

# VEGETATION AND THEIR IMPACTS ON HERITAGE BUILDINGS AT POLICE TRAINING CENTRE (PULAPOL) KUALA LUMPUR, MALAYSIA : A CRITICAL ANALYSIS

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## Abstract

Police Training Centre (PULAPOL) Kuala Lumpur has been gazetted as a heritage site since the year 2004. Since its inception, this academy houses various species of landscaping plants sheltering the area away from the sun and in turn giving it a refreshing atmosphere. However, the study found that the heritage buildings at PULAPOL have been affected by the surrounding vegetation. Although the previous studies stated that the damages on the heritage buildings were caused by several different factors, the damage caused by the vegetation factor is less studied and highlighted. Therefore, this study aims to identify the type of plants that contribute to the damages of the heritage buildings at PULAPOL as well as to analyze the damages based on the plants' characteristics. This qualitative study has been carried out through the employment of a case study approach that involves site observation and interview. The study found out that out of the 143 species of plants that have been planted at PULAPOL, 68 of them carry the potential to damage the heritage buildings due to inefficiency in management and their unsuitability.

**Keywords:** *Landscape Plants; Heritage Building; Conservation; PULAPOL.*

## INTRODUCTION

Kuala Lumpur Police Training Centre (PULAPOL) is the oldest police academy in Malaysia. The academy was established in 20 November 1904 established by Captain Graham who is a former Malay States Guides Officer and has been coordinating the police system in the country to date. It has also been recognized as a heritage site in Malaysia since 2004. The construction work of PULAPOL started around the 1930s and the construction was fully completed in 1936. To date, a total of 27 buildings and a monument were gazetted as heritage site making the academy as a historical building complex (Abu Bakar, 2017). This makes the PULAPOL building complex in Kuala Lumpur distinctive compared to any other heritage sites in Malaysia due to their large number of buildings in one area. Therefore, it is the Facility Management's responsibility to run the maintenance task on the heritage buildings since the management ought to be carried out by the proprietor.

Even so, the buildings listed as national heritage found in PULAPOL are also facing the threat of damage considering that the 27 buildings are old buildings that existed before independence. Most of the the buildings are using fair faced bricks and cement plastered walls. While the roof part uses clay tiles and wood finish as fascia board (Awang et al., 2021). The damages to buildings in PULAPOL were reported such as cracked aprons, rotting wooden finishes, roof damage, cracked walls and pillars, most of which were caused by the threat of the surrounding vegetation (Awang et al., 2021). The issue of plants that threaten heritage buildings, whether they are planted or grow naturally, is not taken very seriously because the

solution that is often taken during building conservation works is to cut down or prune. This situation is to preserve the heritage building from being continuously threatened in the future. Therefore, the study of the characteristics of plants found around heritage buildings is to identify the causes of damage to heritage buildings. Next, this will help conservators, building owners and local authorities take appropriate action to solve problems and reduce the impact on heritage buildings, especially in handling existing plants so as not to threaten heritage buildings and help in the selection of plants that want to be planted in the future.

## **OBJECTIVES AND METHODS OF STUDY**

This research aims to identify the type of plants or trees that could affect the heritage buildings at PULAPOL as well as to analyze the damages in the buildings based on the plants' characteristics. This study is carried out using qualitative case study approach. PULAPOL Kuala Lumpur is selected as the research subject because this location is the only site that consists of clustered buildings in one place which are 27 buildings in total. The building involved is a masonry type built in the 1930s, which is when this area was established. Its management is coordinated by the Management and Facility Unit led by an assistant manager who has been working there for 30 years. Instrumentally, the study is carried out through the employment of field observation method and interviews with the PULAPOL'S Facility Management. The observation method is carried out on all buildings in this academy that are listed as the heritage site by the National Heritage Department (JWN). Observations are made using plant inventory form combined with a dilapidated study form for building damage. Meanwhile, the interview method is carried out as purposive sampling by identifying the background of the sample; - the individual who is known to manage the organization of the buildings and landscape area in PULAPOL. The use of an interview candidate is because PULAPOL is a non-public area that conducts policing training activities. The buildings in this area are fully under the responsibility of PULAPOL management and do not involve conservators and other interested bodies. To conduct research in the PULAPOL area also requires some strict procedures where the number of visitors is also limited. The data then analyzed using content analysis from both instruments of the research method. This study has also been sent to the Official Administration Deputy Commander (General Police), PULAPOL Kuala Lumpur as a research procedure required for the government building as well as to be reviewed for data validation before being published to the public.

