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THE UPTAKE AND EFFECT OF FORMALDEHYDE ON *Jasminum sambac* PLANTS USING ULTRAVIOLET-VISIBLE SPECTROPHOTOMETER

by

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A report submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Sustainable Science) with Honours

FACULTY OF EARTH SCIENCE

UNIVERSITI MALAYSIA KELANTAN

2020

DECLARATION

I declare that this thesis entitled "The Uptake and Effect of Formaldehyde on *Jasminum sambac* Plants Using UV-Vis Spectrophotometer" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 7th January 2020

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ACKNOWLEDGEMENT

Firstly, the most important is I want to thanks to Allah SWT and not forgettable His Messenger, Muhammad SAW because without of His will I could not finish my study in University Malaysia Kelantan. I would like to express my deepest thanks to University Malaysia Kelantan Jeli Campus, for giving me the chance to finish up my study and completing this thesis for my degree. Most importantly, I would like to show highest and sincere gratitude to my final year project supervisor, Dr. Musfiroh binti Jani, for giving me the best guidance, continuous support, valuable lessons, useful advices and sincere supervision throughout the completion of my thesis. Without your guidance, I would not be able to complete my thesis in an ordered way.

Not to forget, I also would like to thank my co-supervisor, Dr. Shahirul Umirah binti Idris for giving me support during the research period, giving me the best assistance and guidance in this study. I also would like to acknowledge Mr. Mohammad Rohanif bin Mohamed Ali, Mrs Nur Izzati binti Salleh and Mrs Nur Syahida binti Ibrahim for their technical guide during the study. My sincere thanks also go to all my friends and final year project's teammates, for continuously supporting and helping me in completing this journey.

Last but not least, I would like to express my special thanks to the person that always in my mind which are both my parent, my father Muhammad Hisyam bin Abdullah and my mother Wan Sharifah binti Salleh for given their 100% full of support and prayed for my successful in completing my thesis. This thesis would not have been completed without all the mentioned assistance.

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The Uptake and Effect of Formaldehyde on *Jasminum sambac* Plants Using UV-Vis Spectrophotometer

ABSTRACT

Over the past few years, the issue of pollution from the grave is often taken into account and always become a study material and research. The most commonly used method for disposal of dead bodies and limbs is incineration. Incineration has been used for decades. Previously, biological specimen at the Hospital University of Sains Malaysia (HUSM) was disposed of through incinerators. Given that the majority of HUSM patients are Muslim societies, then proposals to dispose biological waste in an Islamic-compliant through burial method is done. Incineration of dead bodies will have a bad impact on the environment and human health. New ways have been introduced to overcome this problem by burial of formalin fixed specimen onto the soil. However, formalin preservation on specimen is a main concern. This study was done to determine the effect of the formaldehyde on the growth of the *Jasminum sambac* and the physical characteristic of the plant hence to determine the uptake of formaldehyde that the plants absorb. The results obtained from this research will give valuable information on the effect of formaldehyde on the environment specifically on the plant to the community at HUSM. This study also determines whether the formalin fixed specimen by burial method give negative or positive effect to the environment. The physical characteristics of the plant after treated with formaldehyde shows a negative growth with decrease in number of leaves and flowers as well as in the surface area of leaf. Other than that, the colors of leaves were changes from dark green to brownish color for the plants that treated with formaldehyde. The relative water content in leaves were achieved by measured the fresh, dry and turgid weight of leaves. The *Jasminum sambac* root, stem, flowers and leaves were blended to obtain the powder form. The uptakes of formaldehyde were obtained using UV-Vis Spectrophotometer. The result demonstrated that the highest formaldehyde concentration uptakes were found in the root with 0.02% from the actual concentration that applied to the plants. The evidence provided by this study demonstrated that the formaldehyde uptake followed the order of root>stem>flowers>leaves. In conclusion, formaldehyde application destroyed the plant and cause the physical characteristic of the plants does not grow well even with the lower concentration.

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Penyerapan dan Kesan Formaldehid terhadap Tumbuhan *Jasminum sambac* Menggunakan UV-Vis Spektrofotometer

ABSTRAK

Sejak beberapa tahun kebelakangan ini, masalah pencemaran dari kubur sering dipertimbangkan dan sentiasa menjadi bahan kajian dan penyelidikan. Kaedah yang paling biasa digunakan untuk pelupusan mayat dan anggota badan adalah pembakaran. Pembakaran telah digunakan selama beberapa dekad. Sebelum ini, spesimen biologi di Hospital Universiti Sains Malaysia (HUSM) telah dilupuskan melalui insinerator. Memandangkan majoriti pesakit HUSM adalah masyarakat Islam, maka cadangan untuk membuang sisa biologi dalam syariah Islam telah dilakukan melalui kaedah pengebumian. Pembakaran mayat akan memberi kesan buruk terhadap alam sekitar dan kesihatan manusia. Cara baru telah diperkenalkan untuk mengatasi masalah ini dengan menguburkan spesimen tetap formalin ke tanah. Walau bagaimanapun, pemeliharaan formalin pada spesimen adalah kebimbangan utama. Kajian ini dilakukan untuk menentukan kesan formaldehid terhadap tumbuhan *Jasminum sambac* dan ciri fizikal tumbuhan tersebut di samping untuk menentukan penyerapan formaldehid yang diserap oleh tumbuhan tersebut. Keputusan yang diperolehi daripada kajian ini akan memberi maklumat yang berharga kepada masyarakat di HUSM mengenai kesan formaldehid terhadap alam sekitar khususnya pada tumbuhan. Kajian ini juga dapat menentukan sama ada spesimen tetap formalin dengan kaedah pengebumian memberi kesan negatif atau positif kepada alam sekitar. Ciri-ciri fizikal tumbuhan selepas dirawat dengan formaldehid menunjukkan pertumbuhan negatif dengan penurunan jumlah daun dan bunga serta berlaku penurunan untuk luas permukaan daun. Selain itu, warna daun berubah daripada warna hijau gelap menjadi warna kecoklatan untuk tumbuh-tumbuhan yang dirawat dengan formaldehid. Kandungan air relatif di dalam daun dicapai dengan mengukur berat daun segar, kering dan turgid. Akar, batang, bunga dan daun *Jasminum sambac* diblender untuk mendapatkan serbuk bagi bahagian tumbuhan tersebut. Penyerapan formaldehid diperoleh dengan menggunakan Spektrofotometer ultraviolet terlihat. Hasil dapatan menunjukkan bahawa kandungan formaldehid tertinggi terdapat di akar dengan 0.02% dari kepekatan sebenar yang digunakan pada tumbuhan. Bukti yang disediakan oleh kajian ini menunjukkan bahawa pengambilan formaldehid mengikut urutan akar>batang>bunga>daun. Sebagai kesimpulannya, aplikasi formaldehid memusnahkan tumbuhan dan menyebabkan ciri fizikal tumbuhan tidak tumbuh dengan baik walaupun dengan kepekatan yang lebih rendah.

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LIST OF ABBREVIATIONS

HCHO	Formaldehyde
PAH	Polycyclic Aromatic Hydrocarbons
pH	Potential of Hydrogen
mg / L	Milligrams per Liter
CO_2	Carbon dioxide
PPM	Parts per Million
M	Molarity
V	Volume
X	Unknown
ml	Milliliter
g	Gram
N	Normality
nm	Nanometers
HUSM	Hospital University of Sains Malaysia
UF	Post-Industrial Urea
SPAD	Soil Plant Analysis Development
RTC	Rural Transformation Centre
DG	Dark green
LG	Light green
LB	Light brown
MB	Medium brown
DB	Dark brown
B	Black
YB	Yellow brownish
Y	Yellow
cm	Centimeter
A	Plant A
B	Plant B

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sq.cm	Square centimeter
µmol m^{-2}	Micromole per meter square
RWC	Relative water content
UV-Vis	Ultraviolet-Visible
y	y-axis
x	x-axis
R^2	R-squared
UMK	University Malaysia Kelantan

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LIST OF SYMBOLS

+	Addition
%	Percentage
℃	Degree Celsius
>	Greater than

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Over the past few years, the issue of pollution from the grave is often taken into account and always become a study material and research. However, the study about the embalming fluid for example formalin has not been discovered by the researchers. One of the chemicals recognized as a carcinogen is formaldehyde. Often, it will be toxic after inhalation, skin contact and ingestion. Formalin will break down and form harmless blends. With the presence of formaldehyde in the embalming liquid, it can eliminate germs and also preserve the body. According to (Nissa, 2019), in biology teaching, fluids used to treat biological specimens are formalin. The biological specimen will be slowly rotted due to the formation of formaldehyde in the embalming fluid.

The most commonly used method for disposal of dead bodies and limbs is incineration. Incineration has been used for decades. Incineration of dead bodies will have a bad impact on the environment and human health. National Center for Biotechnology Information (2000) stated that among the consequences is that the environment will become more polluted and will cause health damage to the human. Hazardous toxic substances such as bromine and chlorine will be released through incineration. New ways have been introduced to overcome this problem by burial of formalin fixed specimen onto the soil. However, formalin preservation on specimen is a

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main concern. This is why this research is required to investigate this problem. In such a way, the formaldehyde toxicity can affect this method. There has been much research done on the effect of formalin on organisms, but studies on the effects of formalin on plants have not yet to be investigated.

The determination of total concentration formalin uptake by the plant was known using the UV-Vis Spectrophotometer while observation was done to investigate the effect of formaldehyde on the *Jasminum sambac* plant. The physical characteristics of the *Jasminum sambac* plant were measured at in-situ and ex-situ. This study is done to determine the effect of the formaldehyde on the growth of the *Jasminum sambac* and the physical characteristic of the plant. This study also determines whether the formalin fixed specimen by burial method give negative or positive effect to the environment especially on the plant.

In this research, the concentration of the formalin uptake by the plant was measured. Other than that, the growth of plant at the biological waste disposal located in Kampung Demit, Kubang Kerian, Kelantan cemetery was observed. Lastly, the physical changes of *Jasminum sambac* between control plant and plant that treated with different concentration of formaldehyde was evaluated.

1.2 Problem Statement

The most commonly used method for disposal of dead bodies and limbs is incineration. Incineration has been used for decades. Previously, biological specimen at the USM Hospital was disposed of through incinerators. Given that the majority of HUSM patients are Muslim societies, then proposals to dispose biological waste in an

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Islamic-compliant through burial method is done. Incineration of dead bodies will have a bad impact on the environment and human health. Among the consequences is that the environment will become more polluted and will cause health damage. Hazardous toxic substances will be released through incineration. Bromine, chlorine, hydrogen bromide, sulfur oxides and nitrogen oxides are the examples of the hazardous toxic substances (National Center for Biotechnology Information, 2000). Indirectly, this will cause the general public and the environment to be threatened by this incineration of dead body process. New ways have been introduced to overcome this problem by burial of formalin fixed specimen into the soil. However, formalin preservation on specimen is a main concern. Among the benefits of using formalin methods are cheap (Eva, Alexander & Michael, 2007). Additionally, burial method also reduces the use of time as well as it maybe will not adversely affect the soil. This is why this research is required to investigate this problem. In such a way, the formaldehyde toxicity can affect this method. There has been much research done on the effect of formalin on organisms, but studies on the effects of formalin on plants have not yet to be investigated. Formalin is selected because it is suitable for the preservation and will kill the microorganism contain in the body part. Scottish Environment Protection Agency (2019) stated that the formalin in the environment gives little adverse effect to the environment such as to the soil and the groundwater from the previous research. Previous research only observe the effect of formaldehyde on the plant in the gaseous form so the exactly effect could not be determined. In this research, the effect of formaldehyde were obtained by using the liquid formaldehyde to get the exactly effect of formaldehyde on the plant.

