INTERNATIONAL JOURNAL OF INTEGRATED ENGINEERING
ISSN: 2229-838X e-ISSN: 2600-7916

IJIE

Vol. 16 No. 4 (2024) 104-112
https://publisher.uthm.edu.my/ojs/index.php/ijie

Inventory of Pollution Sources for The Lakes of Universiti Tun Hussein Onn Malaysia

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DOI: https://doi.org/10.30880/ijie.2024.16.04.013

Article Info

Received: 9 November 2023
Accepted: 29 May 2024
Available online: 27 August 2024

Keywords

Eutrophication, pollution sources inventory, point sources, non-point sources

Abstract

Eutrophication affects freshwater systems worldwide. Eutrophication can occur naturally, but man-made causes are also common. Human activities that release phosphorus and nitrogen lead to anthropogenic eutrophication, which increases organic matter production. Lake eutrophication affects surface waters all over the world. Water pollution can be assessed regarding point sources (PS) and non-point sources (NPS). PS is the intentional or unintentional release of pollutants from industrial and wastewater facilities into waterways. Agriculture, urban development, and natural processes in the lake's catchment area can cause NPS pollution. NPS pollution has many causes, including precipitation, airborne deposition, infiltration, drainage, and fluctuations in water flow in the catchment. The pollution inventory was conducted in UTHM lakes such as Tasik Kemajuan, Tasik Teknologi (FKAAB), Tasik Teknologi (FPTV), and Tasik Pembangunan. The PS and NPS in the study area were assessed through an on-site investigation. The UTHM water discharge plan is being analyzed to determine the inflow sources into the lake. The PS pollutant inventory revealed that the cafeteria wastewater, business buildings, and faculty drainage systems pollute all lakes. Tasik Teknologi (FPTV) identified runoff from palm oil plantations as a source of pollutants that can increase the nutrient content of the lake. Leaves, grass clippings, and other garden waste were in the water in all the lakes analysed. The Tasik Kemajuan, the Tasik Teknologi (FKAAB), and the Tasik Teknologi (FPTV) received water discharges from other lakes transporting pollutants. The assessment of pollutant sources revealed that most NPS originate from surface runoff. Road runoff contains several pollutants. Stormwater runoff or surface runoff can carry these pollutants from roads into waterways. Stormwater washes fertilizers into storm drains and lakes. To summarise, all pollutant sources that contributed to the eutrophication of the Tasik Kemajuan, Tasik Teknologi (FKAAB), Tasik Teknologi (FPTV), and Tasik Pembangunan were identified through a pollutant source inventory.

1. Introduction

Eutrophication is a major challenge for freshwater systems on a global scale. The understanding of eutrophication began in the early 20th century near urban and industrial centres in the developed countries of the Northern Hemisphere [1]. In the scientific literature, "eutrophication" describes a natural process in which organic matter production increases over time as an aquatic ecosystem develops, eventually reaching its maximum capacity [1]. This term can also refer to a phenomenon caused by human activities within relatively short periods of time, ranging from hours to years. Eutrophication can occur naturally but is often associated with nutrient inputs caused by human activities [2]. Anthropogenic eutrophication results from human activities that introduce phosphorus and nitrogen.

The eutrophication of lakes is a major environmental problem that has far-reaching effects on surface waters worldwide [3]. Despite their relatively small size in the biosphere, inland lakes and reservoirs provide ecosystem services that greatly benefit human activities. These functions include flood management, biodiversity conservation, climate change mitigation, river flow regulation, hydropower generation, and water purification and storage [4].

Water pollution can be assessed based on point sources (PS) and non-point sources (NPS). PS refers to the intentional or accidental discharge of pollutants into water bodies from identifiable sources, such as industrial facilities and wastewater treatment plants [5]. PS includes various pollutants such as heavy metals, organic substances, and nutrients that can have a negative impact on water quality and the balance of aquatic ecosystems [6]. PS are generally easier to manage compared to NPS as there are established regulations and monitoring measures for these sources.

On the other hand, non-point source pollution can result from various activities and land uses in the lake catchment, including agriculture, urban growth and development, and natural processes [7]. Non-point source pollution is often due to various factors, such as the movement of precipitation, atmospheric deposition, infiltration, drainage problems or changes in water flow in a particular catchment [8].

