change, pollution, and other challenges have cause major impacts on our social, economic, and environmental well-being. As wetlands continue to be degraded in quality by the growing pressure, our failure to meet effective or inappropriate institutions and management, underinvestment, failure to apply existing technology and our inability to balance human needs with the needs of the natural world continue to be the main factor of this problem. It is essential for an effective management and technologies to be a part of dynamic and continuing planning process in ensuring the efficiency of Putrajaya Wetland for future generation.

Wetland Management

Managing wetlands requires an understanding of basic ecosystem processes, animal and plant life history strategies, and principles of wildlife management. Each management technique differs depending on the available infrastructure, resources, and management objectives. Ideally, wetlands are managed as a complex with many required stages which involves manipulation of ecosystem processes prescribed techniques to create high quality habitat for various wildlife.

Sustainability Concept

Innovation and the emergence of new technologies play a crucial role in driving green growth in the water sector to achieve sustainable and effective management that can adapt quickly to changes in demand caused by economic and demographic transition. The implementation of green growth policies requires full commitment from different parties involving the community, business, regulators and policy makers. This holistic approach taking broad economic, environmental and social issues into account is essential to produce sustainable water management in the future.

Water Quantity

Irrigation which have similar concept of Putrajaya Wetland could also influence the water level within the downstream area [2]. This may contribute to different sort of potential threats such as increased erosion, pollution of surface water, deterioration of water quality and increased nutrient levels in the irrigation. The concept of irrigation which impound or divert the river may result in the decrease of river flow containing dilution of municipal and industrial wastes to the downstream thus affecting the recovery rate. When the recovery rate of the water body is affected, it could be more exposed to water pollution and health hazards [3].

Suspended Solid

The source of sediments can affect water quality as it brings nutrient and pollutants which can cause eutrophication and toxic effects while in suspension. Suspended solid may harm aquatic species by clogging the fish gills and reducing their growth rate. Moreover, it can cause reduction of light penetration required by algae to produce food and oxygen. This disturbance of the photosynthesis rate is affected by the low light penetration due to the turbidity and cloudiness of water contributed by the amount of suspended solids. The effect of this problem could increase if no efficient practice is taken. To overcome this problem can be demonstrated through countries such as Australia in handling this issue to meet its urban cycle water management objectives. The common practices used in Australia are shown below [4]:

Road Layout and streetscape.

a) Gross pollutant trap (GPTs): Designed to trap litter, debris and coarse sediments in drains.

b) Bio retention systems: Treatment by vegetation prior to filtration of sediment and other solids through prescribed media.
c) Porous paving: Alternative to conventional impermeable pavement and allows infiltration of runoff water to the soil.

Public open space

a) Sedimentation basins: To remove (by settling) coarse to medium-sized sediments and to regulate water flows promoting settling of sediments out of the water column.
b) Swales and buffer strips: Used to convey storm water in lieu of pipes and provide a buffer strip between receiving waters.
c) Rainwater tanks: To conserve potable water by harvesting rain thus reducing storm water runoff volume carrying pollutants to the water stream.

Nutrition

Pesticides and herbicides can enter through surface runoff, leaching or erosion. The presence of herbicides and pesticides can bring profound impacts towards the water quality due to its ability to accumulate through the food chain and remain in sediments for many years. Due to the application of reliable sustainable system, farmers can use variety of cultural, biological, and mechanical methods in avoiding excessive usage of pesticides and fertilizers. Agriculture practices that can be used to avoid the threat of water pollution are [5]:

a) Use of injection syringe: Can reduce pesticide usage.
b) Weed-eye technology: A recognition technology placed in front of the sprayer, where the different weed species can be distinguished and could determine which pesticide to use and the dosage.

New Emerging Pollutant

Emerging pollutants created by the synthesis of new chemicals and disposal of existing chemicals which are not commonly monitored in the environment can cause adverse ecological impact or human health effect. Usually, these pollutants come from urban areas, atmospheric deposition or from crop and animal production.

Oil from Roads and Parking. Polycyclic aromatic hydrocarbon (PAH) as one of the new emerging pollutant consists of separate chemicals that occur together as mixtures. The PAH which are concentrated by the burning of fossil fuels and the incomplete burning of carbon- containing materials are varied in group of compounds whose sources comes from tire particle, leaking motor oil, vehicle exhaust and parking lot sealants. Extreme elevation of PAH concentration can affect the quality of water resources which can be toxic to aquatic life [6].

Chemical from Building. One of the important families of chemicals to consider when attempting outdoor building paintings is volatile organic compounds. High concentration of VOC can lead to a number of water quality problems and could be deposited in outdoor impervious surfaces. This threat can also be facilitated by the event of urban runoff surrounding the water body in Putrajaya.

New Emergent Pollutant Treatments

Most emerging pollutants are not regulated in environmental, water quality and wastewater discharge regulations. Hence, there is an urgent need to adopt appropriate technology and policy approaches to monitor the effect of the emerging pollutant towards the water body. The variety of technological approach that can be applied based on the list below [7]:

Reducing Risk of PAH Contamination from Storm Water Runoff

a) Use of asphalt sealant: Protecting parking lots from petroleum and UV degradation.
b) Installing bio retention cells: To treat parking lot runoff which reduce PAH in storm water

c) Intercept and manage storm water runoff from all parking lots and roads: Reduce emission of PAH compounds from these areas.