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1.3 Expected Outcome

In this study, it is expected that the burial of formalin fixed specimen can reduce the threat to the environment compared to combustion methods. Works by Linus (2007) have shown that the use of very weak formaldehyde concentrations gives a positive stimulus. Radical of peas grow up successfully in dark conditions. Food reserves from cotyledons are more quickly available due to formaldehyde. This is because formaldehyde can increase enzyme activity. Formaldehyde is able to prevent enzyme action. Among the actionable enzymes is amylase. Other than that, Linus (2007) stated that with the use of *Tradescantia* herbs as evidence, root growth can be increased by the presence of formaldehyde. The strong formaldehyde concentration will cause the roots to be short while the weak formaldehyde concentration will cause the roots to become longer. According to Linus (2007), weak formaldehyde concentrations will not have a bad effect on plant growth according to previous research. In addition this burial of formalin fixed specimen method can give new knowledge to the community because this method is safe for the environment. In general, formalin does not affect too much on the plant (Linus, 2007). This study is conduct so that the method of incineration of dead body could be replaced by a burial of formalin fixed specimen which greatly benefits the environment, especially to the plant.

1.4 Objectives

The objectives of this study were:

- To observe the growth of plant at the biological waste disposal site located in Kampung Demit, Kubang Kerian, Kelantan cemetery.

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- To evaluate physical changes of *Jasminum sambac* plant between the control plant and the plants that treated with different concentration of formaldehyde.
- To determine the concentration of the formaldehyde uptake by the *Jasminum sambac* plant (leaves, flowers, stems and roots).

1.5 Scope of Study

In this research, the determination of total concentration of formaldehyde uptake by the plant and the effect of formaldehyde on the *Jasminum sambac* plant were considered. The site samples of plants were observed from the biological waste disposal located at Kampung Demit, Kubang Kerian, Kelantan cemetery beside the USM Hospital. The physical characteristics of the *Jasminum sambac* plant were identified and measured in-situ and ex-situ. The height of plants, surface area of leaves, leaves color, the number of leaves the number of flowers were measured in-situ while the dry weight of plants, fresh wet weight of plants, turgid weight and chlorophyll content were measured ex-situ. The *Jasminum sambac* plant growths were observed and the data obtained were recorded.

1.6 Significance of Study

This study was done to determine the effect of the formaldehyde on the growth of the *Jasminum sambac* and the physical characteristic of the plant. The results obtained from this research will give valuable information on the effect of formaldehyde on the environment specifically on the plant to the community at HUSM.

This study also determines whether the formalin fixed specimen by burial method give negative or positive effect to the environment. Other than that, the

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understanding about the suitable method to dispose the biological waste is crucial because it can result toward safe and clean environment.

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CHAPTER 2

LITERATURE REVIEW

2.1 Formaldehyde Solution

Formaldehyde solution is known as formalin which is corrosive and flammable. Formalin has a very unpleasant smell and is colorless liquids. About 37% to 50% of formaldehyde is found in formalin fluids (Tulpule, Hohnholt, & Dringen, 2013). The different amounts of methanol are also found in formalin liquid. Precipitation of formaldehyde polymers can be prevented by adding different amounts of methanol fluid. HCHO formula represents the formaldehyde that contained in the formalin liquids. Warm temperatures of 30℃ are required by methanol-free formalin (Tulpule et al., 2013). This is because the temperature can prevent polymerization from occurring. Formaldehyde that does not require handling commercially is known as the original formaldehyde which is gas (Tulpule et al., 2013). This is because the formaldehyde can easily to ignite. Additionally, explosion can easily occur when dealing with fire and heat. This is due to the vapor of the formalin fluid that is easy to flammable. Formalin can affect the skin and eyes (Tulpule et al., 2013). The eyes and skin will feel irritating.

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2.2 Physical and Chemical Properties of Formaldehyde

The formaldehyde properties are as follows, formaldehyde is a flammable and reactive gas. Additionally, at normal temperature and pressure, formaldehyde gases are easy to polymerize. At atmospheric pressure, explosive blends between oxygen and air will occur as a result of the heat of formaldehyde gas combustion. The extremely volatile formaldehyde gas is between 65% and 70% (World Health Organization, 2002). Formaldehyde is easily polymerized in aqueous solution state. World Health Organization (2002) stated that the aqueous solution will be turbid and precipitation of polymer will be produced if placed at room temperature and when the formaldehyde content is more than 30%. Formaldehyde can be photo oxidized to carbon dioxide under atmospheric state. The process of photo oxidized occurs because of the sunlight. The formaldehyde life span with the presence of sunlight is short. Additionally, when formaldehyde meets pollutants and trace substances in the air, it will react very rapidly. According to World Health Organization (2002) during the day, with the presence of nitrogen dioxide, the life expectancy of formaldehyde is about 35 minutes while with the absence of nitrogen dioxide, the lifetime of formaldehyde is 50 minutes.

2.3 Chemistry of Formalin Fixation

One of the most important steps in the processing of biopsy tissue specimens is fixation. This step is most important for maintaining and checking the archives. The composition of the cells in the tissues can be maintained with the method of fixation (Sean, 2018). In addition, fixation can also maintain proteins and carbohydrates in tissues for study purposes. Works by Sean (2018) have shown that fixation is one of the

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complex and difficult processes. This is because this process involves the absorption of the fetus into the tissues. Furthermore, this process involves many physical phenomena and potential chemical reactions. Fixation consists of 4 main groups. Among them are flexible metal groups, metal-based flexibility, oxidizing agents and aldehydes. Examples of commonly used aldehydes are formaldehyde.

Formalin is often used in fixation methods. Formalin is often used because the way in which formalin is used is much easier than the others. According to Nissa (2019), formalin will seep into the deepest cell specimens through formaldehyde penetration. There are physical factors that control the formalin movement. A solution of formaldehyde in water is called as the formalin. Cross-linking of aim proteins with unassociated proteins may lessen immune reactivity with aim-particular antibodies because the formalin fixation is not selective (Nissa, 2019).

One of the properties of formalin is the repairing takes a long time but the formalin can absorb the tissue quickly. Repairing take a long time since the cross-linking to tissue proteins takes a long period. Other than that, less shrinkage of tissue occurs due to formalin. Another characteristic of formalin is that it can harden tissue, but less than alcohol and acetone (MediaLab, 2019). In addition, formalin is much cheaper than other fixative and also in stable condition. Formalin also could maintain lipid but cannot dissolve it. According to MediaLab (2019), a shorter period of time can correct the biopsy specimens correctly while longer time is required for larger surgical samples. The time allocated is more than eight hours but before processing begins small specimens will be placed in room temperature conditions. However, for large samples, they will continue to be processed at the first level (MediaLab, 2019). Some intermediate methods

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should be taken into account before being placed in paraffin. This is because formalin and paraffin will not mix.

2.4 Sources of Formaldehyde

2.4.1 Outdoor Sources

Formaldehyde has many natural and anthropogenic outdoor sources. Formaldehyde is involved in plant physiology exchange. Formaldehyde is also a biogenic mixture that has the same function as the other volatile organic compounds. In addition, the decomposition product of lignin is known as formaldehyde. There is a case study stating that, in a coniferous forest located in Germany has formaldehyde content (Tunga, Sibel & Rainer, 2010). In addition, formaldehyde is the result of degradation of isoprene in the eucalyptus forest located in Portugal. Formaldehyde is released from solid wood and will be absorbed by various types of plants. The formaldehyde is determined as a result of the oxidation of methanol. Sea area also releases formaldehyde gas (Tunga et al., 2010).

Atmospheric reaction is one example of the outdoor sources of formaldehyde. Biogenic sources release many organic compounds into the atmosphere. Isoprene and oxygenated compounds are the example of the organic compounds. Aldehydes, ketones and acids are produced when the ozone react with the unsaturated hydrocarbons in the state of gas. Other than that, formaldehyde also can be produced from the process of ozonolysis of carvone and carveol (Tunga et al., 2010). The polluted city has very bad air quality and will cause the concentration of formaldehyde produced is high (Tunga et al., 2010). In addition, outdoor combustion such as combustion of wood is one

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of the natural sources of formaldehyde. Formaldehyde emission rate is high at the burning of the birch wood. Wildfire activity is one of the causes that release high concentration of formaldehyde (Tunga et al., 2010). Transport that categorized under automobiles has exhausted that release formaldehyde into the atmosphere. The release of carbonyl content may be high if the use of biodiesel is high. In the industrial sector, the release of formaldehyde gases can occur at all levels including production, use and storage level. Paper factories, chemical factories and automotive manufacturing factories are the example of the industrial sector that releases the formaldehyde gas (Tunga et al., 2010).

2.4.2 Indoor Sources

Formaldehyde content at the outside is higher than inside (Tunga et al., 2010). This occurs because in a closed area, the air exchange rate is lower than open area. One of the sources is wood-based materials. High formaldehyde content is produced from the UF bonded particle board. The boards are usually found in home and give an unpleasant smell to the people. Other adhesives that can be used to replace the formaldehyde-based adhesive are adhesive that made from natural tannin. Other than that, the adhesive that made from natural tannin is also environmental friendly (Tunga et al., 2010). In addition, flooring materials also contribute to the release of formaldehyde in the indoor environment. The formaldehyde release is due to the adhesives and gluing that is used in wood-based products. Wall covering that made from paper is the largest contributor in formaldehyde release. In the absence of ozone, the release of formaldehyde is less through the carpet and parquet. In addition, other material that releases formaldehyde is insulation materials (Tunga et al., 2010).

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Walls and floors use mineral wool as insulation material. Water or stone glass is used to make the mineral wool. The most commonly found in the stone wool is an inorganic and a slab stone. Percentage of the content is more than half that is 97% (Tunga et al., 2010). The rest of the content is composed of organic materials such as oil and thermoset resin binders. In addition, materials like sand, unused glass, limestone and soda ash are used to make glass wool. The materials contain high inorganic content. Low formaldehyde rates are released when the phenol-formaldehyde resin urea resin is used as a binder while high formaldehyde levels are released during the use of insulating material made from UF foam (Tunga et al., 2010).

Coating materials contain formaldehyde content such as melamine-formaldehyde resins. Therefore, some countries do not use the material. However, some countries still use the material to make packaging for wood. Latex paints release high levels of formaldehyde into the atmosphere. Formerly, water-based paints contain substances that release formaldehyde gases such as urea dimethylol but nowadays, the content is replaced with other substances such as isothiazolinones (Tunga et al., 2010). Among the highest contributors of formaldehyde is through combustion. The advanced state has citizen who uses fuel such as biomass for everyday use. Citizens use the fuel for cooking activities. The population that using fuel is about half. Biomass produces various types of particles such as carbon monoxide, polycyclic aromatic hydrocarbons (PAH) and formaldehyde (Tunga et al., 2010). In addition, cigarette also contributes to the cause of internal combustion. Other sources of formaldehyde are from the electronic equipment, fabric dyes and other indoor material.

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2.5 Uses of Formaldehyde

2.5.1 Preservation

The most appropriate method to delay the body decomposition is embalming. It is also the funeral of a corpse. Formaldehyde is often used as an embalming liquid. With the presence of formaldehyde in the embalming liquid, it can eliminate germs and also preserve the body. In biology teaching, fluids used to treat biological specimens are formalin (Nissa, 2019). The biological specimen will be slowly rotted due to the formation of formaldehyde in the embalming fluid. As it slows down the decay process, this will allow students to learn about biological specimens over a relatively long period of time. In learning about microscopic tissues also use formalin to treat tissue samples.

2.5.2 Aquaculture

Formalin is used as a means of controlling fish parasites infection. The method is called bath treatment. This way can eliminate protozoa and also some large parasites. Furthermore, this method is very effective. The gills, skin and fish fins have parasites and can be eliminated through the use of formalin. Fish eggs contain fungi and can be controlled and eliminated using high formalin concentrations. Ruth (2019) stated that there is also evidence and confirmation that formalin can eliminate fungi in fish egg. Formalin has also been recognized as the elimination of fungus at fish penetration centers. Hatching managers should also play an important role. Among them is that the manager should be sensitive when there is a dead egg in the system. The manager should remove the dead egg immediately. This is because the dead egg will give an infection to the egg next to it.

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Formalin can also be used in fish ponds. Formalin is much cheaper than other chemicals. In addition, formalin is also capable of removing dissolved oxygen in water chemically (Ruth, 2019). Formalin also reduces the uncontrolled condition of oxygen. However, the use of formalin in the pond is very difficult to get the permission. This is due to the risks involved in the use of formalin. Formalin can also be used in carrier boxes. Population diseases among species of fish can be spread when fish move from one place to another. Water in the box should be same in terms of pH and temperature so that formalin treatments can be given when the fish is still in the box.