## **LITERATURE REVIEW**

Many studies state that heritage buildings often face physical damage because of their ages, reaching to hundreds of years old. The damages are usually caused by various factors such as weather, pests, traffic, and plants (Awang et al., 2021; Ahmad, 2018; Ahmad & Rahman, 2010; Hanafi et al., 2018; Salleh & Ahmad, 2009; Talib et al., 2014; Tan et al., 2016). Moisture is found to be the main issue that threatens the heritage buildings especially in the tropical area (Jim, 2018; Jim & Chen, 2010). This moisture issue is not only caused by the weather but also due to the presence of the trees in its surroundings (Awang et al., 2021; Ahmad, 2018). Similarly, other damages such as fractures, termite issues and structural damage also occur as a result of the existence of plants in the vicinity (Awang et al., 2020). The presence of termites poses a threat to the building structures, especially for areas with tropical climate (Muvengwi et al., 2017; Verma et al., 2018).

Plants are able to live longer than the buildings next to them, which can damage the building and pose a threat to its occupants (Catt, 1993). Hitchhiking plants are more likely to grow on old buildings such as palaces, fortresses, tombs, places of worship and archaeological sites (Caneva et al., 2009; Ceschin et al., 2016; Giulia et al., 2018; Awang et al., 2021). The tropical climate gives plants the advantage to grow easily no matter where they are, including on buildings such as walls (Jim, 1998, 2013, 2018). The presence of plants around the building causes moisture on the walls and interior spaces to activate the growth of moss and the formation of green stains (Ahmad, 2018; Kayan, 2006; Ayub et al., 2021). As in the case of the buildings of Angkor, Cambodia, the canopy of plants was found to prevent sunlight from reaching the building and creating a mossy area, always dim and humid. (Giulia et al., 2018). Plants that have sparse leaves are more suitable than plants that have dense foliage because they do not block the sunlight from penetrating them and also do not block the visual view of the building. (Catt, 1993). In addition, the moss or fungus that grows releases spores into the air that can affect the health of the building's occupants (Bakri dan Mydin, 2014).

The stone wall is the main habitat for some plants to live which then spread on the wall of the building (Ceschin et al., 2016). Plants that have a strong root system and the ability to grow quickly such as *Ficus* spp. tends to damage brick walls and structures (Caneva et al., 2009). In addition, plant roots can cause cracks in walls and pavements (Ahmad 2004; Caneva et al., 2009; Catt, 1993; Halwatura et al., 2013; Kayan, 2006; Satriani et al., 2010; Yadav, 2015). The damage is caused by plants planted or plants close to the building (Catt, 1993; Mattheck et al., 2003; Young dan Ellsmore, 2008). Most cases of insurance claims against insurance companies against building damage often involve the attack of tree roots that are adjacent to the building which eventually causes the plant to be removed and cut down to reduce damage to the building structure (Biddle, 1979). Plant roots are able to lift heavy loads which this attack will cause vertical cracks, horizontal cracks and lateral forces (Mattheck et al., 2003).

## **FINDINGS**

In general, the landscape design at the academy focuses on beautification and brightening the environment with no specific concepts applied (Zahari, 2020). This can be observed in terms of the selection of different species of plants that display different shapes and functions. Meanwhile, the management and maintenance work of the landscape are more concentrated at the entrance and main management buildings such as the Commander's Office building, the Financial Office Building, around the marching field, the main road, and Gurdwara Sahib. The management unit gives the least attention to the landscape in the area of the Men's and Women's hostel barrack as this area is not a place of interest and not the main area.

The damaging impact of plants identified in PULAPOL Kuala Lumpur creating untidy surrounding, causing plant remains pollutants on the roof, gutter, drainage, and leading to formation of moss as well as stain (Table 1). The study has found that there are 143 species of landscape plants that have been planted throughout the area of PULAPOL Kuala Lumpur which are 51 species of trees, 35 species of woody shrubs, 25 species of herbaceous plants, 11 species of palms & cycads, 9 species of cacti & succulents, 6 species of epiphytes & lithophytes, 3 species of bamboo, grass & sedge plants, 2 species of climbers & creepers plants, and 1 species of fern & allies. Meanwhile, Overall, the study has found that there are 68 out of 143 species of these plants that are capable of affecting the heritage buildings in

PULAPOL which consist of 43 trees species, 8 palm species, 13 woody shrub species, 3 herbs species and 1 species of climbers & creepers. From that number, the findings concluded that there are 25 species of plants threatening the heritage building which involve 21 species of trees, 3 species of woody shrubs and 1 species of palms & cycads (Table 2).