2. Methodology

2.1 Study Area

The study was conducted in Universiti Tun Hussein Onn Malaysia (UTHM) lakes in Parit Raja, Johor. The pollution inventory activity has been carried out in several selected lakes at UTHM, specifically Tasik Kemajuan (in front of the G3 building), Tasik Teknologi (in front of Fakulti Kejuruteraan Awam dan Alam Bina, FKAAB), Tasik Teknologi (in front of Fakulti Pendidikan Teknikal dan Vokasional, FPTV), and Tasik Pembangunan (in front of Perpustakaan Tunku Tun Aminah, PTTA). Fig. 1 shows the selected lake location and the water flow plan at UTHM. Table 1 shows the current condition of the lakes.

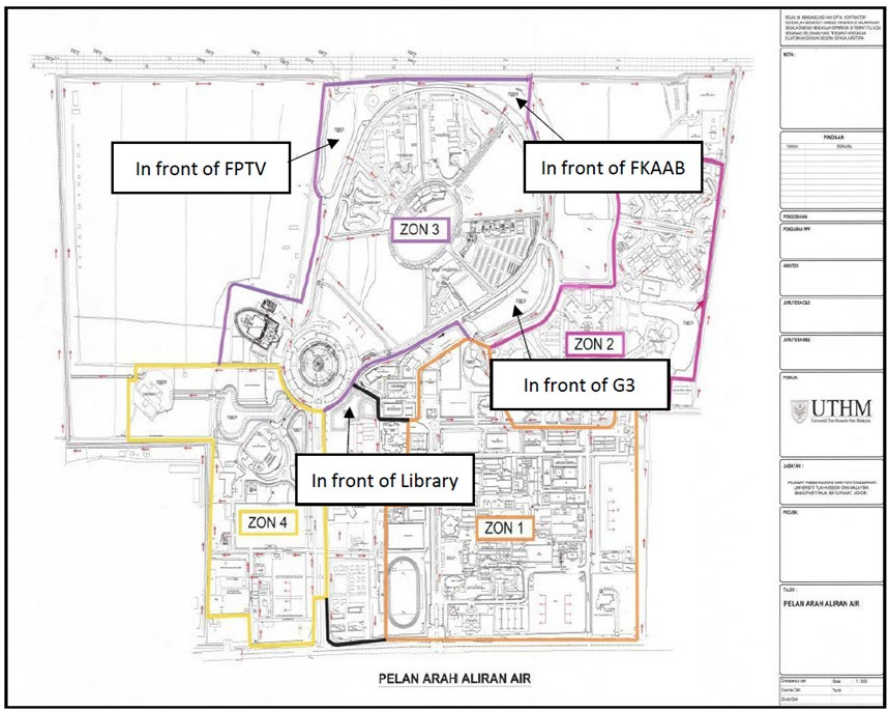

Fig. 1 *Selected lake location and UTHM's water flow plan*

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Table 1 *The current condition of the lakes*

Location	Latest Condition of The Lakes
Tasik Kemajuan (in front of the G3 building)	 
Tasik Teknologi (in front of Fakulti Kejuruteraan Awam dan Alam Bina, FKAAB)	 
Tasik Teknologi (in front of Fakulti Pendidikan Teknikal dan Vokasional, FPTV)	 
Tasik Pembangunan (in front of Perpustakaan Tunku Tun Aminah, PTTA)	

2.2 Water Pollution Sources Inventory

The following is an example that may be useful to the authors. A site investigation was conducted to identify the sources of pollution in the study area, both point and non-point sources. Pollutant discharge inventories play a crucial role in controlling the environment by companies by analysing the number of pollutants released into the environment and effectively reducing the negative impact on human health [9]. It has been analysed where the water discharged into the lake comes from and what pollutants may be discharged with the water. When conducting an inventory, it is important to consider both point and non-point sources when reviewing the results. This inventory typically requires collecting data, monitoring, and assessing the level of pollution from various sources. UTHM's water plan is being studied to identify potential sources that could enter the lake. A solid understanding of the sources and origins of nutrient pollution is necessary to manage and address water pollution effectively.