Chemicals from Buildings

a) Reduce usage of chemical compounds in exterior of buildings
b) Native species of plant often need less water so design and landscape the grounds in keeping with the existing environment.

Methodology

Interview and Study Literature

The interview technique applied in this research will involve the usage of In-depth interview with the representative from Perbadanan Putrajaya. The interview will be based on the problems considering the three elements mentioned in the scope of the research. Information regarding the application of the ISO standard by PPJ is also collected where it is essential in ensuring the effectiveness of the water management. Besides that, we can assess the application of sustainability concept through the existing water management as stated in the first objective. The water management in PPJ depends on the Putrajaya Lake Management Guide which consists of [1] policy for lake quality management, lake management strategy, administrative responsibilities, pertinent information related to the lake system, lake monitoring program, operation program, research and development.

Data collection and Lab Analysis

Determining the water quality of the Putrajaya Wetland can be conducted by the implementation of data collection from Putrajaya (as shown in Figure 1). According to the stated problem, the parameters that will be observed are turbidity, COD, pH and ammonia nitrogen based on the second objective. The major purposes for this activity is to characterize water, identify changes in water quality over time, determine specific existing water quality problems, gather information to design specific pollution prevention or remediation programs, determine whether the program goals are being met, and response action towards the any emergencies, such as spill.

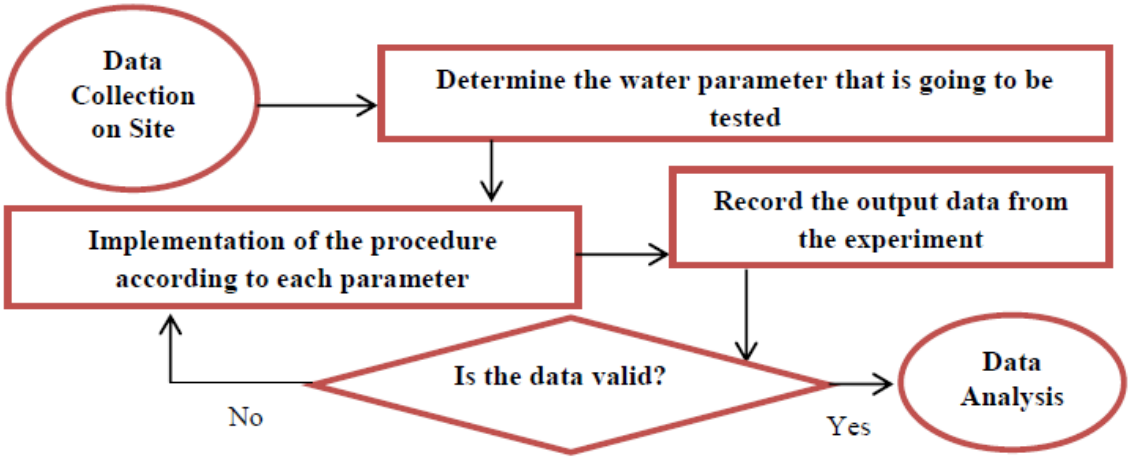

Figure 1: Flow chart for data collection and lab analysis

Specification of Measures: Duplication of the System outside Malaysia

Technological opportunities must be assessed across multiple green growth sustainability indicators, such as lower energy and resource demand, reduced pollutants, increased economic efficiency, and the conservation of natural assets. The impact of deploying an innovative or

advanced technology used by other countries can be very essential in ensuring financial benefits for the authority such as PPJ. Therefore, strategic policies that drive long-term sustainability, beyond an election key, are of key importance. Improving treatment technologies and standardizing them across the Putrajaya Wetland should all be assessed as potential methods for control [8].

Result and Discussion

Existing Water Management within the Putrajaya Wetland

According to the first objectives, this part will highlight the management details and its application by PPJ towards the Putrajaya Wetland which straddles the water courses of Sungai Cuau, Sungai Bisa and three tributaries. It is very important for the water management to maintain the wetland and lake according to the standard set by Perbadanan Putrajaya [9].

Putrajaya Lake Management Details

To achieve the standards, Perbadanan Putrajaya has developed very detailed specific procedures and management guidelines. Guidelines such as Lake Management Guidelines are the main key role which contains the Putrajaya Lake Use Master Plan and Environmental Management Guidelines considering the overall lake and wetland management scope. Every aspect of the guidelines details out very specific lake management issues, among other are policy for lake quality management, lake management strategy, administrative responsibilities, pertinent information related to the lake system, lake monitoring program, operation programme, research and development [9].

Policy for Lake Quality Management. In organizations such as Perbadanan Putrajaya, it is very essential for the application of efficient polices to ensure good governance within the Putrajaya Lake and Wetland. To avoid any potential risk, the policy management cycle is observed to be platform of the application of the Putrajaya Lake Management Plan Policy Statement. Figure 2 shows the three steps in policy management cycle [10]:

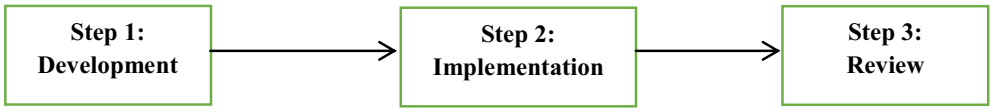

Figure 2: Policy Management Cycle

Step 1 (Development): In keeping up with the development on-going stage, it is required for the cooperation and coordination amongst the stakeholders together with the implementation of various regulations and control land development and human activities.