**Table 1.** List of Heritage Buildings in PULAPOL Kuala Lumpur by Type of Damage Caused by Plants

NO	CODES	LIST OF BUILDINGS Building category: Listed as a Heritage Site by Jabatan Warisan Negara Building type: Masonry	IMPACTS CAUSED BY PLANTS TO HERITAGE BUILDINGS				
			Untidy Surrounding	Waste on Rooftops	Waste in the Gutter	Waste in the Drainage	Moss and Stain
1	JKR 341	Male Barrack	/	/	/	/	
2	JKR 342	Male Barrack	/	/	/	/	
3	JKR 386	Female Barrack	/	/	/	/	
4	JKR 394	Female Barrack	/	/	/	/	
5	JKR 817	Commander's Residence	/	/			
6	JKR 1331	Adjutant Residence	/		/		
7	JKR 1332	Assistant Commander's Residence (Training)	/				
8	JKR 1333	Assistant Commander's Residence	/			/	
9	JKR 1541-44	Class F Family House	/	/			
10	JKR 1744-55	Women Police's Children Dormitory	/	/	/	/	
11	JKR 1874	Office of The Art of Self-Defense Building (SMD)	/		/		
12	JKR 1875	Physical Intelligence Test Building (UKF)	/		/		
13	JKR 1876	Cyberpool Building	/		/		
14	JKR 1877	Sports Building (Gymnasium)	/	/	/		
15	JKR 1878	Marching Band Building	/		/		
16	JKR 1879	Diner Building	/		/	/	
17	JKR 1786	Commander's Office Building (Guard Hall)	/		/		
18	JKR 1896	KEMAS Kindergarten Building	/		/	/	
19	JKR 2003	Male Police's Children Dormitory	/	/	/	/	
20	JKR 2004	Finance Office Building				/	
21	JKR 2005	Central Weapons & Armament Workshop	/		/	/	
22	JKR 2006	Hall One	/		/	/	
23	JKR 2006	Batu Lama School Building	/		/	/	
24	JKR 2019	Commander's Office Building	/				
25	JKR 2076	Sport Building	/		/		
26	JKR 2078	Gurdwara Sahib PULAPOL	/		/	/	
27	JKR 2085	Musolla/Mosque PULAPOL	/				

The study has identified that there are a total of 21 plants that cause the environment of the building areas to be untidy. This condition is caused by leaves, twigs and flowers that often fall and accumulate at the corners of the buildings that are difficult to clean. These types of plants are identified as *Hopea odorata*, *Loropetalum chinensis*, *Mangifera indica*, *Peltophorum pterocarpum*, *Pterocarpus indicus*, *Samanea saman*, *Terminalia mentaly*, *Juniperus chinensis*, *Spathodea campanulata*, *Phyllanthus acidus*, *Moringa oleifera*, *Artocarpus heterophyllus*, *Artocarpus integer*, *Dalbergia latifolia*, *Syzygium campanulata*, *Syzygium aqueum*, and *Averrhoa bilimbi*. While plants like *Bougainvillea spectabilis* and *Veitchia merillii* which produce flowers and fruits, although not much, have been found to affect the buildings due to lack of maintenance.

There are six (6) species of plants that cause the accumulation of plant residues on the buildings' roof such as *Dalbergia latifolia*, *Durio zibethinus*, *Juniperus chinensis*, *Mangifera indica*, *Peltophorum pterocarpum* and *Spathodea campanulatum*. The existence of these plants have made the surrounding area untidy because they produce and drop their leaves, fruits and twigs. As these plants are planted near the buildings, the physical condition of the plants is higher than the buildings and such location is less suitable due to wind factor that causes leaves to accumulate and get trapped on the roof. Plants from the species of *Dalbergia latifolia* and *Peltophorum pterocarpum* are found to be far from the building but still, their small leaves have been found to be carried by the wind and trapped on the roof.