2.5.3 Animal Nutrition and Agriculture

The digestive system of animals can be prevented from growth of microorganisms by adding formaldehyde in the animal feed. Dry products can also be produced with the use of formaldehyde. Formaldehyde is placed so that animal fat and oilseed cattle food will not merge. In soil, soil biological activity can be increased. Nitrogen found in urea formaldehyde fertilizers is often used in agriculture. Indirectly, using such fertilizers, the soil biological activity can be enhanced (World Health Organization, 2002).

2.5.4 Pharmaceutical and Cosmetics Products

Formaldehyde content is found in some pharmaceutical products. In the past, to remove germs from the skin, products containing formaldehyde were often used. Formaldehyde acts as a fumigant that aims to kill various types of microorganisms such as bacteria, fungi and parasites. World Health Organization (2002) stated that formaldehyde has a fast efficiency so it is widely used in clinical areas that aimed at

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disinfecting. In addition, in the dental surgery industry, formaldehyde is used to remove root canal salts. Cosmetic products often contain formaldehyde. It is used as a preservative in cosmetics as well as an agent to harden the nail. Tools used in cosmetics manufacturing will use formaldehyde to kill microorganisms. Products such as shampoo, dry skin lotion and shower oil soap use formaldehyde (World Health Organization, 2002).

2.6 Effects of Formaldehyde

2.6.1 Human Beings

Formaldehyde characteristics that have strong sensitization and irritant make it affect human health. If someone is exposed to formaldehyde, it will give a bad effect on humans (Gupta, Ulsamer & Preuss, 2019). The effect depends on the exposure concentration as well as the duration of the exposure. The effects of little irritation on the eyes, throat and nose are caused by low level exposure to formaldehyde. Formaldehyde in residential and work areas affects people. Among the adverse effects on humans is that humans will experience eye irritation, nose and throat, diarrhea, nausea, vomiting, headache and even bloody cough (Gupta et al., 2019). Exposure to low formaldehyde concentrations may adversely affect human health. Low formaldehyde concentrations can be found at home. Among the effects are vomiting, headache and skin rashes. However, for patients with asthma problems, exposure to low concentrations of formaldehyde may also cause asthma patients difficult to breathe.

Jobs at chemicals and paper factories provide formaldehyde exposure to workers. As a result, workers will experience various types of problems such as throat becoming

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dry and painful, eye, nose and skin irritation, excessive fatigue, headache and dizziness, body fatigue, thirsty, inadequate sleep due to frequent interruption, mind becoming less focused, always feeling lonely, and crying for no reason (Gupta et al., 2019). In addition, changes in the reproductive function will occur if female workers are exposed to formaldehyde. Among the changes that will occur is, the woman will have an irregular menstrual system, having difficulty during pregnancy and the weight of the baby will be very light and unhealthy. In addition, ovarian women who are exposed to formaldehyde will produce less urinary steroids. Furthermore, for workers with asthma problems, the worker will experience a diffusive breathing tract such as chronic rhinitis that is a result of long periods of time (Gupta et al., 2019). The skin will have allergies and itching if exposed to formaldehyde. The amount of formaldehyde concentration that gives less sensitive to human beings is 30 mg/L.

2.6.2 Environment

The natural component of the environment consists of formaldehyde. In the presence of oxygen and absence of oxygen, formaldehyde is a rapidly biodegradable chemical either in air, water and soil (Toxics Use Reduction Institute, 2019). In the air, carbon monoxide and formic acid will form because the formaldehyde is broken down under the sunlight. Carbon monoxide will cause acid rain which is harmful. Acid rain can also cause erosion in the building and cause paint on the building to fade. Additionally, National Pollutant Inventory (2019) stated that formaldehyde gives toxic effect to aquatic life such as fish and other organisms that are also live in the river, lake and sea. Formaldehyde does not pollute the environment too much because formaldehyde undergoes rapid decomposition (World Health Organization, 2002).

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2.6.3 Plants

Formalin treated plants produce CO_2 less than the control plant. On the plots treated with formalin, only a few vegetation cover occur compared to controlled plots. The plants in the formalin-treated area are almost dead but some species of plants are able to survive. Formalin can damage plants but some species of plants can survive. Formalin will disturb the plants transpiration, the rate of growth of the flower and can also cause death of plant cells (Eva et al., 2007). The presence of formaldehyde causes the dry weight of plant to increase (Sarah, 2010). The resulting formaldehyde that cause increase in weight is not great because it is caused by carbon dioxide. With the use of *Tradescantia* herbs as evidence, root growth can be increased by the presence of formaldehyde (Linus, 2007). The strong formaldehyde concentration will cause the roots to be short while the weak formaldehyde concentration will cause the roots to become longer. Weak formaldehyde concentrations will not have a bad effect on plant growth according to previous research (Linus, 2007). Cotyledons have some sugar. However, in light or dark conditions there is no starch that results from formaldehyde. Most likely, the photosynthesis process will not normally occur with the presence of formalin. In conclusion, after the use of formalin, all plants have been destroyed (Eva et al., 2007). The nitrogen and carbohydrate metabolism found in the plants remain the same when exposed to certain formaldehyde concentrations but when exposed to high formaldehyde concentrations, soil metabolism will have a bad effect. In addition, the presence of formaldehyde in the plants will cause the inflated pollination (World Health Organization, 2002).

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2.6.4 Experimental Animals

Rats and mice are the example of animals that were used as experimental animal. Exposure to formaldehyde at high concentrations causes mice to experience anxiety and death (World Health Organization, 2002). In addition, among other implications is that the mice develops vomiting and dyspnea. However, at lower concentrations, adverse effects on mice still occur. Among these effects are respiratory rate for mice decreased, increased airways and mice experienced eye irritation. At lower concentration of formaldehyde, mice become inflammation, changes in the nose occur and cell growths are increasing. In conclusion, a high concentration of formaldehyde affects mice nasal mucosa while at lower concentration of formaldehyde, there is no change in mice nasal mucosa. Formaldehyde is a carcinogenic in the body of mice. Exposure to high concentration of formaldehyde causes mice tissue to become damaged. In addition, the tumor is found in the area of nose. But the tumor has an unbalanced growth. At the other limbs of the mice do not have tumors growing (World Health Organization, 2002).

2.7 *Jasminum sambac* Plant

Jasmine plant has various types. *Jasminum sambac* plant will be chosen for this research. Jasmine star and maid of orlean are two types of jasmine plants found in Malaysia. Adequate sunlight is required so that the jasmine plants grow healthy and the flower can be produced. The way of planting a jasmine plant is through stem cuttings. Adry (2010) stated that among the characteristics of the jasmine plant are white and very fragrant. Each year the jasmine plant will produce flower. *Jasminum sambac* plant has wide leaves and shiny leaves. The veins on the leaves are also easily visible to the naked

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eye. In addition, the tip of the leaves is sharp. The flower of *Jasminum sambac* plant has a round petal (National Park Board Singapore, 2013). This plant should not always be exposed to water except water spray. When new wood produces new shoots, pruning is needed so that flowers can grow at a rapid rate. A balanced quantity of fertilizer is needed for healthy plant growth. Figure 2.1 shows the picture of the *Jasminum sambac* plants.

Figure 2.1: The picture of *Jasminum sambac* plant

(Source: Gardenia, 2019)

The jasmine tree has many uses and benefits to humans. Jasmine flowers are often used as herbal medicine in Chinese medicine. The herbal remedy is to provide nerves, astringents and even sedatives in a relaxed state. Most perfumes and medicinal oils are made from oil extracted from Jasmine flowers (National Park Board Singapore, 2013). Other than that, jasmine flowers are often found in Islamic cemeteries. In

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addition, the Indians often use jasmine as one of the religious ceremonies. Jasmine flower can also eliminate eye pain. The jasmine flower will be pounded until it is crushed and applied to the forehead. In addition, jasmine flowers can also reduce the pain of stinging bees by spreading the jasmine flowers that are crushed in a swollen place (Adry, 2010). Lastly, jasmine can reduce fever and headache.

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CHAPTER 3

MATERIALS AND METHODS

3.1 The Flow of Research Methodologies

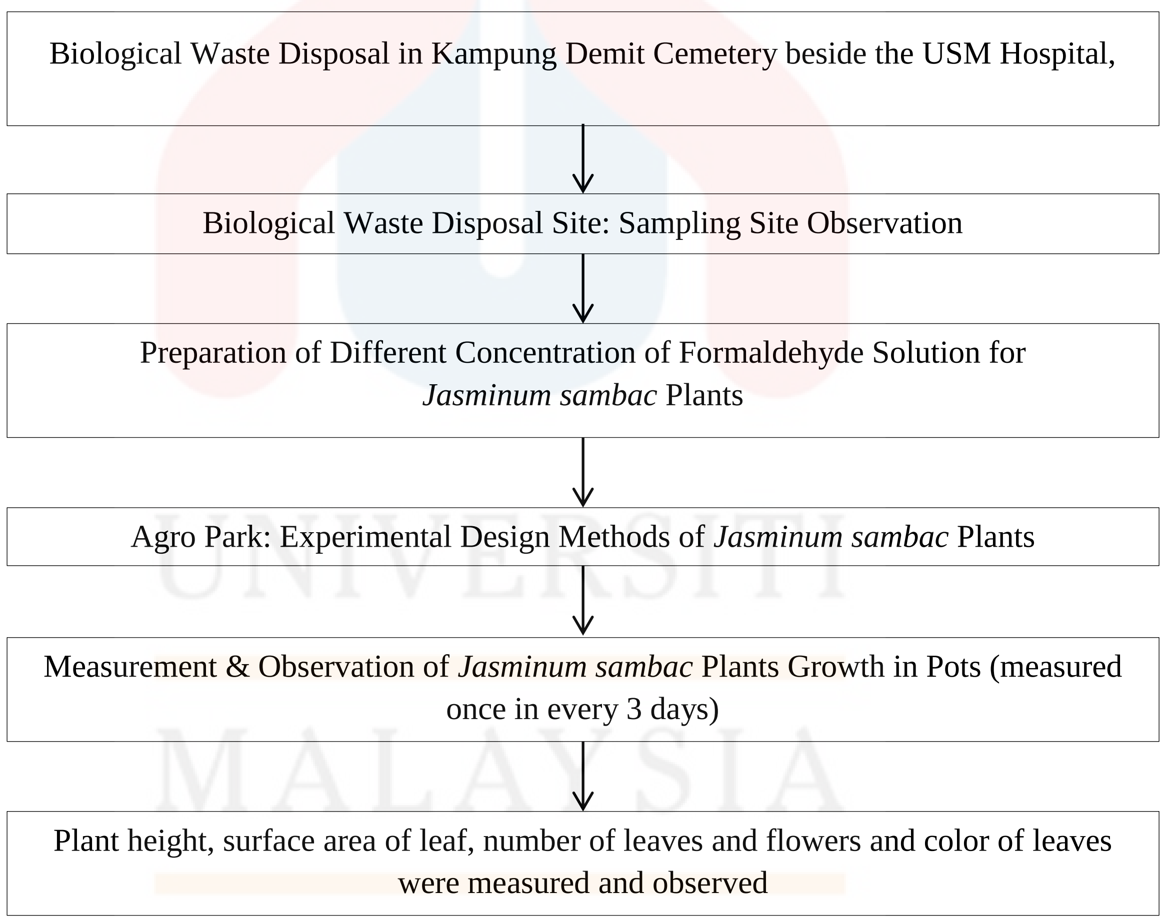

Figure 3.1: The flow of research methodologies

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Preparation of 5 % Chromotropic Acid

↓

Establishment of Standard Curve

↓

Sample Preparation to Determine the Concentration of Formaldehyde Uptake in the Leaves, Flowers, Stems & Roots of *Jasminum sambac* Plants

↓

Biochemical Analysis of *Jasminum sambac* Plants (measured once)

↓

Relative water content and chlorophyll content of leaves were measured

↓

The plant growth were observed and the data obtained were recorded

Figure 3.1: (Continued)