3. Result and Discussion

3.1 Tasik Kemajuan Pollution Inventory

Fig. 2 shows the pollution inventory carried out at Tasik Kemajuan. The pollution inventory for Tasik Kemajuan successfully identified both PS and NPS contributing to pollution. For the PS at Point 1, the G3 building, Arked and Pejabat Pendaftar were found to be notable sources of pollution. Organic contaminants, including food particles, oils, and fats, are a significant pollution factor in wastewater from cafes or cafeterias [10]. The presence of these organic contaminants can lead to a reduction in oxygen levels in water bodies, ultimately deteriorating water quality [11]. Chemicals used for cleaning, disinfection and food preparation can be present in wastewater from cafeterias [12]. Wastewater from commercial buildings can contain a range of pollutants, such as suspended solids, dissolved minerals, oils and fats, nitrogenous compounds, organic sulphides, and other pollutants.

The water that flows into this lake at point 2 comes from the Tasik Pembangunan. Organic matter such as leaves, grass clippings and other garden waste can be carried into the Tasik Kemajuan by water from the Tasik Pembangunan. Organic matter has a decisive influence on the movement and behaviour of pollutants in the water and, therefore, impacts water quality. Organic matter can adsorb pollutants and form complexes, influencing their mobility and bioavailability [13]. In addition, the degradation of organic matter can deplete oxygen in the water,

leading to low oxygen levels and the formation of hypoxic or anoxic conditions [13]. The wastewater system connected to the PTTA, which is connected to Tasik Kemajuan, can transport wastewater from commercial buildings. This water may contain nitrogen, phosphorus, fertilizers, detergents, organic pollutants, and fertilizers from the PTTA's landscaping.

For the NPS, all points at which surface runoff enters the lake were identified. Various pollutants in surface runoff from roads can contaminate the water. One significant pollutant is microplastic particles from car tires, released by tire abrasion and can enter the runoff [14]. These microplastic particles pose an environmental risk and contribute to water pollution. Another important pollutant is nitrogen, which can be present in road runoff and has a negative impact on water quality [15].

Surface water from roads can also contain other pollutants, such as heavy metals, oils, and chemicals from vehicle fluids [14]. Another source that can pollute the lake is fertilizers used in the landscape. Chemical fertilizers containing, e.g., ammonia and phosphorus, can enter the surface water via runoff [16]. Water pollution from surface runoff happens when there is an excess of fertilizer that is not taken in by plants or the soil. Instead, it gets carried away by rainwater or irrigation water [16]. The runoff can potentially carry harmful substances, like ammonia and phosphorus, into the surrounding lakes or rivers, resulting in water pollution [16].