There are six (6) buildings that are found to have the problem of waste accumulation in the gutter channel such as Commander's Office Building (Guard Hall), Male Police's Children Dormitory, PULAPOL Central Weapons and Armament Workshop, Hall One, Batu Lama School Building and Gurdwara Sahib PULAPOL. The accumulation of plant waste such as leaves and twigs is from *Juniperus chinensis*, *Mangifera indica* and *Syzygium campanulatum*. Other buildings are not affected by this problem because there is no tall plant near the building and there is no gutter channel attached to the buildings. These buildings are administrative buildings such as the Commander's Office and Finance Office buildings which only house flowering shrubs.

While 17 species of plants have been found to cause the accumulation of waste in the drains, 15 of them are plants that shed leaves, 1 species drop flower and 1 species drop fruit. The affected buildings are 20 out of 27 buildings where the type of plants that cause this problem are *Anacardium occidentale*, *Artocarpus heterophyllus*, *Averrhoa bilimbi*, *Bougainvillea spectabilis*, *Hopea odorata*, *Juniperus chinensis*, *Mangifera indica*, *Oleiferous moringa*, *Peltophorum pterocarpum*, *Phyllanthus acidus*, *Platyclusus orientalis*, *Pterocarpus indicus*, *Samanea saman*, *Syzygium aqueum*, *Syzygium campanulatum*, *Terminalia mentaly* and *Veitchia merrillii*.

Moss growth and stain effects have been found to result from the existence of shady plants and tall trees that are planted closely along the roads and near the buildings. This condition provides prolonged moisture to the area. The contributing plants are *Peltophorum pterocarpum*, *Juniperus chinensis* and *Mangifera indica*. On the other hand, woody shrubs that are used as a hedge and topiary namely *Ficus microphylla* 'Golden', *Loropetalum chinense* and *Phyllanthus myrtifolius* also provide moisture due to the density of their leaves. As its fallen fruits and flowers are not cleaned, *Veitchia merrillii*, a palm species, also gives a shady effect on the building apron.

For plants that are planted in the pot, one common issue that often occurs is moss and stain formation in their surroundings. The moss formation exists because the pots have no plant saucer at the bottom part and also are arranged too close to each other. The employment of the pots without their saucer has caused some white and yellow stains to form on the floor which then lead to sediment accumulation in the drains. The sediment is actually resulted from the water residues during plant watering work. Species of plants that are planted in the pot are *Aloe arborescens*, *Bougainvillea spectabilis*, *Bulbophyllum* spp., *Calathea makoyana*, *Codiaeum* Cultivars, *Cordyline terminalis*, *Cordyline fruticose*, *Costus woodsonii*, *Dendrobium crumenatum*, *Dendrobium* Hybrids, *Dieffenbachia amoena*, *Dischidia nummularia*, *Dracaena angustifolia*, *Dracaena braunii* 'Lotus', *Dracaena draco*, *Guzmania lingulata*, *Ficus lyrata*, *Premna corymbosa*, *Sansevieria trifasciata* 'Laurentii', *Tabernaemontana divaricata*, *Tradescantia spathacea*, and *Wrightia religiosa*. However, the formation of moss and stain is not associated with the type or species of plant but caused by the usage of the pot that is less practical as well as excessive watering.

In addition, many plants that could risk the buildings are also planted in the area. However, due to their position that is quite far from the buildings, these plants are seen to have no impact on the building but based on the characteristics indicated, these plants are seen to have potential risks of damaging the structures if they are planted close to the buildings. The plants that are identified to have destructive roots are *Anacardium Occidentale*, *Artocarpus altilis*, *Cinnamomum iners*, *Fagraea fragrans*, *Ficus benjamina*, *Ficus microphylla* 'Golden', *Hopea odorata*, *Lagerstroemia floribunda*, *Peltophorum pterocarpum*, *Psidium guajava*, *Pterocarpus indicus*, *Samanea saman*, *Terminalia catappa* and *Terminalia mentaly*. While *Vanilla planifolia* that is a climber type with aerial root may also affect the building surface if it is planted on the wall of the building.