3.2 Apparatus and Instruments

Table 3.1: The list of apparatus and instruments for each method

Methods	Apparatus and Instruments
Sampling site observation	Measuring tape and graph paper
Preparation of different concentration of formaldehyde solution for *Jasminum sambac* plants	Beaker, micropipette, pipette tips, volumetric flask and dropper
Experimental design methods of *Jasminum sambac* plants	*Jasminum sambac* plants, pots and beaker
Measurement and observation of *Jasminum sambac* plants growth in pots	Measuring tape and graph paper
Preparation of chromotropic acid	Beaker, micropipette, tips, electronic analytical balance and conical flask
Establishment of standard curve	UV-Vis Spectrophotometer and volumetric flask
Sample preparation to determine the concentration of formaldehyde uptake in the roots, stems, leaves and flowers of the *Jasminum sambac* plants	The parts of plants (powder form), blender, mortar and pestle, zip lock bags, glass culture tubes, electronic analytical balance, micropipette, beaker, hot plate, oven, cuvette, dropper and UV-Vis Spectrophotometer

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Table 3.1: (Continued)

Methods	Apparatus and Instruments
Biochemical analysis of *Jasminum sambac* plants	SPAD chlorophyll meter, tissue, fresh leaves, aluminium foil, desiccator, electronic analytical balance and oven

3.3 Chemicals

Table 3.2: The list of chemicals for each method

Methods	Chemicals
Preparation of different concentration of formaldehyde solution for *Jasminum sambac* plants	37% formaldehyde and distilled water
Experimental design methods of *Jasminum sambac* plants	Different concentration of formaldehyde and water
Preparation of chromotropic acid	Concentrated sulfuric acid, chromotropic acid powder and distilled water
Establishment of standard curve	37% formaldehyde and deionized water
Sample preparation to determine the concentration of formaldehyde uptake in the roots, stems, leaves and flowers of the *Jasminum sambac* plants	Prepared chromotropic acid and sulfuric acid

3.4 Sample

Jasminum sambac plants were purchased from the Melur.Com nursery located at Lot F03, Rural Transformation Centre (RTC) Kelantan Batu 4, Lebuhraya Pasir Mas Salor, 15150 Kota Bharu, Kelantan and at the Seri Buyung Nursery located at the Bukit Bunga, Kelantan. The ages of the *Jasminum sambac* plants were about 6 month.

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3.5 Methods

3.5.1 Sampling Site Observation

The observation of plant was conducted at the biological waste disposal site located at Kampung Demit Cemetery beside the Hospital University of Science Malaysia (HUSM) in Kubang Kerian, Kelantan. The physical characteristics of the plant at the biological waste disposal site were observed once in every two months. Some pictures were taken to compare some plants at the biological waste disposal site with the planted plants in pots at the Agro Park.

3.5.2 Preparation of Different Concentration of Formaldehyde Solution for *Jasminum sambac* Plants

Dilution process was required to dilute the concentration of 37% formaldehyde. A 100% formalin solution is equal to 37%–40% formaldehyde (Joanne, 2017). The process to reduce the solute concentration in the solution was known as dilution. The concentration required were calculated and prepared from the 37% of formaldehyde stock solution. 300 ml were prepared for this research. Table 3.3 shows the steps to calculate the dilution of formaldehyde.

Table 3.3: The formaldehyde dilution calculation

Concentration	Ppm	Calculation
0.5%	500	$M_1V_1 = M_2V_2$ (37%) (X) = (0.5%) (300 ml) X = 4.1 ml of formaldehyde solution + 295.9 ml of distilled water
3%	3000	$M_1V_1 = M_2V_2$ (37%) (X) = (3%) (300 ml) X = 24.3 ml of formaldehyde solution + 275.7 ml of distilled water

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Table 3.3: (Continued)

Concentration	Ppm	Calculation
5%	5000	$M_1V_1 = M_2V_2$ (37%) (X) = (5%) (300 ml) X = 40.5 ml of formaldehyde solution + 259.5 ml of distilled water
7%	7000	$M_1V_1 = M_2V_2$ (37%) (X) = (7%) (300 ml) X = 56.8 ml of formaldehyde solution + 243.2 ml of distilled water
14%	14000	$M_1V_1 = M_2V_2$ (37%) (X) = (14%) (300 ml) X = 113.5 ml of formaldehyde solution + 186.5 ml of distilled water
21%	21000	$M_1V_1 = M_2V_2$ (37%) (X) = (21%) (300 ml) X = 170.3 ml of formaldehyde solution + 129.7 ml of distilled water
28%	28000	$M_1V_1 = M_2V_2$ (37%) (X) = (28%) (300 ml) X = 227 ml of formaldehyde solution + 73 ml of distilled water
35%	35000	$M_1V_1 = M_2V_2$ (37%) (X) = (35%) (300 ml) X = 283.8 ml of formaldehyde solution + 16.2 ml of distilled water

3.5.3 Experimental Design Methods of *Jasminum sambac* Plants at the Agro Park, UMK Jeli

Jasminum sambac were planted in a pot at the Agro Park that enabled the plants to get enough sunlight. Next the plants required were twenty pots of *Jasminum sambac* plants. Sixteen pots of the plants were treated with different concentration of formaldehyde while the four pots left were made as control. The concentrations of formaldehyde used were 0.5%, 3%, 5%, 7%, 14%, 21%, 28% and 35% and were

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duplicated for each concentration. All the plants were watered twice every day in the morning and evening.

3.5.4 Measurement and Observation of *Jasminum sambac* Plants Growth in Pots

The plants physical characteristics such as the plants height, surface area of leaves, leaves color, the number of leaves and the number of flowers were measured once in every three days. The plants heights were measured from the border of the pot to the top of the plant shoot. Next, the surface areas of leaves were measured using a graph paper. The numbers of squares covered on the graph paper were counted (Science Buddies, 2019). These steps were repeated for all the leaves at the plants. The number of leaves and flowers were counted. The colors of leaves were measured through the observation.

3.5.5 Preparation of 5 % Chromotropic Acid

The formaldehyde absorbance was known by using the chromotropic acid and sulfuric acid as an indicator. Firstly, the 50% of sulfuric acid need to be prepared. The 98% of sulfuric acid were diluted first to obtain the 50% of sulfuric acid. Next, the 50% of sulfuric acid was added with the 0.5 g of chromotropic acid to obtained 100 ml of chromotropic acid (Dar, Shafique, Anwar, Waheed, & Naseer, 2016).

3.5.6 Establishment of Standard Curve

Different formaldehyde concentrations which are 20, 40, 60, 80 and 100 ppm were prepared from the 1000 ppm of formaldehyde stock solution. The absorbance values were obtained by using spectrophotometer measured at 412 nm. Graph

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absorbance against concentration plotting can determined the standard curve. Table 3.4 shows the steps to calculate the dilution of formaldehyde stock solution.

Table 3.4: The stock solution of formaldehyde dilution calculation

Concentration	Calculation
20 ppm	$M_1V_1 = M_2V_2$ (1000 mg/L) (X) = (20 mg/L) (0.1 L) X = 0.002 L of stock solution X = 2 ml of stock solution+ 98 ml of distilled water
40 ppm	$M_1V_1 = M_2V_2$ (1000 mg/L) (X) = (40 mg/L) (0.1 L) X = 0.004 L of stock solution X = 4 ml of stock solution + 96 ml of distilled water
60 ppm	$M_1V_1 = M_2V_2$ (1000 mg/L) (X) = (60 mg/L) (0.1 L) X = 0.006 L of stock solution X = 6 ml of stock solution + 94 ml of distilled water
80 ppm	$M_1V_1 = M_2V_2$ (1000 mg/L) (X) = (80 mg/L) (0.1 L) X = 0.008 L of stock solution X = 8 ml of stock solution + 92 ml of distilled water
100 ppm	$M_1V_1 = M_2V_2$ (1000 mg/L) (X) = (100 mg/L) (0.1 L) X = 0.01 L of stock solution X = 10 ml of stock solution + 90 ml of distilled water

3.5.7 Sample Preparation to Determine the Concentration of Formaldehyde Uptake in the Leaves, Flowers, Stems and Roots of *Jasminum sambac* Plants

Oven was used to let the part of plants dried. The required temperature was 60°C. Next, the parts of plant were converting into dried powder by grind the parts of plants using the blender for about 25 minutes. Then 0.1 g of plant sample, 0.3 ml of 5% chromotropic acid and 5 ml of concentrated sulfuric acid were placed in a glass culture tubes. This step was repeated for all parts of the plants sample. The glass culture tubes were shaking to mix it well. Subsequently, all the glass culture tubes were placed in the

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boiling water bath for an hour. Then, the samples were cooled at room temperature for about 40 minutes. Next, the samples were poured in the cuvette to get the absorbance value using UV-Vis Spectrophotometer at 412 nm. The absorbance values were recorded. Blank sample was prepared by mix 2 ml of deionized water, 0.3 ml of 5% chromotropic acid and 3 ml of concentrated sulfuric acid (Dar et al., 2016). The way to calculate the amount of formaldehyde in the parts of plants was by placed the sample reading in the standard curve that was done before (Niloy, Sazedul, Subhash, Chandra & Enamul, 2015).

3.5.8 Biochemical Analysis of *Jasminum sambac* Plants

The dry weight, fresh weight and turgid weight of leaves and also chlorophyll content were measured once. Fresh weights were measured by weighed the leaves. Next the leaves were placed in a zip lock bag for 3 hours and under the normal room light. The plants were wiped with tissue to make sure the plant free from moisture. Then the plants were weight quickly to obtain the turgid weight. After that, the plant were placed in an oven at 60℃ for a night to obtained the dry weight (Science Buddies, 2019). Finally, the plants were weight after it dry. The relative water content of leaves was known by measured the fresh, turgid and dry weight of leaves. The chlorophyll content was measured using SPAD chlorophyll meter. Lastly the data obtained were recorded. The formula to obtain the relative water content of leaves was stated in the equation (3.1).

$$Relative\ Water\ Content = \frac{Fresh\ weight - Dry\ weight}{Turgid\ weight} \times 100\ \% \qquad (3.1)$$

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CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Observation of Plants at the Biological Waste Disposal

The growth of plants at biological waste disposal site which is located in Kampung Demit, Kubang Kerian was observed form April 2019 to October 2019. The observations were compared with the plants which located away from the sampling area (Table 4.1). The plant at the study area shows negative growth compared to plant located away from the study area. During the whole experimental period, vegetation cover on the formalin-treated plots was nearly totally killed by the application. Previous research works by Eva et al (2007) also have shown the same growth of plant that treated with formaldehyde as in the study.

Table 4.1: The observation of plants on the first and second visit

Location	Plants at the biological waste disposal site	Plants at the cemetery (far away from the biological waste disposal site)
1st Visit i) Pictures	 	

Table 4.1: (Continued)

Location	Plants at the biological waste disposal site	Plants at the cemetery (far away from the biological waste disposal site)
1st visit ii) Observation	Plots of plants which treated with formalin were found not growing well. Moreover, the colors of leaves from biological waste disposal site are in brownish color and light green.	The plants at the cemetery were growing well and healthy. In addition, the plant from the cemetery area was found dark green in their leaves color plus had many flowers.
2nd Visit i) Pictures		
ii) Observation	The plants were found not growing well with brownish leaves and seem wilt.	The plants stay healthy and the numbers of flowers were kept increasing.

4.2 The Physical Changes of *Jasminum sambac* Plants between the Control Plants and the Plants That Treated with Different Concentration of Formaldehyde

The physical changes and growth of the plants between the control plant and the treated plants were observed. The observations were made from 22th August 2019 until 12th September 2019 which takes 22 days of observation for the concentration of 7%, 14%, 21%, 28% and 35% while the concentrations of formaldehyde for 0.5%, 3% and 5% were observed for only 16 days from 25th September 2019 until 13th October 2019 as the sample were died after treated with formaldehyde. The observations of plant growth for *Jasminum sambac* plants before and after treated with different concentration of formaldehyde were shown in the Figure 4.1.