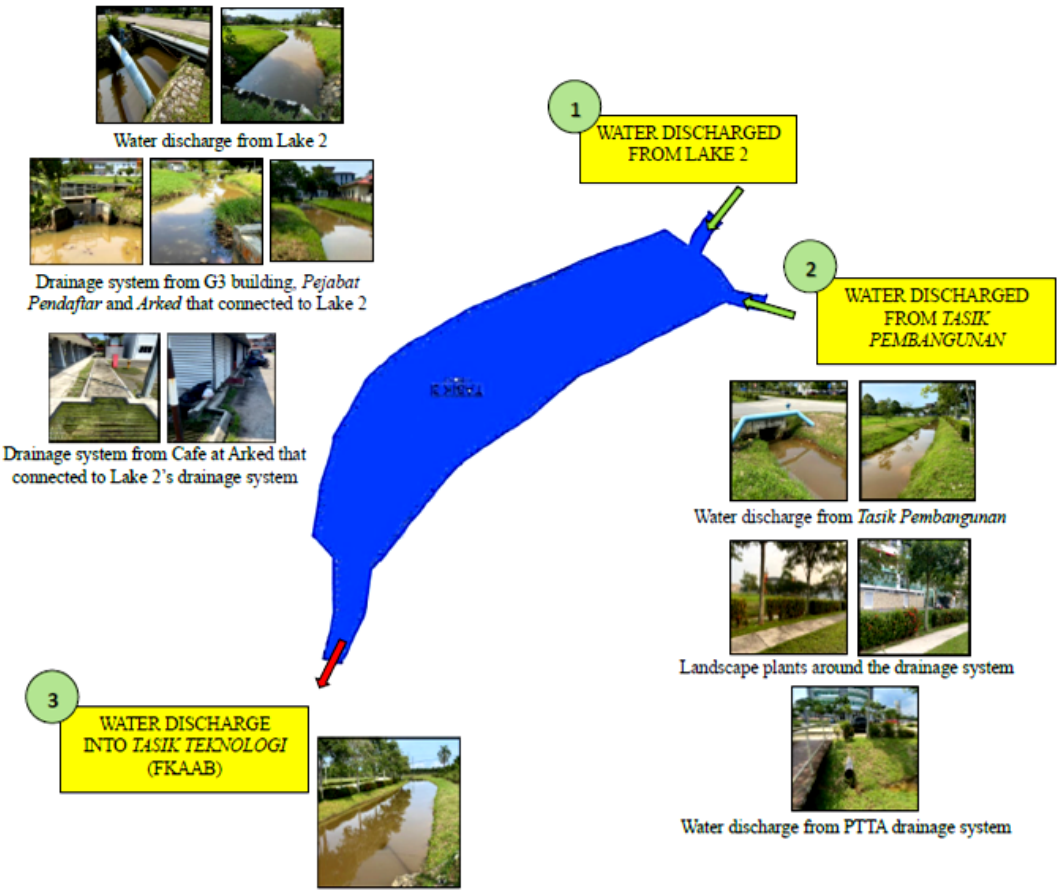

Fig. 2 *Inventory of Tasik Kemajuan*

3.2 Tasik Teknologi (FKAAB) Pollution Inventory

Fig. 3 shows the pollution inventory conducted at Tasik Teknologi (FKAAB). Point 1 in Fig. 3 shows that the water discharge from Tasik Kemajuan and drainage systems connected to the G3 building, Arked and Pejabat Pendaftar enters the Tasik Teknologi (FKAAB). Water pollutants were transported from Tasik Kemajuan by wastewater discharge. Water pollution sources contained in the water discharge include organic debris, including food particles, oils, and grease. Cleaning, disinfection, and food preparation chemicals could also be found in the Tasik Kemajuan water discharge. Organic matter such as leaves, grass clippings, and other types of garden waste can be transported to Tasik Teknologi (FKAAB) through water discharge from Tasik Kemajuan. The concentration of pollutants may decrease as distance increases due to the dilution mechanism.

For PS at point 2, the water discharged into the Tasik Teknologi (FKAAB) was identified from the FKAAB faculty building. Water discharge from the FKAAB faculty building transported organic matter such as leaves, grass clippings, and other garden waste into the Tasik Teknologi (FKAAB). Wastewater from the faculty drainage

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system originated from the Café HEP building, including soap and food particles, and flows into the Tasik Teknologi (FKAAB). Food waste can also play a role in producing organic matter in water bodies. When food particles break down, they release organic compounds that become a source of nourishment for bacteria and other microorganisms. As these microorganisms utilize organic matter, their rapid multiplication can disrupt the microbial community, causing shifts in water quality and the environment's delicate balance [17].

Surface runoff from roadways can contain several pollutants. Heavy metals, lubricants, and vehicle fluid compounds can also pollute road runoff [14]. Landscape fertilizer can potentially pollute the lake. Runoff from chemical fertilizers containing ammonia and phosphorus may reach the water body [16]. An overabundance of fertilizer not absorbed by plants or soil causes runoff. It is transported away by rain or irrigation [16]. Runoff can pollute lakes with ammonia and phosphorus [16]. Lastly, points 3 and 4 discharged the water towards drainage outside UTHM and towards Tasik Teknologi (FPTV) lakes, respectively.