Plants that are identified to have a seasonal leave falling or deciduous, crowded crown types, possess flowers and fruits are capable of damaging the buildings if the remnants are stuck on the gutter, drainage and roof. The identified plants are *Azadirachta indica*, *Caesalpinia ferrea*, *Cinnamomum iners*, *Ficus benjamina*, *Lagerstroemia floribunda*, *Naphelium lappaceum*, *Vitex trifolia*, *Naphelium mutabile*, *Terminalia catappa*, *Tabebuia pentaphylla* and *Ziziphus maitian*. Many of these species should be given more attention because they often drop their leaves in large numbers such as *Azadirachta indica*, *Caesalpinia ferrea* and *Terminalia mentaly*. Plants that drop flowers in large quantities such as *Tabebuia pentaphylla* should also be avoided to be planted too close to the building because the flowers will produce stain if they are not cleaned immediately and will cause clogged gutters if they accumulate in the channels. Plants that need to be avoided due to their risk of causing serious damage to the building are *Ficus benjamina*, *Vitex trifolia*, *Terminalia mantaly*, *Terminalia mantaly* 'Variegata', and *Fagraea fragrans*.

Plants that have dense crown and a high number of leaves carry the risk of making the surrounding area moist as they obstruct the sunlight from penetrating the ground floor. The palm and shrub plants such as *Rhapis excelsa*, *Dyopsis lutescen* and *Heliconia psittacorum* are found to have a crowded-like appearance due to its cluster-grown properties and wide fan-shaped leaves. It is the same with *Rhodomyrtus tomentosa* and *Osmoxylon lineare* plants which are the woody shrub species with a crowded-like appearance that are often used as a fence and planted close to drains and buildings. Other woody shrub plants with the same feature are *Streblus asper*, *Duranta* sp., *Ficus microphylla* 'Golden', *Hibiscus rosa-sinensis*

and *Ixora sunkist*. All of these plants can't be planted too close to the buildings. These plants are often employed for topiary which will leave remains such as leaves and twigs. Some trees like *Cinnamomum iners* and *Ficus benjamina* do not only drop their leaves, but also cause a damp surrounding because they have dense round-shaped crown. Typically, maintenance practices that are insufficient will leave the remains in the surrounding area as mulch. Besides making the environment a bit messy, these remnants if not properly managed will invite termite attack because plant's remains is their food source.

The palm plant, *Roystonea regia* that is planted in the building area of the Office of Martial Arts (SMD) is seen not in good condition and exhibits a withering appearance. Its shoots have been attacked by insects and at risk of dying if not treated. If the plant dies, it will be attacked by wood-feeding insects and termites. However, palm plants such as *Wodeyetia bifurcata* that are planted in some places in this area, are seen as fertile but the location of their cultivation should also be given attention as the plants are at risk to be attacked by pest. Pest like termites are usually attracted to plants that are easy to die because they have decaying parts and high cellulose content. Therefore, the selection of plants needs to be suitable or precise by identifying the characteristics of the plant.

Table 2. Summary of Plants in PULAPOL Kuala Lumpur and Its Characteristics Affecting Heritage Buildings

NO.	PLANTS	FEATURES OF PLANTS THAT AFFECT HERITAGE BUILDING							
		Drop Leaves	Drop Twigs & Branches	Bear Fruits	Drop Flowers	Destructive Roots	Compacted Crown & Shed	Easy to Rot or Die	
1	<i>Acalypha siamensis</i> (Wild Tea)	- **Dry leaves from pruning (topiary) trapped in drainage & surrounding	- **Dry twigs from pruning (topiary) trapped in drainage & surrounding	-	-	-	- **Moisture on wall & apron - **Dry leaves in drainage	-	
2	<i>Alpinia galanga</i> (Lengkuas)	-	-	-	-	-	- **Moisture on wall, apron and drainage	-	
3	<i>Anacardium occidentale</i> (Cashew)	- *Dry leaves stuck in drainage & surrounding	-	-	-	- *Roots attack on floor and apron	- *Moisture on wall & apron	-	
4	<i>Annona muricata</i> (Soursop)	- **Dry leaves stuck in drainage	-	-	-	-	-	-	
5	<i>Annona squamosa</i> (Sweetsop)	- **Dry leaves stuck in drainage	-	-	-	-	-	-	
6	<i>Artocarpus heterophyllus</i> (Nangka)	- *Dry leaves in gutter, roof, drainage surrounding	-	- **Fruits attract civet/ monkey - **Roof damage due to fruits fall	-	-	- *Moisture on wall & apron	-	
7	<i>Artocarpus altilis</i> (Breadfruit)	- *Dry leaves in gutter, roof, drainage & surrounding	-	-	-	- **Roots attack on wall, floor and apron	- **Moisture on wall & apron	-	
8	<i>Artocarpus integer</i> (Cempedak)	- *Dry leaves in gutter, roof, drainage surrounding	-	- **Fruits attracts civet/ monkey - **Roof damage due to fruits fall	-	- **Roots attack on wall, floor and apron	- **Moisture on wall & apron	-	
9	<i>Averrhoa bilimbi</i> (Belimbing)	- *Dry leaves in drainage surrounding	-	-	-	-	-	-	
10	<i>Azadirachta indica</i> (Neem)	- *Dry leaves in gutter, roof, drainage & surrounding	-	-	-	- *Roots attack wall, floor and apron	- *Moisture on wall & apron	-	