Step 2 (Implementation): Upon the implementation of the policy, there is a need to update the plan policy to incorporate years of implementation experience and taking into considerations such as the latest policy, legal, current and future land use of the catchment stakeholders. It is important to ensure the Putrajaya Lake Management Guide comply with the following policies [1].

Step 3 (Review): The policy should be monitored to ensure the efficiency of its application.

Lake Management Strategy. To ensure the efficiency of the Perbadanan Putrajaya to handle this large open space, six zones have been established together with a schedule or permissible and non-permissible land based and water based activities applicable to each zone as described in Figure 3 [11].

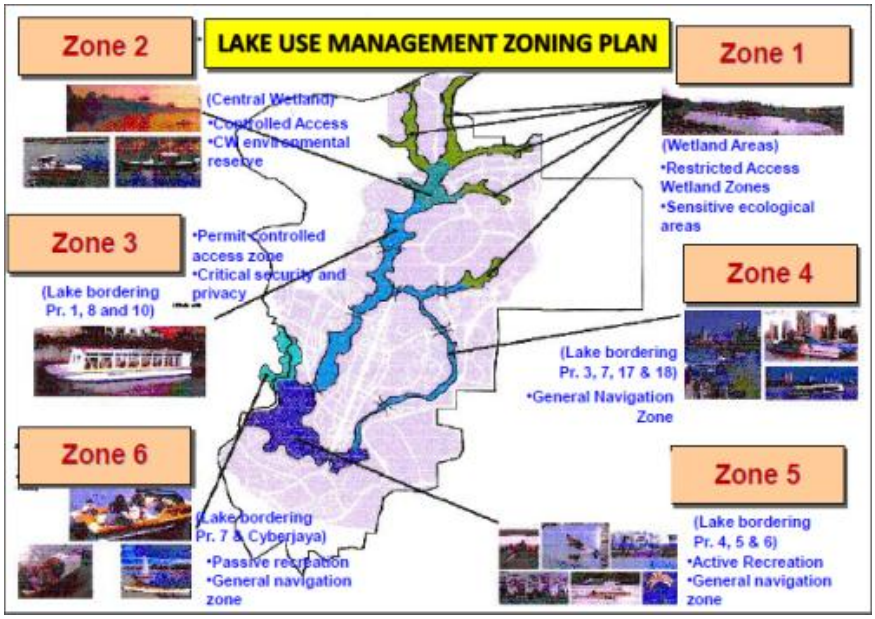

Figure 3: Lake Use Management Zoning Plan [12]

Zone 1: This zone contains sensitive ecological areas which are important to the well-being of the downstream main lake, and accordingly public access to these water areas should be severely restricted.

Zone 2: Contains lush wetland vegetation within its western arm, the Wetland Parklands to its north, a number of central islands, and Taman Botani to the South, be established as a tranquil recreation zone and environmental reserve.

Zone 3: Due to the security and privacy sensitivities associated with land use around this section of the lake, a Permit Controlled Access Zone is proposed.

Zone 4: Is proposed as a General Navigation Zone, being general restricted for private and commercial boating with exception of special advertised sporting, public display and events.

Zone 5: Offers the widest areas of water for motorised and non-motorised water sport and activities.

Zone 6: Provides a desirable fish breeding habitat within the main lake body and can be classified as the Active Recreation Zone.

Administrative Responsibilities. To ensure that the organization structure appropriate with the multi-faceted management of Putrajaya Lake and Wetlands, it is very important for each group of organization to be divided according to skills and expertise so that any work or programme can be divided fairly with full effectiveness. Moreover, clear justification regarding the work scope of each unit can avoid any conflict of interest and enhance the integration between units to work together within the Perbadanan Putrajaya.

Pertinent Information Related to the Lake System. The management of the Putrajaya Lake and Wetland mostly depends on the relationship between water quality and water quantity which influence the functionality of the Lake and Wetlands to survive in the future. Both of the aspect is important due to the fact that weather conditions can influence the dilution of accumulating ions, toxics and entrains organic matter for food webs. The ability to handle both the relationship can be

essential in producing effective water management. With enough information regarding the first aspect, we can determine management issues related to the water quality matters [11]:
Water Quality Indicators and Guidelines: Appropriate water quality indicators and guidelines is essential to be established as it can be the platform for managing and monitoring water quality.

Management of Turbidity: Turbidity can be one of the factors that can influence the perception of water quantity and attractiveness, as well as influencing the plant growth in the lake including the balance between macrophytes and algae. Usually, turbidity is associated with the storm events and implementation of construction sites.

Management of Nutrients: Mostly, phosphorus and nitrogen are the two key elements which associate with the growth of plants in water bodies.

Management of Aquatic Plants in Relation to Water Quality: The benefits and disadvantages of plant growth in relation to other uses and values of the lake are likely to become one of the factors that can influence the lake eco-system.