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4.2.1 Pictures of *Jasminum sambac* Plants before and after Treated with Different Concentration of Formaldehyde

Plants	Before	After	Plants	Before	After
Control Plant A			Control Plant B		
Control Plant C			Control Plant D		
7% (Plant A)			7% (Plant B)		

Figure 4.1: The pictures of *Jasminum sambac* plants before and after treated with different concentration of formaldehyde

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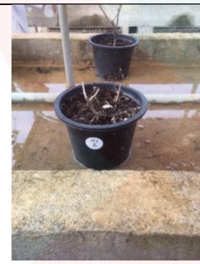
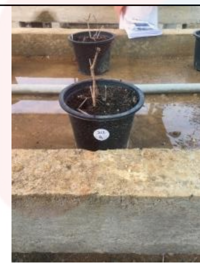
Plants	Before	After	Plants	Before	After
14% (Plant A)			**14% (Plant B)**		
21% (Plant A)			**21% (Plant B)**		
28% (Plant A)			**28% (Plant B)**		

Figure 4.1: (Continued)

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Plants	Before	After	Plants	Before	After
35% (Plant A)			**35% (Plant B)**		
0.5% (Plant A)			**0.5% (Plant B)**		
3% (Plant A)			**3% (Plant B)**		

Figure 4.1: (Continued)

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Plants	**Before**	**After**	**Plants**	**Before**	**After**
5% (Plant A)			**5% (Plant B)**		

Figure 4.1: (Continued)

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4.2.2 Data Measurement and Graph for *Jasminum sambac* Plants That Treated with Different Concentration of Formaldehyde

Table 4.2 demonstrated the height of plant, surface area of leaf, number of leaves and flowers, color of leaves and chlorophyll content of leaf observed before and after the plants was treated with formaldehyde. The color of leaves were indicate as dark green (DG), light green (LG), light brown (LB), medium brown (MB), dark brown (DB), black (B), yellow brownish (YB) and yellow (Y). The (-) sign indicates there was no reading for the observation. The growth of *Jasminum sambac* plants shows a negative growth day by day for the plants that treated with different concentration of formaldehyde. However the plant height still increases even after treated with formaldehyde. The parameters below were observed:

i) Plant height

ii) Surface area of leaf

iii) Number of leaves

iv) Color of leaves

v) Number of flowers

vi) Chlorophyll content of leaves

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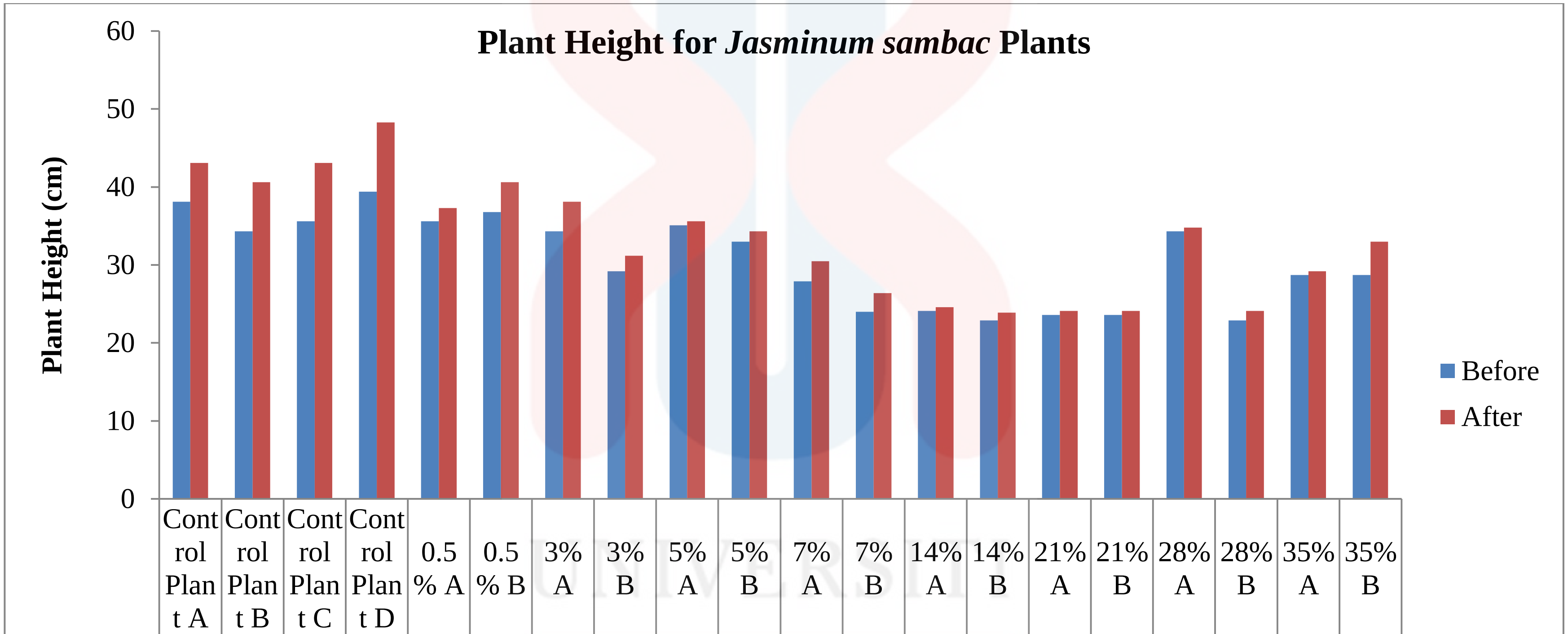
i) Plant height:



	Control Plant A	Control Plant B	Control Plant C	Control Plant D	0.5% A	0.5% B	3% A	3% B	5% A	5% B	7% A	7% B	14% A	14% B	21% A	21% B	28% A	28% B	35% A	35% B
Before	38.1	34.3	35.6	39.4	35.6	36.8	34.3	29.2	35.1	33	27.9	24	24.1	22.9	23.6	23.6	34.3	22.9	28.7	28.7
After	43.1	40.6	43.1	48.3	37.3	40.6	38.1	31.2	35.6	34.3	30.5	26.4	24.6	23.9	24.1	24.1	34.8	24.1	29.2	33

Figure 4.2: The observation of plant height for *Jasminum sambac* plants before and after treated with different concentration of formaldehyde

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The heights of the *Jasminum sambac* plants bought were not in the same heights. Each plant has different height. The height for Control Plant A, B, C and D rising sharply from the first day until the last day. However the height of plants for 0.5%, 3% and 5% does not increase significantly. The amounts of increase were only about 1.00 cm. For example for the 0.5%, 3%, 5%, 7% and 14% plants. It increases from 35.6 cm to 37.3 cm for the 0.5% (Plant A). Then, for the 3% (Plant B) it rise from 29.2 cm to 31.2 cm. Besides, the plant height increase from 33 cm to 34.3 cm for the 5% (Plant B) and for the 14% (Plant B) it rise from 22.9 cm to 23.9 cm.

As for the 21%, 28% and 35% plants, the amount of increase were only around 0.5 cm. It can be seen in the 21% (Plant A), it only rise from 23.6 cm to 24.1 cm. Subsequently, it increases from 34.3 cm to 34.8 cm for the 28% (Plant A) and for the 35% (Plant A) it only rise from 28.7 cm to 29.2 cm. Overall, if the concentration of formaldehyde were high, the plant height was increase slightly compared to the control plant which rising sharply.

The control plants were significantly increased from Day 1 until Day 22 compared to plants that treated with formaldehyde that only slightly increases from day by day (Figure 4.2). The control plants increased significantly every day because all the environmental factors that affecting plant growth was obtained. The factors include light, moisture, air, temperature and nutrients (Easton, 2015). At the Agro Park, the plants get sufficient sunlight. Carbon dioxide and water in the presence of chlorophyll will produce food which important factor in plant growth. Plant growth is influenced by light in terms of quality, quantity and rate of influence of light on plants. Plants that grow under the sunlight will grow healthy.

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Other than that, another important element in plant growth are water, air and temperature (Easton, 2015). As for the plants that treated with formaldehyde, the heights of plants were slightly increased and keep constant after a few days. The height of plants does not decrease even treated with formaldehyde. Study from Lipford (2008) stated that fertilizers make the plant height keep growing. Fertilizers contain the nitrogen and phosphorus that make the plant height keep increases.

This is because organic fertilizers can improve soil structure and conditions while also improving the soils ability to hold water and nutrients (Lipford, 2008). The plants will become healthier and the soil will become stronger after the use of fertilizers. Organic fertilizers also do not harm the environment because they are environmentally friendly.

Research done by Mutters & Madore (1993) also stated that the plant height still increases even though the plants were exposed to the formaldehyde. It stated that formaldehyde was incorporated into sugars and amino acids if there is presence of sunlight. This is because, the fixed carbon compounds in the plants were stimulated by the formaldehyde hence it will increase the plant height.

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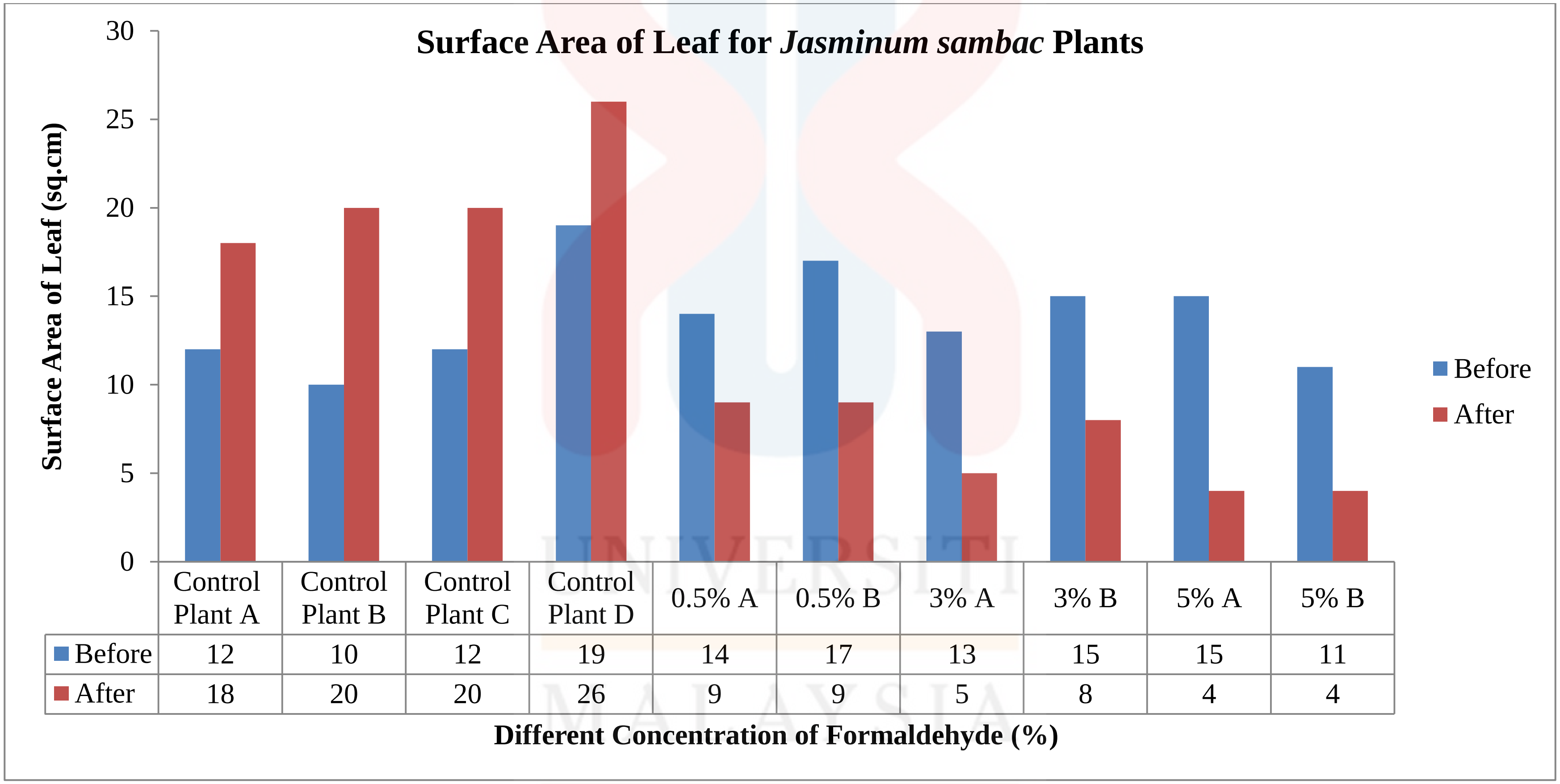
ii) <u>Surface area of leaf:</u>



	Control Plant A	Control Plant B	Control Plant C	Control Plant D	0.5% A	0.5% B	3% A	3% B	5% A	5% B
Before	12	10	12	19	14	17	13	15	15	11
After	18	20	20	26	9	9	5	8	4	4

Figure 4.3: The surface area of leaf for *Jasminum sambac* plants before and after treated with different concentration of formaldehyde

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The surface area of leaf for plants (7%, 14%, 21%, 28% and 35%) could not be observed because the sizes of leaves were very small. Based on the graph in the Figure 4.3, it can be seen clearly that the surface area of leaf for Control Plant A, B, C and D were increases from the first day until the last day. Most of the control plant had increases for about 10 square cm as revealed by Control Plant B, the surface area rise from 10 square cm to 20 square cm.