**Table 2.** Summary of Plants in PULAPOL Kuala Lumpur and Its Characteristics Affecting Heritage Buildings (continued)

24	<i>Fagraea fragrans</i> (Tembusu)	- **Dry leaves in gutter, roof, drainage & surrounding	-	-	-	- **Roots attack walls, floor, apron and drainage	- **Moisture on wall & apron	-
25	<i>Ficus benjamina</i> (Jejawi)	- **Dry leaves in gutter, roof, drainage & surrounding	-	- **Fruits attract birds	-	- ** Roots attack on wall, column, roof & floor - Strangler species	- *Moisture on wall & apron	-
26	<i>Ficus microphylla</i> 'Golden' (Golden Fig)	- **Dry leaves in gutter, roof, drainage & surrounding	-	- **Fruits attract birds	-	- **Roots attack on wall, column, roof & floor - Strangler species	- *Moisture on wall & apron	-
27	<i>Hibiscus rosa-sinensis</i> (Bunga Raya)	-	-	-	-	-	- *Moisture on wall & apron	-
28	<i>Heliconia psittacorum</i> (Septit Udang)	-	-	-	-	-	- **Moisture on wall & apron	-
29	<i>Hopea odorata</i> (Chengal Pasir)	- *Dry leaves in gutter, roof, drainage & surrounding	- **Dry twigs in gutter, roof, drainage & surrounding	-	-	- ** Roots attack wall, floor and apron	- *Moisture on wall & apron	-
30	<i>Ixora sunkist</i> (Ixora)	- **Dry leaves from pruning (topiary) trapped in drainage & surrounding	- **Dry twigs from pruning (topiary) trapped in drainage & surrounding	-	- **Dry flowers in drainage	-	- **Moisture on wall & apron	-
31	<i>Juniperus chinensis</i> (Chinese Juniper)	- *Dry leaves in gutter, roof, drainage & surrounding	-	-	-	-	- *Moisture on wall & apron	-
32	<i>Lagerstroemia floribunda</i> (Bungor)	- **Dry leaves in gutter, roof, drainage & surrounding	- **Dry twigs in gutter, roof, drainage & surrounding	-	- **Dry flowers in drainage	- ** Roots attack walls, floor, apron and drainage	- *Moisture on wall & apron	-
33	<i>Lagerstroemia indica</i> (Crepe Myrtle)	- **Dry leaves from pruning trapped in drainage & surrounding	- **Dry twigs from pruning trapped in drainage & surrounding	-	- **Dry flowers in drainage	-	-	-



Table 2. Summary of Plants in PULAPOL Kuala Lumpur and Its Characteristics Affecting Heritage Buildings (continued)