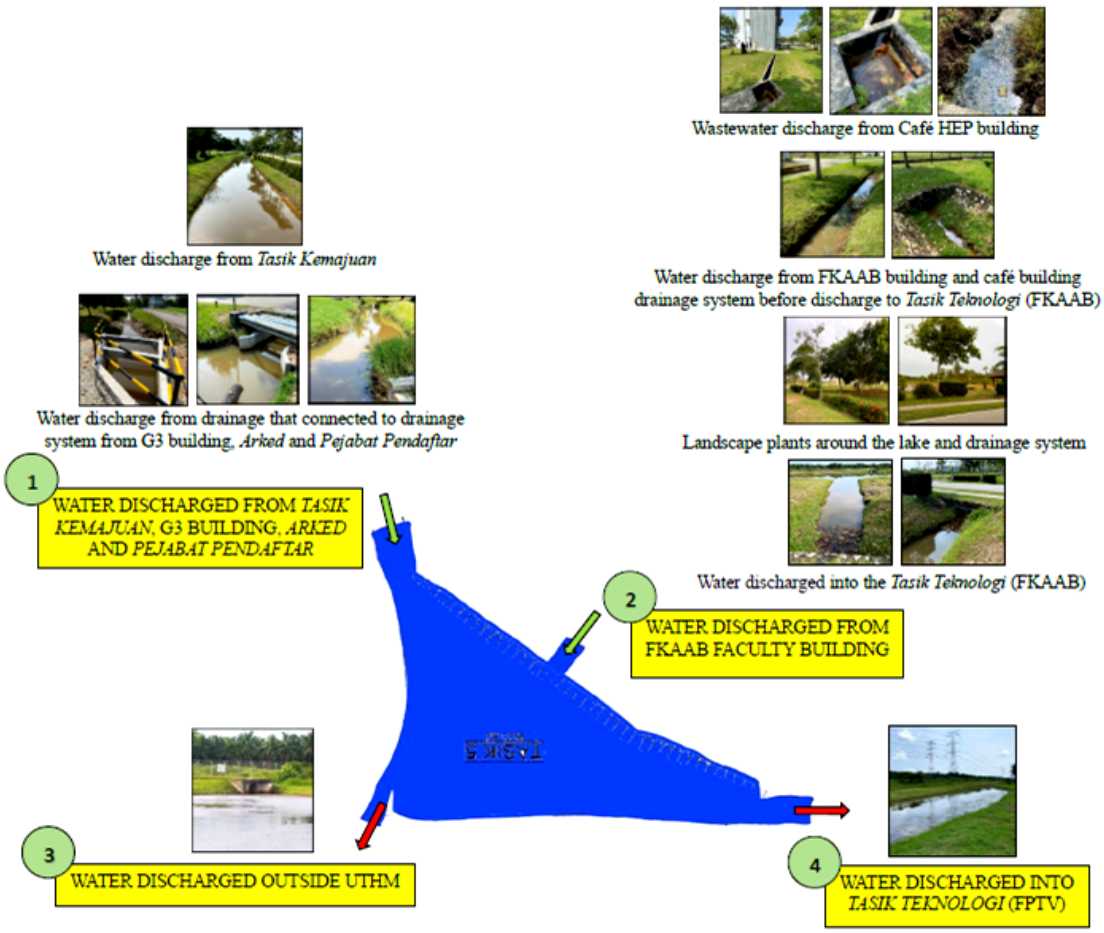

Fig. 3 *Inventory of Tasik Teknologi (FKAAB)*

3.3 Tasik Teknologi (FPTV) Pollution Inventory

Fig. 4 illustrates the water discharges that enter the Tasik Teknologi (FPTV). Water from Lake 7 is discharged into this lake at point 1. The water discharge from Lake 7 in the commercial building area may contain a variety of pollutants commonly associated with urban areas. Industrial sewage from commercial buildings can harm the nearby water areas [18]. Water pollution can be caused by runoff from commercial buildings. The runoff can potentially carry a range of pollutants, such as nitrogen, bacteria, heavy metals, and organic contaminants [19]. Tasik Teknologi (FPTV) received leaves, grass clippings, and other garden waste from the FPTV faculty building water outflow. This lake receives faculty drainage wastewater with soap and food particles. Soap and cleaning goods include toxins that can harm aquatic life. These products contain surfactants and phosphates, which may damage aquatic species and disturb their biological functions [20].