Management of Sedimentation: The primary means of reducing sedimentation in the lake will be by primarily aimed at controlling the rate of soil erosion within the catchments as a result of inappropriate land clearing practices and inadequate control of earthworks during construction.

The next aspect will touch on the water quantity within the Putrajaya Wetland and Lake. Issues regarding the change of flow can be crucial to be overcome so that PPJ can maintain the efficiency of the Lake and Wetland in any weather conditions. Strategies and policies will be established based upon a hierarchy of priorities including maintenance of the health of wetland vegetation by pumped recirculation of water from the main dam as necessary, progressive restriction on abstraction of water for irrigation purposes and the diminished aesthetic effect [11].

Lake Monitoring Program to Ensure Efficient Lake Management. To maintain high level of effectiveness within the lake management, frequent lake monitoring programs are implemented and applied twice a month. This is to ensure a fair assessment of the wetland functions in relation to its ecological and management requirements as well as confirming the water quality status of the operational objectives for future development program.

*Operation and Maintenance Program of the Lake System Integrity.*The overall aim of operation and maintenance is to ensure efficiency, effectiveness, and sustainability of the Lake and Wetland. The implementation of maintenance activities in the Lake and Wetland comprises all components that may influence the water resource in Putrajaya.

Research and Development to Support Decision Making on Lake System Management. Putrajaya Lake and Wetland is beneficial not just only to the aspect of water quality and quantity but also as a medium for education resource for the society. The use of Putrajaya Lake as an education resource, research and development should be encouraged to increase public participation within the lake system management. Research and monitoring aimed at recording the characteristic of the Lake and its uses, understanding the physical, biological and social processes associated with the lake. The research and monitoring projects can be related with water quality monitoring, biological research, recreational use surveys covering the lake in general and visitor perception of the lake in relation to the Nation's Administrative Centre [11].

Integrated Management System
An efficient and operative management structure is essential to cut-down resource requirements without affecting the management effectiveness could only be achieved when the unique requirements of the management process and techniques be fully integrated into existing and future

policy development and resource management systems. It is imperative for Perbadanan Putrajaya to acquire an efficient and cost-effective integrated management structure to minimise resources requirements as well as manage, administer, regulate, and control virtually every management plan of Putrajaya Lake.

The Approach by the Management toward Any Problems within the Putrajaya Lake and Wetland.

In this part, the most important element to be highlighted is how the Perbadanan Putrajaya response towards any emergency that may occur concerning the lake and wetland and the effectiveness of the actions taken. Mostly, matters regarding the Lake and Wetlands are carefully monitored by the Lake Environmental Unit from the Lake and Wetland Division of Perbadanan Putrajaya. Any problems that occur in the Lake and Wetland will mainly involve the Lake Environmental Unit, Head of the Lake Division, and assistant lake directory (ALD) of PPJ. Different problems may result changes within the actions to be taken. The problems are usually classified according to the pollution risk level shown in Table 1 below:

Table 1: Risk Pollution Level

Pollution Risk Level	Remarks
Level P1	Clean litter
Level P2	Dirty litter/ rubbish/ sewage/ decomposed body/ algae bloom/ floating fish/ plant disease/ pest
Level P3L	Oily water, Oil spill with Low risk (below 50 litres for wetlands and below 100 litres for others)
Level P3H	Oil spill with High risk (50 litres and above for wetlands and 100 litres and above for others)
Level PC	Chemical spill of any amount including pesticides

The process in dealing with the problem can simplified through the application of flowchart which can be used to assess, strategize evaluate potential risk, to determine if and when particular risk require action and who will manage the risk. With clear justification on the flow chart, planning can be provided considering the source of the problem, monitoring activity and the management handling. The four main primary steps of the approach process as shown in Figure 4 [11].

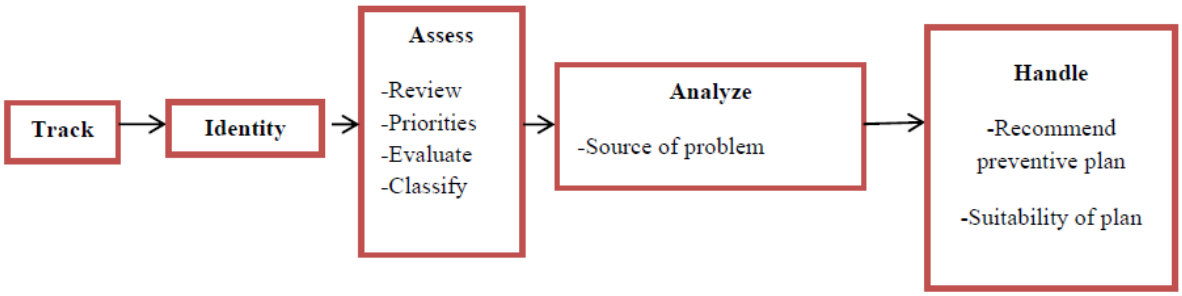

Figure 4: Communication Flowchart

Risk Identification– Stage 1, taking into consideration anticipated basic activities and facilities in or near lake