On the other hand, the surface area of leaf was observed decreases around 8 square cm. It can be seen in the 0.5% (Plant B) and 3% (Plant A). The surface area of leaf for 0.5% (Plant B) fell drastically from 17 square cm to 9 square cm. Furthermore, the surface area of leaf reduces from 13 square cm to 5 square cm in the 3% (Plant A).

The surface area of leaf for control plant getting bigger day by day compared to plants that treated with formaldehyde (Figure 4.3). The control plants show a positive growth because it absorbed enough sunlight as the surface area are bigger. The rates of photosynthesis also speed up. Parker (2014) stated that the bigger surface area of leaf, the more light can be absorbed into the plant and in addition will fasten the rate of photosynthesis. Every day, the surface area of leaf for plants that treated with formaldehyde decreased slightly and shows a negative growth (Figure 4.3). This is because it absorbed little amount of sunlight because the surface area of leaf were small. The leaves actually shrink. The rates of photosynthesis also slow down.

Previous study done by Erofeeva (2012), obtained the same result stated that the surface area of the leaf will change depending on the concentration of formaldehyde used. The study shows that formaldehyde contains a toxic effect and lead to the decrease

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of surface area of leaves after a few days of exposure even in a low concentration of formaldehyde. Subsequently, the high concentration of formaldehyde indicates a decrease in the surface area of leaf. This is due to the toxic effects.

The number of genes in the plant can determine the surface area of the leaf as well as the development of leaf formation. Thus, the surface area of the leaves exposed to formaldehyde decreases due to the decrease in molecular processes underlying the expression of similar genes. In addition, this causes the enzyme activity resulting from formaldehyde detoxification to increase and may cause the protein to break down. In conclusion, as proven by the previous study, the surface area of leaf decreases after treated with different concentration of formaldehyde (Erofeeva, 2012).

iii) Number of leaves:

The number of leaves for Control Plant A and D were increases every day for about 20 leaves. The number of leaves decreases in the range of 13 to 15 leaves from the first day until the last day for the 0.5% (Plant B) and 5% (Plant B). It can be seen from the graph (Figure 4.4) that shows the number of leaves for 0.5% (Plant B) decline from 45 to 30 leaves after treated by formaldehyde. Subsequently, the number of leaves for 5% (Plant B) fell slightly from 53 to 40 leaves. Most of the plants were found had only 1 leaves on the last day after treated with formaldehyde. It can be found in the 7% (Plant B), 14% (Plant A), 21% (Plant A and B) and 35% (Plant B). The number of leaves decrease minimally from 3 to 1 leaves for 7% (Plant B), 10 to 1 leaves for 14% (Plant A), 2 to 1 leaves for 21% (Plant A), 6 to 1 leaves for 21% (Plant B) and lastly 7 to 1 leaves for 35% (Plant B).

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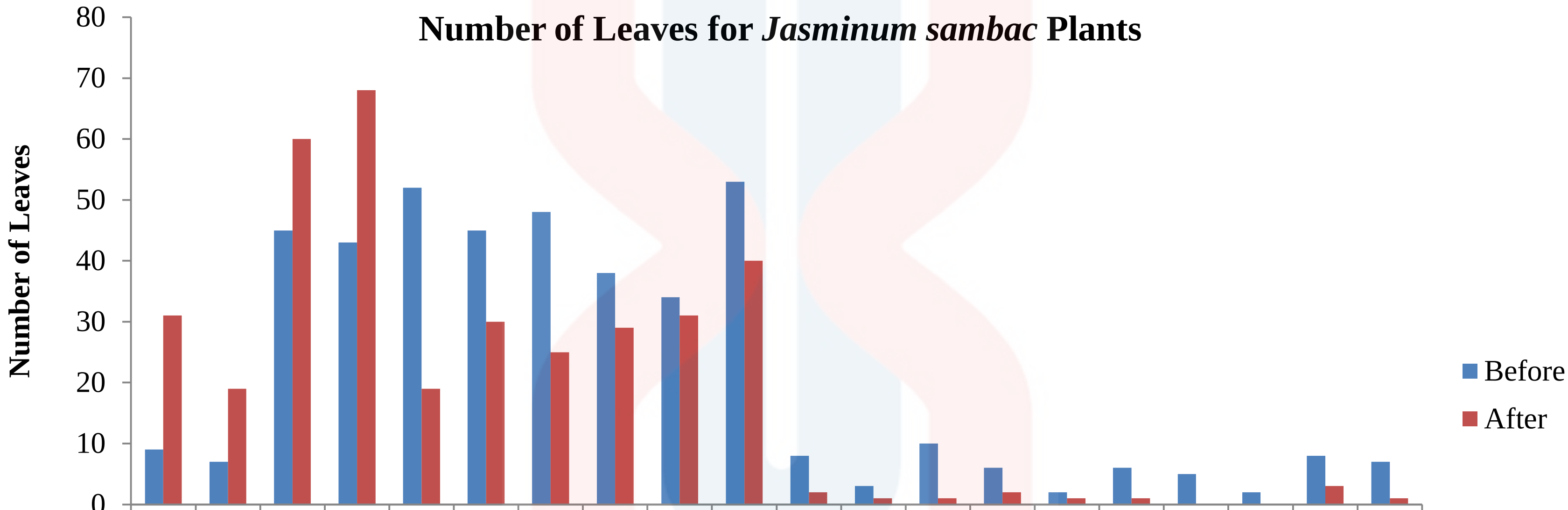

	Control Plant A	Control Plant B	Control Plant C	Control Plant D	0.5% A	0.5% B	3% A	3% B	5% A	5% B	7% A	7% B	14% A	14% B	21% A	21% B	28% A	28% B	35% A	35% B
Before	9	7	45	43	52	45	48	38	34	53	8	3	10	6	2	6	5	2	8	7
After	31	19	60	68	19	30	25	29	31	40	2	1	1	2	1	1	0	0	3	1

Different Concentration of Formaldehyde (%)

Figure 4.4: The number of leaves for *Jasminum sambac* plants before and after treated with different concentration of formaldehyde

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The arrangement of leaves on the stem is determined by plant genetics. In addition, the number of leaves is also based on the genetics of a plant (Hewitson, 2019). But, Cross & Zuber (1973) stated that morphological properties such as the number of leaves on a plant are actually influenced by the environment that exposed to the plant. In this study, the plants were exposed to the formaldehyde. Number of leaves for control plant always increases from the first day until the last day of observation. However, number of leaves for plants that treated with formaldehyde was decreased day by day (Figure 4.4). Rucińska-Sobkowiak (2016) obtained similar results, verifying that number of leaves do not continued to grow after the application of higher concentration of formaldehyde and number of leaves decreases for the plants that were treated with low concentration of formaldehyde. This is because inhibition of transpiration occurs when plants are exposed to formaldehyde. Formaldehyde causes water to not reach the leaves. This causes the surface area of the leaves and the number of leaves to decrease. In addition, the laminate thickness also decreased. This decrease will result in reduced intercellular spaces and will also affect the density of stomata (Rucińska-Sobkowiak, 2016).

iv) Color of leaves:

It is shown that the color of leaves for the control plant was dark green from the first day until the last day of observation (Table 4.2). Plant cells with high chlorophyll content are usually having green leaves. The leaves are green as they reflect the green color and absorb other colors. The health of plants can be determined by the color of the leaves. West (2018) stated that the darker the green color of leaves, the more chlorophyll

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content in it and the sunlight can be converted to food and other growth enhancers in faster way.

However, plants treated with formaldehyde shows the changes in leaves color from dark green to yellowish and brownish color (Table 4.2). The color of leaves for 0.5% (Plant A and B) on the 1st day until the 4th day were dark green. Then, the color of leaves changed to became light green on the 7th day until the 10th day. Next, on the 13th day, some of the leaves became yellow brownish and started to wilted. As observed, on the 16th day, all of the leaves became yellow brownish and had wilted on the last day.

Furthermore, the colors of leaves for 3% (Plant A and B) on the 1st day was dark green. Then, the color of leaves changed to became light green on the 4th day. Next, on the 7th day, the leaves became yellowish and started wilted. As observed, on the 10th day, all of the leaves became yellow brownish. The color of leaves became dark brown on the 13th day until the last day. In addition, the leaves had wilted on the last day.

Moreover, the colors of leaves for 5% (Plant A and B) on the 1st day were dark green. Then, the color of leaves changed to became light green on the 4th day. Next, on the 7th day, the leaves became yellowish and started wilted. As observed, on the 10th day, all of the leaves became light brown. The color of leaves became dark brown on the 13th day until the last day. In addition, the leaves had wilted on the last day.

Meanwhile, the color of leaves for 14% (Plant A and B) on the 1^{st} day was dark green. Then the color of the leaves changed to became light green on the 4^{th} day. Next, on the 7^{th} day, some of the leaves became light brown. As observed, on the 10^{th} day until the 16^{th} day, all of the leaves become dark brown and started to became wilted on the

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13th day until the 16th day. The color of leaves started to become black and wilted on the 19th day until the 22th day.

Lastly, the color of leaves for 28% and 35% (Plant A and B) on the 1st day was dark green. Then, the color of leaves changed to became light green on the 4th day. Next, on the 7th day until the 10th day, all the leaves started to became dark brown. As observed, on the 13th day until the 16th day, all of the leaves become black and started to became wilted. The leaves started to became black on the 19th day. The leaves had wilted on the 19th day until the 22th day.

Leaves with a small amount of chlorophyll green pigments are known as chlorosis. Chlorosis has yellowish leaf tissue. Roots were found damaged by application of formaldehyde is the main reason of the formation of chlorosis and bleach on the leaves. It also occurs due to the compacted roots and the high soil pH in the pots. According to Sandra (2007), nutrients from organic fertilizers may not be absorbed by the roots and cause damaged roots and weak plant growth in the presence of formaldehyde.

Previous study reported by Wang et al (2012) verifying that the plants that undergoing formaldehyde stress will cause the leaves of the plants became chlorosis and bleach after one month. However, no visible changes were observed in the leaves of the control plants. The pressure exerted by formaldehyde will significantly affect the transcription of genes associated with photosynthesis. The research done by Ambika, Mohnish & Kumar (2016) also obtained the same result verifying that when plants are exposed to formaldehyde, the color of the leaves will discolor.

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Chlorosis will cause the leaves to turn yellow. It will sprout from the ends of the leaves and will spread throughout the leaves and will eventually turn brown and cause the plants to die. When the whole leaves show a brown color, it indicates that the plant was actually stressed due to the presence of formaldehyde which causes the root became damaged (Rhoades, 2018).

v) Number of flowers:

Flower for Control Plant A and B, 7%, 14%, 21%, 28% and 35% does not growing from the 1st day until the 22nd day. The *Jasminum sambac* plants take about 3 to 4 months to flowering. Control Plant C and D flowers had increases in the range of 8 to 14 flowers from the first day until the last day observation. For instance, it grows from 10 to 24 flowers for Control Plant C and for Control Plant D it grows from 12 to 20 flowers.