Tasik Teknologi (FKAAB) water flows into this lake at point 3. The pollutants present in Tasik Teknologi (FKAAB) are carried to the lake, potentially including waste like organic matter such as leaves, grass clippings, and other garden waste. This lake may also receive wastewater, which contains soap and food particles. The level of contaminants tends to lower with increasing distance as a result of the process of dilution.

At point 4, a water inlet was identified that discharges water from the Pejabat Pembangunan dan Penyenggaraan lake and palm oil plantations area. In addition, the application of mineral fertilisers and herbicides in oil palm plantations can also have a negative impact on water quality [21]. These chemicals can seep into the soil and ultimately make their way into nearby water sources, resulting in pollution. At this point, the water from this lake was discharged via the outlet outside UTHM.

Surface runoff can contain pollutants from different origins. While some of these sources are natural, like soil, leaves, and organic debris, others result from human activity, such as construction materials, exhausted particles, roadway debris, and fertilizers [22]. Rainwater can carry these contaminants from the road surface and enter water bodies through storm drains or surface runoff [22]. Urban runoff, including stormwater runoff from residential and commercial areas, can transport fertilizers from lawns, gardens, and other landscaped areas [23]. During rainfall, the water washes away the fertilizers and transports them into storm drains, ultimately releasing them into water bodies. This runoff could result in nutrient pollution in water bodies, which can cause eutrophication and harmful algae blooms.

Fig. 4 *Inventory of Tasik Teknologi (FPTV)*

3.4 Tasik Pembangunan Pollution Inventory

Fig. 5 shows the pollution inventory conducted at Tasik Pembangunan. At point 1, the water discharged was identified from zone 5, meanwhile at point 2, the water discharged from the Pusat Kesihatan Universiti, Pusat Penyelidikan, Pusat Teknousahawan and Pusat Khidmat Pelajar. At point 3, the water discharged was identified from the Pusat Penyelidikan drainage system. Water pollution from commercial buildings can arise from various pollutants frequently linked to urban areas. Industrial sewage, discharged from commercial buildings, has the potential to pollute nearby water areas [18].

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Water runoff from commercial buildings has the potential to cause water pollution. This runoff can contain nitrogen, bacteria, heavy metals, and organic contaminants [19]. There are various sources of pollutants in surface runoff. Some of these sources are natural, like soil, leaves, and organic debris. Others are caused by human activity, such as construction materials, exhausted particles, roadway debris, and fertilizers [22]. These contaminants have the potential to be carried away from the road surface during rainfall and find their way into water bodies via storm drains or surface runoff [22]. Finally, water from Tasik Pembangunan is discharged into Tasik Kemajuan at point 4, transporting pollutants into the lake.