Risk Assessment– Stage 2, based on identified problems

Risk Analysis– Stage 3, to be executed upon obtaining more detailed information on overall lake development

Risk Handling– Stage 4, actions taken after analysing more detailed information on the problem

Analysis on the Water Resource Management Based on the Sustainability Concept

This part will discuss on the potential problems that may affect the Putrajaya Lake and Wetland as mentioned in the problem background. The 4 potential problems will consist of:

a) Water quantity: A reduction in the natural river flow together with a discharge of lower quality drainage water can have severe impacts on the downstream users.
b) High discharge suspended solids: Suspended matter due to the development surrounding the Putrajaya Wetland can affect the amount of light entering water and restrict the amount of photosynthesis for growth requirement of plants.
c) Increment of nutrition/fertilizer: When talking about the harm of fertilizer and pesticides containing phosphorus and nitrogen, it can flow into the surface of water from areas such as Taman Botani which can pollute the water and it is highly toxic.

With the potential problems identified, it is very crucial to select suitable location for the sampling to identify the source of the problem. This research will involve the collection of sampling in the upstream, middle, and downstream of the Putrajay Lake and Wetland according to the map given by PPJ (as presented in Figure 5). Different location is essential to produce various measurements which are important for the lab analysis. Things need to be highlighted regarding the upstream location is the rapid development of construction sites in the precinct 12. The detailed information regarding the location of data collection as shown in Table 2 (PERBADANAN PUTRAJAYA, 2001):

Table 2: Location of Sampling

Location	Code
Upstream	LE2
Middle	CW
Downstream	PLf4

Figure 5: Whole map of Putrajaya Lake and Wetland

After obtaining the water sampling throughout all the location, two properties will be focused which consist of physical and chemical according to the potential problems that may occur within the three location of the sample. Physical properties of water include temperature and turbidity. Meanwhile, chemical characteristic involve parameters such as pH, COD, and nitrogen ammonia. The actions taken by PPJ to maintain the 4 parameters within standard will be assessed with the sustainability concept. The tested pillars of sustainability concept consist of:

a) Social development: In this aspect, most importantly is awareness of a legislation protection upon the importance of the Putrajaya Lake and Wetland for the future.
b) Environmental protection: It defines how we should study and protect the ecosystems, water quality, integrity and sustainability of our resources and focusing on the elements that place stress on the environment.

The whole result of the 4 parameters can be shown according to the National Water Quality Standard (refer Figure 6).

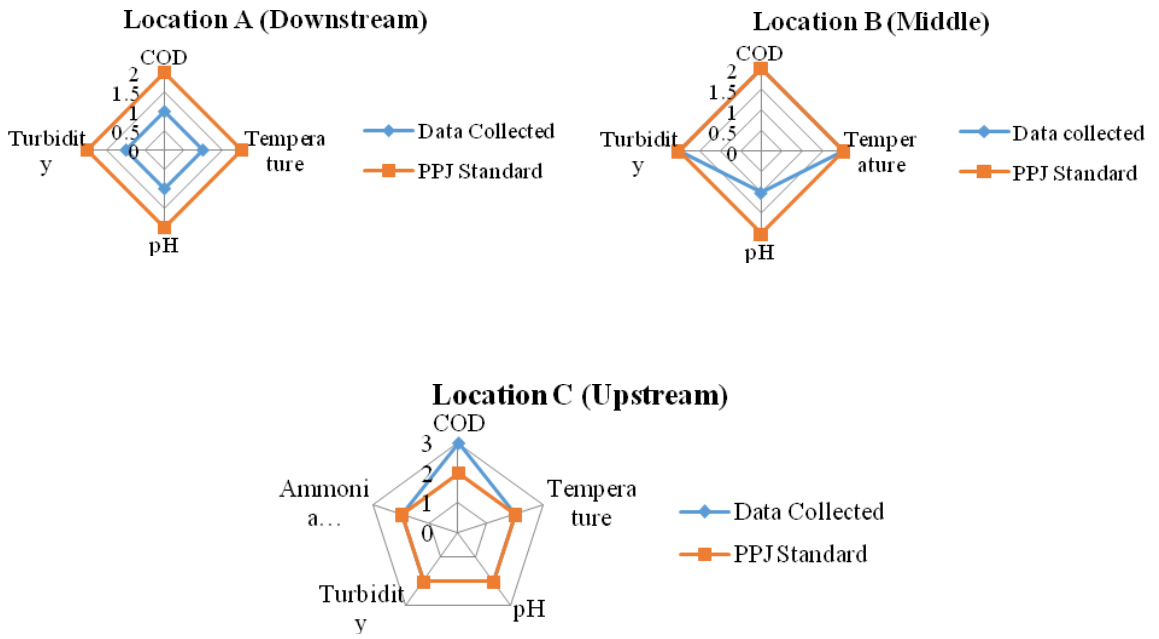

Figure 6: Classes of each parameter according to the three locations

Turbidity

Due to the potential problem of high discharge from the construction site in the upstream are, the parameter of turbidity is important to be implemented as an optical determination of water clarity. Usually, turbidity may affect the physical look of water due to suspended sediments such as silt or clay, inorganic materials or organic matter such as algae, plankton and decaying material. It is very crucial to have the ability to differentiate the source of the brown colour of water to prevent any misunderstood on the result obtained. Brown colour water has many potential sources whether it is from the construction nearby or the high amounts or the high amounts of decaying vegetation. Five days were required to take the water sampling in the three decided location. Moreover, the result of the upstream location within the area of lowest east will be focused due to the undergoing construction there. Factors such as the weather condition will also be recorded due to its ability to influence the measurement. The results:

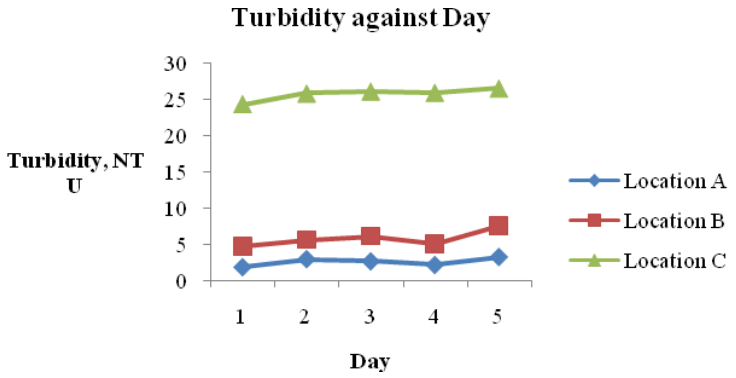

Figure 7: Turbidity against day

From the Figure 7, we can observe that there is inconsistent value of turbidity in each location of A, B and C throughout the five days. This inconsistent value of each day is affected by the weather conditions during the days of sampling. The value of turbidity in day 5 on each location show highest value meanwhile day 1 is the lowest. The day 5 is influenced by the particularly heavy rainfall which affects water flow, which in turn affects turbidity. Rainfall can directly increase the level of total suspended solids through runoff. Even though the rate of surface runoff is lower during a good weather, there are also some sources that can contribute to the increase of turbidity value from wind action that blow dust, sediment and other particles into water.

The Figure 6 shows the water quality classes on each location of A, B and C. The high value of turbidity in the upstream area of location C is due to the undergoing construction in the area of lower east 1 and 2 which increased the exposure to soil and decreased vegetation. The value of location B upon passing the wetland shows a turbidity value of class 2 meanwhile location A shows class 1. Even through the distance of both B and C is not that far, it still shows a different value of turbidity. This is due to the location of B near to the Taman Botani which is exposed to the nutrients coming from the area. The area of A which shows the lowest value of turbidity is affected by the absence of construction activities in the area.

pH

The event of surface runoff from construction site, agriculture area, and roads could influence the reading of pH. It is important to implement the pH parameter as the result could be the indicator whether the source of runoff affects the reading of pH. Water sampling conducted considering the three locations where the upstream will be focused as the area is now undergoing construction. The results for pH studies aspresented in Figure 8.

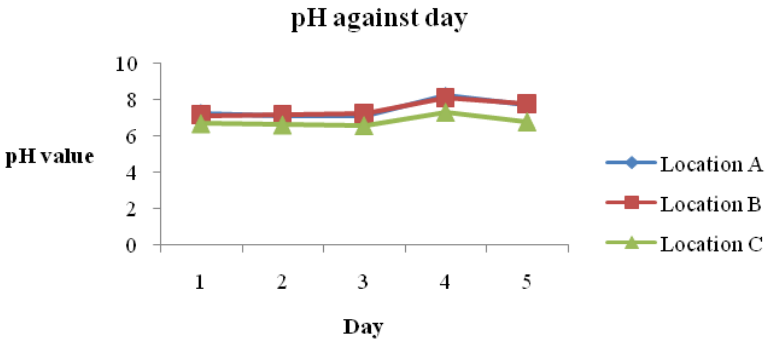

Figure 8: pH against day

The highest value and lowest value of pH throughout the five days of sampling resulted in small margin of difference. This shows that the weather condition does not affect too much on the pH

value. As similar to turbidity parameter, the condition of rainy days has caused the value of day 4 to be the highest. Meanwhile, the good condition weather in day 3 has the lowest value of pH.

The value of pH obtained from location C has a margin difference from location A and B due to the fact that there is construction site within the location C. The sources from construction site can be classified as a common cause that can increase and decrease pH depending on the chemical involved. Even though, there is construction site in the upstream affecting the pH value, PPJ still managed to maintain the pH of class 2 within the standard. Meanwhile, similar results shown for location A and B which have value of class 1. This shows that surface runoff in location A and B does not affect the value of pH.

Chemical Oxygen Demand (COD)

There are about two main potential problems that may which is the high discharge of suspended solids and increment of nutrition/fertilizers due to construction site upstream, discharge from upstream, and surface runoff from roads surrounding the Lake and Wetland. To determine whether the problem is significant towards the water quality, it is very crucial to implement the chemical oxygen demand (COD) parameter. Chemical oxygen demand (COD) is measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrate. Figure 9 shows the value of COD obtained on each location.