There were no flowers blooms after the 7th day. The number of flowers left after being treated with different concentration of formaldehyde was zero. It can be seen in the 0.5% (Plant A and B), 3% (Plant A and B) and 5% (Plant A and B). It fell slightly from nine to zero flower for 0.5% (Plant A and B), four to zero flower for 3% (Plant A), ten to zero flower for 3% (Plant B) and lastly four to zero flower for 5% (Plant A and B).

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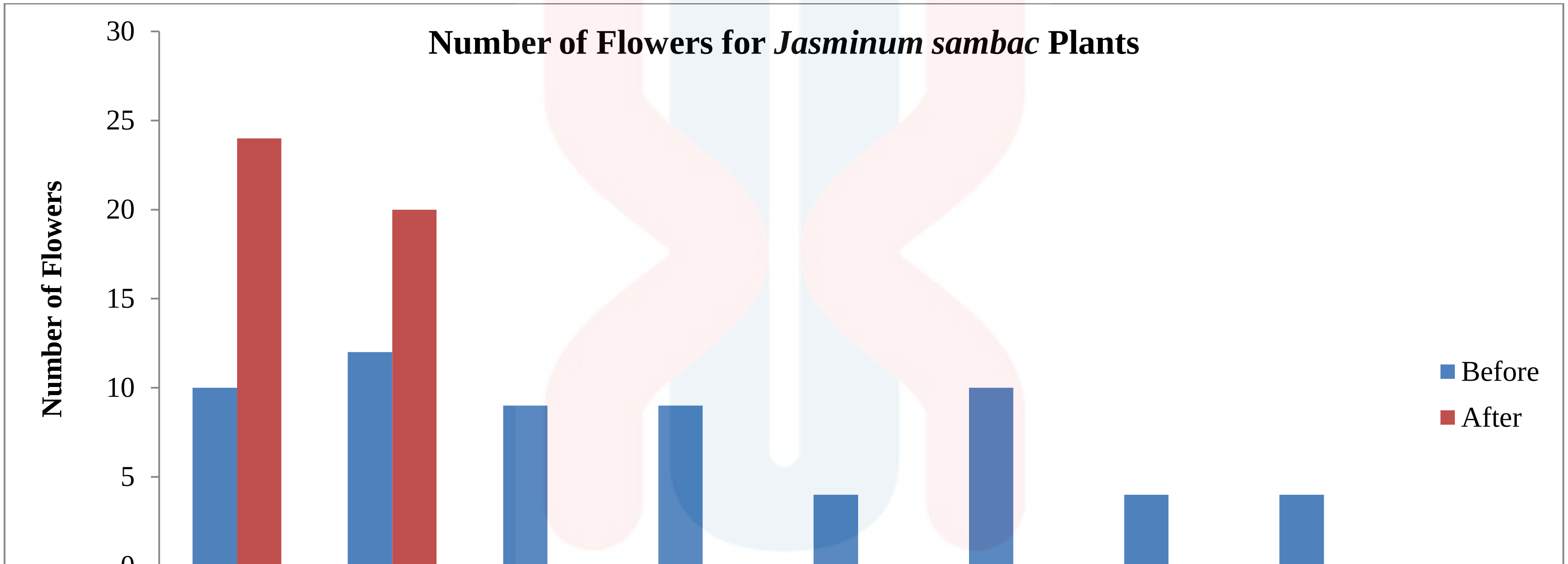

	Control Plant C	Control Plant D	0.5% A	0.5% B	3% A	3% B	5% A	5% B
Before	10	12	9	9	4	10	4	4
After	24	20	0	0	0	0	0	0

Different Concentration of Formaldehyde (%)

Figure 4.5: The number of flowers for *Jasminum sambac* plants before and after treated with different concentration of formaldehyde

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Flowers were found do not bloom for the Control Plant A and B and also the plant that treated with high concentration of formaldehyde. The number of flowers decreased for the plants which treated with low concentration of formaldehyde (Figure 4.5). It was found that application of formaldehyde affect the quality and number of flowers. Saikkonen, Koivunen, Vuorisalo, & Mutikainen (1998) reported similar result, with decreased number of flowers after treated with heavy metals. The amount of flowers and biomass decreases after exposure to formaldehyde. Other than that, it also delays the formation of the flower bud.

vi) Chlorophyll content of leaves:

The chlorophyll content for all the control plants were increase rapidly from 29.5 µmol m^{-2} to 103.8 µmol m^{-2} for Control Plant A and from 25.9 µmol m^{-2} to 101.5 µmol m^{-2} for Control Plant B. As for the lower concentration which was 0.5%, the amount of chlorophyll content decreases was about 29 µmol m^{-2}. It can be seen in the 0.5% (Plant A). The amount of chlorophyll content decreases was about 10 µmol m-^{2} can be seen in the higher concentration as revealed in the concentration of 3% and 5%.

Chlorophyll content for the control plant increased significantly while the chlorophyll content were found decreased in number for those plant treated with formaldehyde (Figure 4.6). The effects of environmental stress can be determined by measuring the chlorophyll content in plants. Plants are damaged and photosynthesis productivity will slow down if changes in pigment content occur (Ean, Vulgaris, Engin & Unzuroglu, 2005). Enzyme is responsible for the process of chlorophyll biosynthesis. Enzymes can be retarded if exposed to environmental stress such as heavy metals and decreased chlorophyll content. In higher concentration of formaldehyde, the process of photosynthesis is slowed down due to the accumulation of chemical in the leaves.

Ean et al (2005) stated that stomata function, photosynthesis rate and direct transpiration are disrupted due to the presence of formaldehyde. Previous study by Wang et al. (2012) found the chlorophyll content in the plants which treated with formaldehyde was decreased while the control plant chlorophyll content was increased.

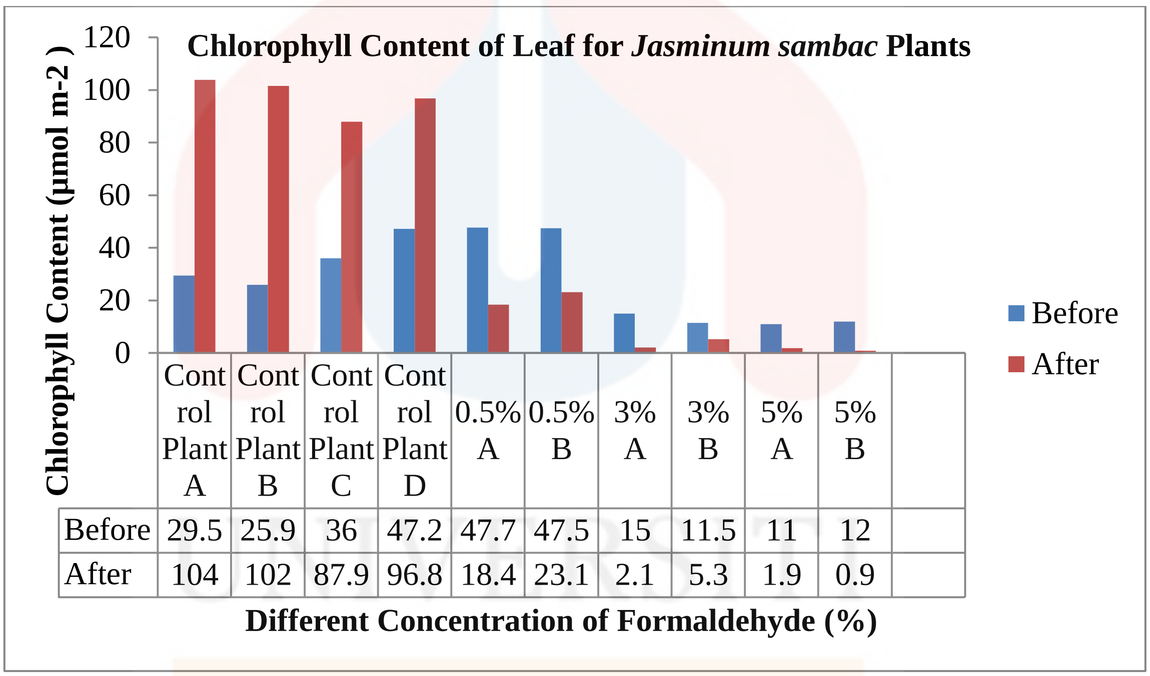

Figure 4.6: The chlorophyll content of leaves for *Jasminum sambac* plants before and after treated with different concentration of formaldehyde

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4.2.3 Data Measurement and Graph for Relative Water Content of Leaves for *Jasminum sambac* Plants

Due to the size limitation for Plants A and B (7%, 14%, 21%, 28% and 35%), the relative water content cannot be measured (Table 4.3). The relative water content of leaves was measured by the fresh weight, turgid weight and dry weight of leaves.

Table 4.3: The relative water content of leaves for *Jasminum sambac* plants

Plants	Relative Water Content of Leaves (%)			
	Fresh Weight (g)	Turgid Weight (g)	Dry Weight (g)	RWC (%)
Control Plant A	9.27	9.07	2.87	70.56
Control Plant B	4.37	4.26	1.38	70.19
Control Plant C	10.10	9.85	3.44	67.61
Control Plant D	16.80	16.47	6.25	64.06
0.5% (Plant A)	4.19	2.99	2.70	49.83
0.5% (Plant B)	4.31	3.01	2.67	54.49
3% (Plant A)	3.93	3.62	2.78	31.77
3% (Plant B)	5.56	4.56	4.15	30.92
5% (Plant A)	5.99	5.00	4.90	21.80
5% (Plant B)	10.66	10.06	7.64	30.02

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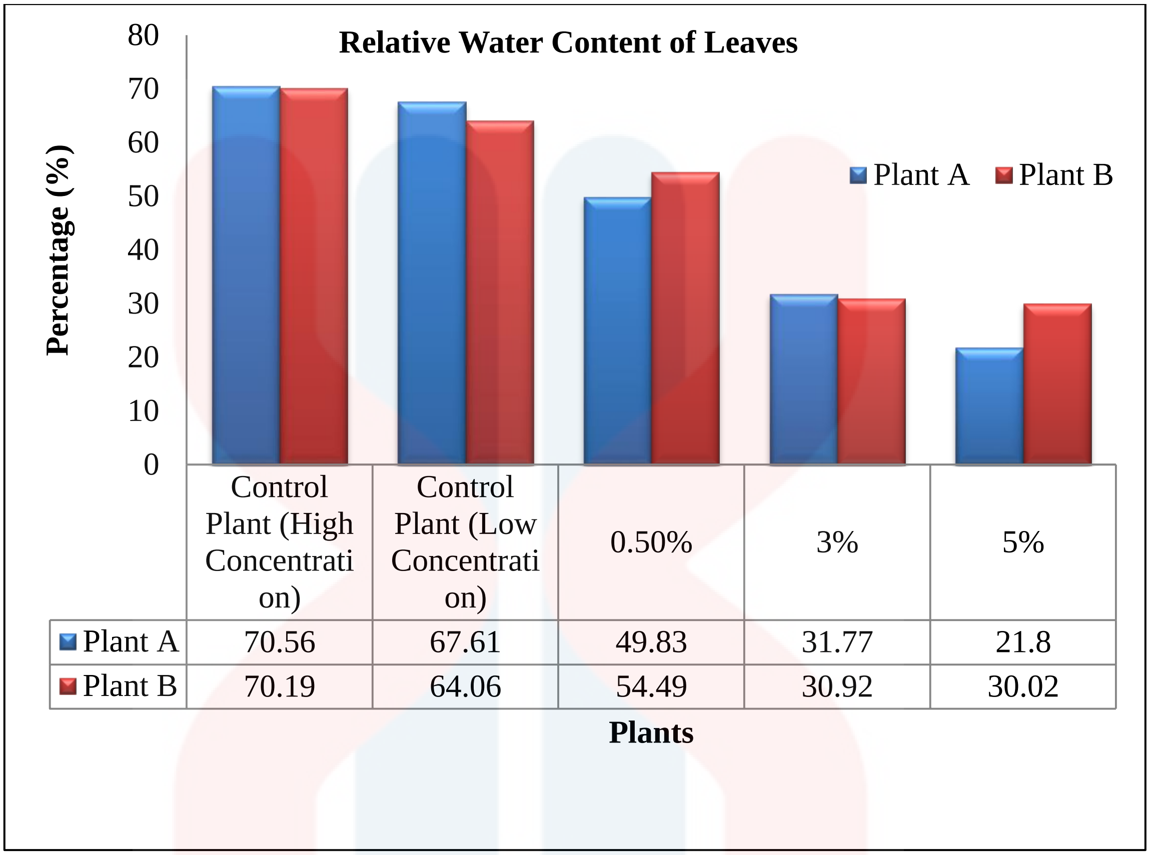

Figure 4.7: The relative water content of leaves for *Jasminum sambac* plants

Photosynthesis, plant respiration, stomata conductance, leaf growth and growth of plants are related to leaf water status. Relative water content will determine the plant water status. Leaf water content is one of the most useful parameters for determining the water balance in a plant. The relative water content of leaves for control plant is higher which was above 50% while it was found lower in the plant that treated with formaldehyde which was below 50% (Figure 4.7). As the concentration of formaldehyde increases, the percentage of relative water content of leaves decreases. When the water content was deficit, the photosynthesis rate also will become slower and cause the plant to die. Works by Lee & Mudge (2013) have shown that photosynthesis and transpiration

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are reduced by water deficit. Overall, the water content of leaves decreases as the concentration of formaldehyde increases.