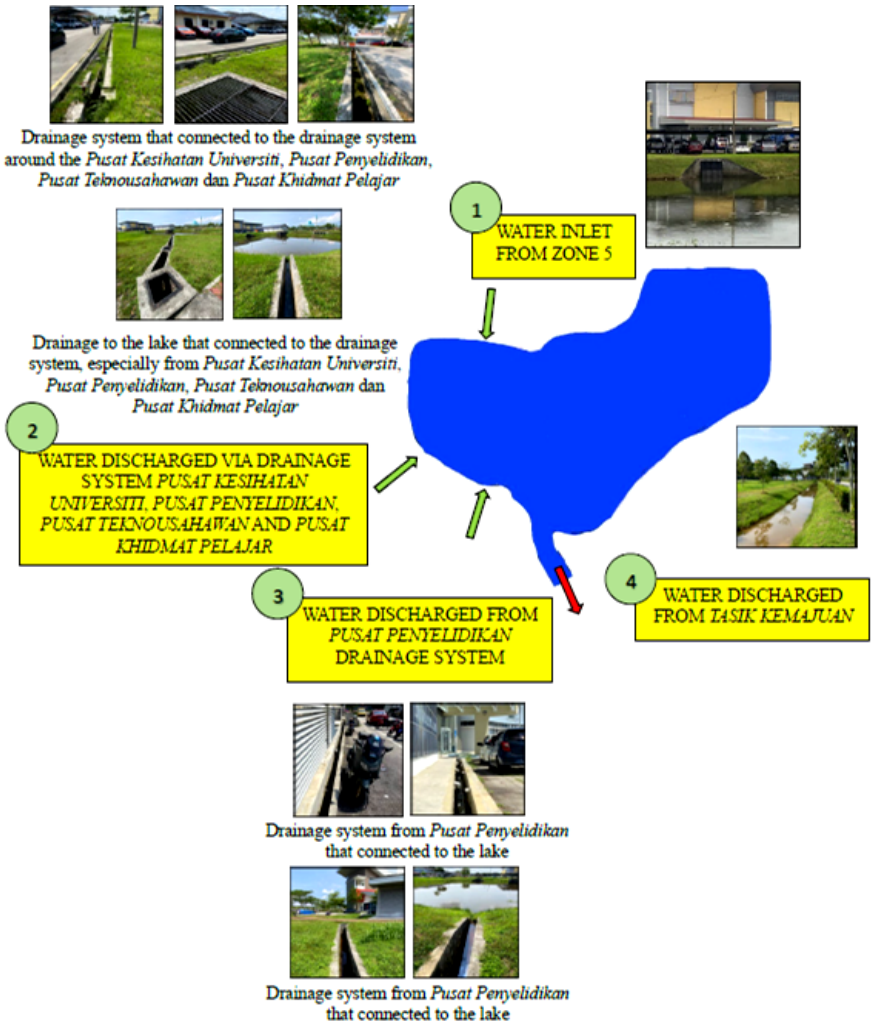

Fig. 5 *Inventory of Tasik Pembangunan*

4. Conclusion

Understanding the origins of pollutants is crucial in managing eutrophication. By identifying and resolving specific sources of nutrient inputs and contaminants, precise interventions and management strategies can be implemented to decrease nutrient runoff, prevent pollution inputs, and effectively manage eutrophication in water bodies. Based on the comprehensive pollutant sources inventory, it has been determined that the lakes are exposed to both point and non-point pollutant sources, with variations observed between each lake. According to the conducted pollutant inventory for PS, it has been found that the pollution sources are the cafeteria wastewater and the drainage system from the commercial building and faculty, which enter all the observed lakes. Water discharge from the palm oil plantation area was also identified as a pollutant source for Tasik Teknologi (FPTV), which can lead to a higher concentration of nutrients in the lake. Organic matter like leaves, grass clippings, and other yard waste was observed that entered the water body in all the study's lakes. Tasik Kemajuan, Tasik Teknologi (FKAAB), and Tasik Teknologi (FPTV) were observed receiving water discharge from other lakes, which means the pollutants were transported from one lake to another.

Most of the NPS identified via this pollutant's sources investigation were from surface runoff. Various contaminants can be found in road surface runoff. Construction materials, exhausted particles, roadside waste, and fertilizers are human-made sources, while soil, leaves, and organic detritus are natural. Rainwater from storm

drains or surface runoff may transport these pollutants from roadways to waterways. Urban stormwater runoff from domestic and commercial sectors can carry fertilizer from lawns, gardens, and other well-maintained areas. Rainwater washes fertilizers into storm drains and releases them into waterways. This runoff may pollute waterways, causing eutrophication and algae blooms. In conclusion, all pollutant sources that contributed to the eutrophication for Tasik Kemajuan, Tasik Teknologi (FKAAB), Tasik Teknologi (FPTV), and Tasik Pembangunan have been identified by conducting the pollutants sources inventory.

Acknowledgement

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through TIER 1 grant (Vot Q478) and GPPS (Vot Q307). In addition, the authors would like to express their gratitude to the people at Faculty of Civil Engineering and Built Environment at Universiti Tun Hussein Onn Malaysia for their assistance throughout the study.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Muhammad Hafiq Afifi Azman, Rafidah Hamdan, Zarina Md Ali;* ***data collection:*** *Muhammad Hafiq Afifi Azman, Rafidah Hamdan, Muhammad Afif Noor Azlan;* ***analysis and interpretation of results:*** *Muhammad Hafiq Afifi Azman, Rafidah Hamdan, Zuhaib Siddiqui;* ***draft manuscript preparation:*** *Muhammad Hafiq Afifi Azman, Rafidah Hamdan. All authors reviewed the results and approved the final version of the manuscript.*

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