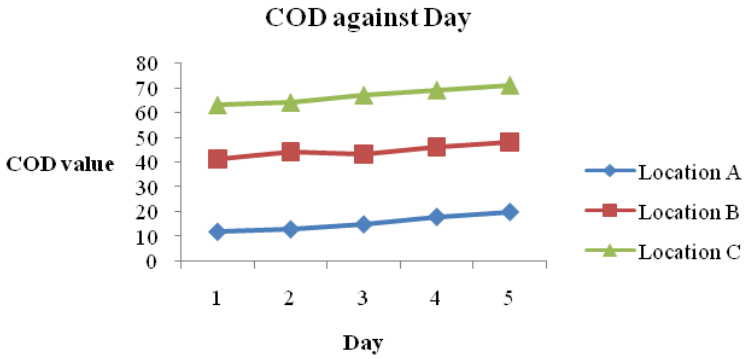

Figure 9: COD against day

Based on the Figure 9, we can observe that there is different value of COD of each location A, B and C throughout the five days. This is due to the weather conditions affecting the value of each day. The COD value of day 4 and 5 is slightly higher than the other days caused by rainy conditions where the high rate of surface runoff may affect the value. We can observe that the COD value of dry conditions during the day 1, 2, and 3 do not show too much margin difference compared to the value caused by rain conditions due to the low tendency of the water stream to carry the organic material during dry conditions causing the material to be settled.

The COD value obtained in the location C of upstream area is class 3 from the national water quality standard which is not within the targeted limit of class 1-2 set by PPJ. This happens due to the undergoing construction where the occurrence of silt from construction sites, logging, slash and land clearing could increase the inorganic content in water stream. Meanwhile, the lowest value of COD could be location A (downstream) with class 1. The lowest value is contributed by the low discharge of inorganic and organic material due to gross pollutant trap (GPT) and the absent of construction area in this area.

Nitrogen, ammonia

Based on the nitrogen parameter, there are two potential sources that could cause problem which is the undergoing construction site and surface runoff from the agriculture, domestic and residential areas. We will focus the upstream area due to the fact that all the sources could contribute to the

readings of nitrogen, ammonia value. The upstream area is critical due to the presence of construction site and certain area of agriculture where it can affect nitrogen ammonia value.

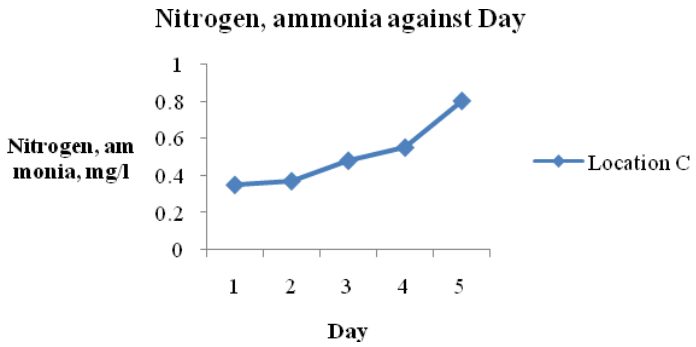

Figure 10: Result of nitrogen, ammonia

According to the Figure 10, the different values of nitrogen, ammonia throughout the five days in location C is due to the weather conditions. This can be shown where the rain conditions in day 4 and 5 causes the value to be higher than the other days during dry conditions. High rate of surface runoff affects the value of readings.

The location C shows nitrogen, ammonia value of class 2 which is still within the range of standard set by PPJ. Even through there is potential that the construction site and agriculture areas could bring impacts to the parameter, PPJ still managed to maintain the readings within standard. This is hugely due to the effectiveness of the action taken by PPJ to be sustained in the future.

Actions taken by PPJ to Overcome Problems Related to the Four Parameters That Obey the Pillars of Sustainability Concept

Based on the four parameter assessed on each location, we can observe that most of the class of water obtained is within the range of limit 1-2 set by PPJ. Even though there are undergoing constructions in the upstream area, still PPJ can maintain parameter value of turbidity, pH and ammonia and COD within standard accept for the COD upstream value of class 3 which exceeds the limit. The best management practices applied could be factors that influence the effectiveness of PPPJ to maintain most of the parameters to class 1-2. The BMP which consist aspects such as agriculture and development will focus on potential problems such as the high discharge of suspended solids and increment of nutrition/fertilizers. The classification can illustrated below:

Development Best Management Practices. Firstly, one of the aspects from this part of BMP is through the management applied by PPJ through frequent implementation of monitoring and maintenance activity to prevent any problems related to the parameters. This frequent implementation of the activity can be very important as the data regarding each parameter is assessed twice a month by the authority of PPJ. Secondly, the next aspect will touch on the technology usage by PPJ to prevent problems related to the parameters caused by high discharge of suspended solids due to the construction site within upstream area and surface runoffs within the middle and downstream area. The technologies applied through the BMP applied by PPJ consist of:

a) Silt trap: Designed to trap suspended sediment from entering water streams.
b) Vegetation Management and Re-vegetation: Keeps soil secure and leaves and ground cover reduces raindrop velocities.
c) Sediment Trap: Perbadanan Putrajaya will encourage contractors to build a sediment basin before any construction to trap suspended solids.

d) Gross Pollutant Trap (GPT): Installed in every inlets of water within the Putrajaya Lake and Wetland which remove solids from storm water at high flow rates.
e) Parking Lots and Street Cleaning: High-efficiency street sweepings by capturing pollutants before they are made soluble by rainwater.