43	<i>Peltophorum pterocarpum</i> (Batai)	- *Dry leaves trapped in gutter, roof, drainage & surrounding	- *Dry twigs trapped in gutter, roof, drainage & surrounding	- *Dry fruits trapped in gutter, roof, drainage & surrounding	- **Small flowers accumulate in gutter roof and drain	- **Roots attack on floor, apron and drainage	- **Moisture on wall & apron	-
44	<i>Phaleria marcocarpa</i> (Mahkota Dewa)	-	-	- **Fruits trapped in drainage & surrounding	-	-	-	-
45	<i>Phyllanthus acidus</i> (Cermal)	- *Dry leaves trapped in drainage & surrounding	-	- *Fruits trapped in drainage & surrounding	-	-	-	-
46	<i>Phyllanthus myrtifolius</i> (Mousetail Plant)	-	-	-	-	-	- *Moisture on wall & apron	-
47	<i>Plumeria obtusa</i> (Kemboja Putih)	- *Dry leaves trapped in drainage & surrounding	-	-	- **Flowers accumulate in drain	- **Roots attack on floor, apron and drainage	-	-
48	<i>Plumeria rubra</i> (Kemboja Merah)	- *Dry leaves trapped in drainage & surrounding	-	-	- **Flowers accumulate in drain	- **Roots attack on floor, apron and drainage	-	-
49	<i>Platycladus orientalis</i> (Chinese Aborvitae)	- *Dry leaves trapped in drainage & surrounding	-	-	-	-	- *Moisture on wall & apron	-
50	<i>Psidium guajava</i> (Guava)	-	-	- *Fruits attract civet and other animals	-	- **Roots attack on floor, apron and drainage	-	-
51	<i>Pterocarpus indicus</i> (Angsana)	- *Dry leaves trapped in gutter, roof, drainage & surrounding	- *Dry twigs trapped in gutter, roof, drainage & surrounding	- *Dry fruits trapped in gutter, roof, drainage & surrounding	- **Small flowers accumulate in drain	- ** Roots attack on floor, apron and drainage	- *Moisture on wall & apron	- **Building damage due to easy to rot and fall
52	<i>Rhapis excelsa</i> (Patas)	-	-	-	-	-	- *Moisture on roof, wall & apron	-



Table 2. Summary of Plants in PULAPOL Kuala Lumpur and Its Characteristics Affecting Heritage Buildings (continued)

62	<i>Terminalia mentaly</i> (Doa Tree)	- *Dry leaves trapped in gutter, roof, drainage & surrounding	-	- *Fruits trapped in gutter, roof, drainage & surrounding	-	- ** Roots attack on floor, apron and drainage	- *Moisture on wall & apron	-
63	<i>Terminalia mantaly</i> 'Variegata' (Doa Tree)	- *Dry leaves trapped in gutter, roof, drainage & surrounding	-	- *Fruits trapped in gutter, roof, drainage & surrounding	-	- ** Roots attack on floor, apron and drainage	- *Moisture on wall & apron	-
64	<i>Vanilla planifolia</i> (Vanilla)	-	-	-	-	- **Roots attack on wall surfaces	-	-
65	<i>Veitchia merrillii</i> (Manila Palm)	-	-	- *Floor stain due to ripe fruits fall	- *Flowers accumulate in drain	-	-	-
66	<i>Vitex trifolia</i> (Lemuni)	- *Dry leaves trapped in gutter, roof, drainage & surrounding	-	- *Fruits trapped in gutter, roof, drainage & surrounding	-	-	-	-
67	<i>Wodyetia bifurcata</i> (Foxtail palm)	-	-	- **Floor stain due to ripe fruits fall	- **Flowers accumulate in drain	-	-	- **Trunk that easy to rot attract termites
68	<i>Ziziphus mauritiana</i> (Bidara)	- **Dry leaves trapped in gutter, roof, drainage & surrounding	-	- **Fruits trapped in gutter, roof, drainage & surrounding	-	-	- **Moisture on wall & apron	-

Note: \*Plants that already threat the buildings;

\*\*Plants that potentially threat the buildings.

## FACTORS THAT CAUSE PLANT IMPACTS ON BUILDINGS

In general, there are three factors that contribute to plant impacts towards the heritage buildings which are building factor, plant factor, and landscape management factor. The building factor can be identified based on three elements which are building age, building design, and building material. The age of the building that has reached hundreds of years have made some structures prone to damages and they need to be fixed. That state of the buildings with some already damaged structures will become more vulnerable to the plant's threats such as cracks on the drain part which also encourage the root to grow across the structures. Besides, the architectural design of the building that is too complicated at some parts such as the roof has caused the leaves, fruits, and twigs to be easily trapped. The building material factor also could affect how the plants impact the buildings. Buildings with the employment of facing brick materials are shown to have less damage. Most damages occur on building structures that employ plaster, moisture-prone materials, painted wall, and wood materials with no weather-resistant element. The damages that occur are mostly associated with the moisture problem in which the plants are one of the active agents. Masonry building with the employment of lime plaster and clay brick has been providing mineral source to the plants. Some materials can maintain or preserve the moisture longer than other types of materials encouraging the plants to grow on them. Because of this factor, epiphyte plants such as ferns and strangler, *Ficus sp.* for example, can easily grow on the material surface due to wind pollination and bird dissemination (Zahari, 2020).