Agriculture Best Management Practices. It can be observed that there is some potential agriculture factors from Taman Botani that may influence the water parameters in the location of B (middle area) where the fertilizers and pesticides are usually used. If the fertilizer and pesticides usage is not controlled, it could cause impacts toward the Putrajaya Lake. The Taman Botani which has its own authority is carefully monitored by PPJ by application of an effective agriculture best management practice. The components of the BMP consist of:

a) Nutrient management: Practice by applying fertilizers and manures only in the amounts that can be taken by a crop.
b) Controlling erosion and runoff: Use of cover crops to prevent erosion and reduce the movement of nutrients and pesticides from Taman Botani.
c) Barriers and buffers: Intercept and contain contaminants that are being carried from the Taman Botani.

The integration between departments in PPJ is crucial in handling potential problems that may occur within the Lake and Wetland. The effectiveness of the management in Putrajaya depends on the following components such as water zone allocation, lake planning, stakeholder participation, pollution control, monitoring, and information management.

Sustainability Concept through the Best Management Practices. The steps taken by PPJ to maintain the 4 parameters can be found to obey two of the three pillars of sustainability concept which is environmental protection and social development. The sustainability concept pillars can be observed through the actions taken by PPJ in applying aspects such as:

a) Focus on cost-effective approaches: Seeking "win-win situations when environmental and economic goals are complementary; Cost- effective approaches to carrying out environmental reforms.
b) Mobilizing public support and participation: Raising awareness by formal/informal education on environmental options, solutions, enforcement and monitoring; Involving NGOs and the informal sector in championing local environmental concerns.
c) Improving Governance: Building local capacity to provide adequate operational management of urban services with adequate skills and capabilities-managerial; Establishing pubic –partnership to deliver environmental services.

Considering of New Emerging Pollutant for the Existing Water Management

The threat of PAH can be proven where certain places in Malaysia have already shown the existence of the compounds in water streams such as the coastal of Klang Strait and Langkawi Island where it exceeds the admissible concentration of PAHs of (0.0002 μg/mL) according to water standard of European Union. The occurrence of PAHs exceeding the limit usually happens due to incomplete combustion of diesel fuel and engine oil and direct input of petroleum. The element of PAH can be a potential threat to Putrajaya Lake and Wetland due to the impervious surfaces which are constructed during the land development of Putrajaya. During rain storms and other precipitation events, these surfaces tend to contribute to the source of PAH from storm drains causing negative impacts towards the water streams. PPJ can improve the existing water management to cater the new emerging pollutants by modify the BMP through the technologies applied such as:

a) Intercept and manage storm water runoff from parking lots: To reduce pollutants from these areas.
b) Pervious pavement: To reduce the surface runoff from entering water streams.

Conclusion

Sketching the existing water management implemented by PPJ within the area of Putrajaya Lake and Wetland

- Important objective to determine the ability of the applied water management by PPJ to maintain the water quality and quantity within the standards.
  - The efficiency of the water management depends on the communication between PPJ and all stakeholders with accordance to seven guidelines in Lake Management Guide.
  - The pillars of sustainability concept can be the main platform to ensure that the existing water management can survive in the future through the application of the pillars such as environmental protection, economic factors, and social development.

Analysing these water management based on the sustainability concept

- Potential problems that may be faced nowadays such as high discharge of suspended solids and increment of nutrition/fertilizer.
  - The relevancy of the potential sources of the problem depends on the data collected by 4 parameters of the water quality with reference to the standards set by PPJ within the range of class 1-2.
  - The BMP consisting of development and agriculture aspect which is chosen by PPJ to overcome the potential threat can be seen to obey two pillars from sustainability concept such as environmental protection (cost-effective approach and improving governance) and social development (mobilizing public support and participation).

Considering new emerging pollutant (PAH) in Putrajaya Lake and Wetland

- Production of new emerging pollutants within the Putrajaya area can be due to the synthesis of new chemicals and disposal of existing chemicals to water streams.
  - The existence of this PAH had already been shown in other areas such as the coastal of Kland Strait and Langkawi Island which exceed the admissible PAH concentration.
  - Impervious surfaces in Putrajaya may contribute to the source of PAH which contains the incomplete combustion of diesel fuel and engine oil from roadways and parking lots carried by storm water to storm drains that will eventually enter the water stream.
  - In tackling the new emerging pollutants in Putrajaya, PPJ need to made changes through the aspect of management and technology based on the best management practice.

Recommendations

There are certain recommendations that can be made so that the water management in Putrajaya can continue to be sustained in the future. The recommendations that can be made are:

COD value in upstream are exceeding the standard by PPJ

a) Enforcement: Implementing strict enforcement can prevent pollution from construction sites.
b) Regular maintenance: Monitoring data can be used to determine whether the pollution can affect the standard set by PPJ.
c) Increase performance: Improving the water management through appropriate investments.

Threat from PAH

a) Modification in the existing management: Certain modification can be made in the existing best management practice to overcome the problem of PAH.
b) Frequent monitoring: Frequent monitoring can help protect the Putrajaya Lake and Wetland from early potential threat of PAH.

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