The second factor is the plant factor which can be identified into two elements namely the species of plant and the planting location. These two factors are seen as interconnected because each species has different impacts. Some plants are planted in an area far from the building but still contribute to the damage of the building. Some of the plants are *Peltophorum pterocarpum*, *Pterocarpus indicus*, *Samanea saman*, *Terminalia mantaly*, *Schizolobium parahyba* and *Hopea odorata* which are categorised as deciduous plants in which their leaves are easily scattered due to wind gusts. Among these plants, some plants have fine leaves such as *Peltophorum pterocarpum*, *Samanea saman*, *Schizolobium parahyba* and *Terminalia mantaly* and their leaves could scatter at a far distance from the trees. Due to their small size, there will be some difficulties in cleaning work. This situation will become more complicated if the leaves are stuck in hard-to-reach places such as gutter channels (Zahari, 2020). This location factor concerns more on the threats from the roots beneath the soil that are difficult to detect with naked eyes. The practice of tree planting is usually based on the spread of roots through observation of the widening of the crown. If the plant's crown reaches the building, most likely the roots have also touched the structure of the building in the soil. Plants that could reach the building could also build a connecting way for insects and dangerous animals to get through to the building.

Furthermore, the landscape management factor should also be given attention because inefficient management will negatively affect the building. Inconsistent maintenance with no planned schedule will expose the building to the plants' threats (Zahari, 2020). In this academy, the maintenance work is only seen to be done consistently in the Commander's Office, Guard Hall, Finance Office, Gurdwara Sahib, and Hall One. This situation can be seen through the condition of plants that are maintained only in those areas and the selection of plant species such as flowering and decorative plants is only focused on the main area. The most under-performed maintenance is in Men & Women's Barracks, Deputy Commander's

Residence (Training), Deputy Commander's Residence (Administration & Garage), and Sports Building. This inconsistent landscape management is seen as a factor causing serious damage to the buildings. The maintenance work at the administrative building and the main entrance is excellent because the concerned buildings act as a welcoming landmark to the visitors. However, the buildings that are located at hidden location with less attraction to the visitors are somewhat ignored. Some trees have been planted not for beautification purposes but more towards medical purposes and providing fruits and other supplies for kitchen such as *Durio zibethinus*, *Capsicum annum*, *Carica papaya*, *Jatropha curcas*, *Mangifera indica*, *Manihot utilissima*, *Musa* Cultivars, *Oroxylum indicum*, *Artocarpus altilis*, *Artocarpus integer* and so on. These plants can be found around the buildings of Men and Women's Barracks, Sports Building, KEMAS Kindergarten Building, and behind the Office of Martial Art Building (SMD). These types of plants could make the maintenance work more difficult not just because of the high production of leaves, but also unattended rotten fruits that will contribute to a dirty environment as well as attracting insects and animals such as bat and civet. The most worrying situation is the existence of termite colonies due to poorly cleaned environment with an abundance of its food source even though the treatment of insects has been done. Therefore, plants that drop leaves, twigs, branches, fruits & flowers, have destructive roots (hard and rising roots) and dense shade causing prolonged shading are characteristics that need attention due to the excessive moisture and structural damages that they have caused.

## CONCLUSION

In conclusion, not all plants affect the condition of heritage buildings at PULAPOL Kuala Lumpur. Plants that drop leaves & branches, produce fruit, flower heavily, pest roots, thick stems and plants that rot or die easily are characteristics that need to be paid attention in preserving heritage buildings. In building conservation works, identifying the plants in the surrounding area is very important in order to prevent repeated damages in the future. In addition, the types of vegetation that threaten heritage buildings can be avoided for landscape design after the conservation project is fully completed. This is especially important for the Management and Facilities Unit of PULAPOL as the academy has the greatest number of heritage buildings in one area. Therefore, the botanical knowledge in identifying the characteristics and types of appropriate plant species is essential to ensure that the beautiful landscape and scenery of the academy can be maintained without any restrictions. Besides, the academy location is situated in the centre of Kuala Lumpur city which requires it to follow the National Urbanisation Policy (2016) 2<sup>nd</sup> edition which is in Principle 5 of Green Development and Clean Environment emphasising that the landscape in municipalities should be intensified to reduce carbon dioxide intensity to 45% by 2030. Therefore, the landscape design in this area cannot be ignored simply to preserve the heritage buildings but a more efficient approach should be implemented so that the landscape and preservation of heritage buildings are balanced and interdependent.

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