4.3 Standard Calibration Curve of Formaldehyde

Figure 4.8 shows the graph for standard calibration curve of formaldehyde. The absorbance values were increased as the concentration of formaldehyde increases. The absorbance values were measured using UV-Vis Spectrophotometer at 412 nm.

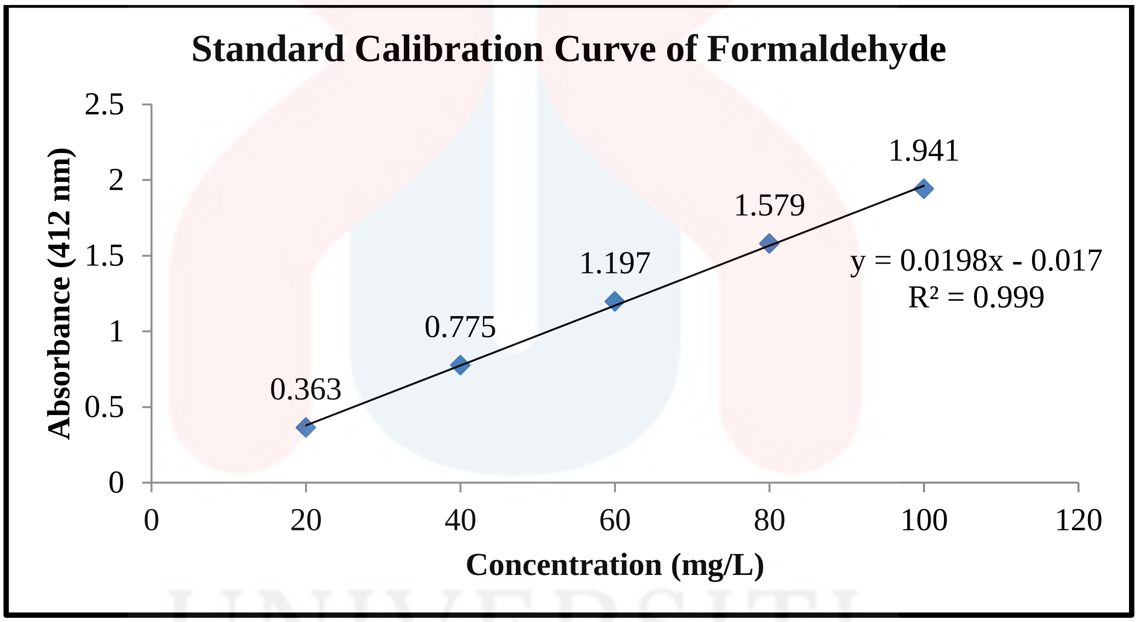

Figure 4.8: The standard calibration curve of formaldehyde

4.4 The Amount of Concentration Uptake by the *Jasminum sambac* Plants

The total formaldehyde content for the Control Plant A and B were same in the following order leaves>stem>root. For example, the highest concentration of formaldehyde in Control Plant A was found in the leaves with the total amount of 0.0016% and then followed by stem with concentration of 0.0015% while the root contained 0.0012% which was the lowest level of formaldehyde in the plant.

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Table 4.4: The calculation for the uptake of formaldehyde for the *Jasminum sambac* plants

Plants	Parts of Plant	Concentration Uptake (%)
Control Plant A	**Root**	Absorbance= 0.222 y= 0.0198x – 0.017 0.222= 0.0198x – 0.017 X= 12.07 mg / L 10 000 mg / L = 1% 12.07 mg / L = % Concentration Uptake = 0.0012%
	Stem	Absorbance= 0.291 y= 0.0198x – 0.017 0.291= 0.0198x – 0.017 X= 15.46 mg / L 10 000 mg / L = 1% 15.46 mg / L = % Concentration Uptake = 0.0015%
	Leaves	Absorbance= 0.304 y= 0.0198x – 0.017 0.304= 0.0198x – 0.017 X= 16.21 mg / L 10 000 mg / L = 1% 16.21 mg / L = % Concentration Uptake = 0.0016%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
Control Plant B	**Root**	Absorbance= 0.203 y= 0.0198x – 0.017 0.203= 0.0198x – 0.017 X= 11.11 mg / L 10 000 mg / L = 1% 11.11 mg / L = % Concentration Uptake = 0.0011%
	Stem	Absorbance= 0.253 y= 0.0198x – 0.017 0.253= 0.0198x – 0.017 X= 13.64 mg / L 10 000 mg / L = 1% 13.64 mg / L = % Concentration Uptake = 0.0014%
	Leaves	Absorbance= 0.303 y= 0.0198x – 0.017 0.303= 0.0198x – 0.017 X= 16.16 mg / L 10 000 mg / L = 1% 16.16 mg / L = % Concentration Uptake = 0.0016%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
Control Plant C	**Root**	Absorbance= 0.281 y= 0.0198x – 0.017 0.281= 0.0198x – 0.017 X= 15.05 mg / L 10 000 mg / L = 1% 15.05 mg / L = % Concentration Uptake = 0.0015%
	Stem	Absorbance= 0.122 y= 0.0198x – 0.017 0.122= 0.0198x – 0.017 X= 7.02 mg / L 10 000 mg / L = 1% 7.02 mg / L = % Concentration Uptake = 0.0007%
	Flowers	Absorbance= 0.390 y= 0.0198x – 0.017 0.390= 0.0198x – 0.017 X= 20.56 mg / L 10 000 mg / L = 1% 20.56 mg / L = % Concentration Uptake = 0.0021%
	Leaves	Absorbance= 0.601 y= 0.0198x – 0.017 0.601= 0.0198x – 0.017 X= 31.21 mg / L 10 000 mg / L = 1% 31.21 mg / L = % Concentration Uptake = 0.0031%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
Control Plant D	**Root**	Absorbance= 0.297 y= 0.0198x – 0.017 0.297= 0.0198 – 0.017 X= 15.86 mg / L 10 000 mg / L = 1% 15.86 mg / L = % Concentration Uptake = 0.0016%
	Stem	Absorbance= 0.192 y= 0.0198x – 0.017 0.192= 0.0198x – 0.017 X= 10.56 mg / L 10 000 mg / L = 1% 10.56 mg / L = % Concentration Uptake = 0.0011%
	Flowers	Absorbance= 0.259 y= 0.0198x – 0.017 0.259= 0.0198x – 0.017 X= 13.94 mg / L 10 000 mg / L = 1% 13.94 mg / L = % Concentration Uptake = 0.0014%
	Leaves	Absorbance= 0.334 y= 0.0198x – 0.017 0.334= 0.0198x – 0.017 X= 17.73 mg / L 10 000 mg / L = 1% 17.73 mg / L = % Concentration Uptake = 0.0018%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
0.5% (Plant A)	**Root**	Absorbance= 3.463 y= 0.0198x – 0.017 3.463= 0.0198x – 0.017 X= 175.76 mg / L 10 000 mg / L = 1% 175.76 mg / L = % Concentration Uptake = 0.0176%
	Stem	Absorbance= 1.839 y= 0.0198x – 0.017 1.839= 0.0198x – 0.017 X= 93.74 mg / L 10 000 mg / L = 1% 93.74 mg / L = % Concentration Uptake = 0.0094%
	Flowers	Absorbance= 2.317 y= 0.0198x – 0.017 2.317= 0.0198x – 0.017 X= 117.88 mg / L 10 000 mg / L = 1% 117.88 mg / L = % Concentration Uptake = 0.0118%
	Leaves	Absorbance= 3.412 y= 0.0198x – 0.017 3.412= 0.0198x – 0.017 X= 173.18 mg / L 10 000 mg / L = 1% 173.18 mg / L = % Concentration Uptake = 0.0173%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
0.5% (Plant B)	**Root**	Absorbance= 3.109 y= 0.0198x – 0.017 3.109= 0.0198x – 0.017 X= 157.88 mg / L 10 000 mg / L = 1% 157.88 mg / L = % Concentration Uptake = 0.0158%
	Stem	Absorbance= 2.165 y= 0.0198x – 0.017 2.165= 0.0198x – 0.017 X= 110.20 mg / L 10 000 mg / L = 1% 110.20 mg / L = % Concentration Uptake = 0.0110%
	Flowers	Absorbance= 2.118 y= 0.0198x – 0.017 2.118= 0.0198x – 0.017 X= 107.83 mg / L 10 000 mg / L = 1% 107.83 mg / L = % Concentration Uptake = 0.0108%
	Leaves	Absorbance= 2.337 y= 0.0198x – 0.017 2.337= 0.0198x – 0.017 X= 118.89 mg / L 10 000 mg / L = 1% 118.89 mg / L = % Concentration Uptake = 0.0119%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
3% (Plant A)	**Root**	Absorbance= 2.965 y= 0.0198x – 0.017 2.965= 0.0198x – 0.017 X= 150.61 mg / L 10 000 mg / L = 1% 150.61 mg / L = % Concentration Uptake = 0.0151%
	Stem	Absorbance= 1.175 y= 0.0198x – 0.017 1.175= 0.0198x – 0.017 X= 60.20 mg / L 10 000 mg / L = 1% 60.20 mg / L = % Concentration Uptake = 0.0060%
	Flowers	Absorbance= 1.631 y= 0.0198x – 0.017 1.631= 0.0198x – 0.017 X= 83.23 mg / L 10 000 mg / L = 1% 83.23 mg / L = % Concentration Uptake = 0.0083%
	Leaves	Absorbance= 1.875 y= 0.0198x – 0.017 1.875= 0.0198x – 0.017 X= 95.56 mg / L 10 000 mg / L = 1% 95.56 mg / L = % Concentration Uptake = 0.0096%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
3% (Plant B)	**Root**	Absorbance= 3.010 y= 0.0198x – 0.017 3.010= 0.0198x – 0.017 X= 152.88 mg / L 10 000 mg / L = 1% 152.88 mg / L = % Concentration Uptake = 0.0153%
	Stem	Absorbance= 2.647 y= 0.0198x – 0.017 2.647= 0.0198x – 0.017 X= 134.55 mg / L 10 000 mg / L = 1% 134.55 mg / L = % Concentration Uptake = 0.0135%
	Flowers	Absorbance= 2.134 y= 0.0198x – 0.017 2.134= 0.0198x – 0.017 X= 108.64 mg / L 10 000 mg / L = 1% 108.64 mg / L = % Concentration Uptake = 0.0109%
	Leaves	Absorbance= 2.969 y= 0.0198x – 0.017 2.969= 0.0198x – 0.017 X= 150.81 mg / L 10 000 mg / L = 1% 150.81 mg / L = % Concentration Uptake = 0.0151%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
5% (Plant A)	**Root**	Absorbance= 2.883 y= 0.0198x – 0.017 2.883= 0.0198x – 0.017 X= 146.46 mg / L 10 000 mg / L = 1% 146.46 mg / L = % Concentration Uptake = 0.0146%
	Stem	Absorbance= 2.159 y= 0.0198x – 0.017 2.159= 0.0198x – 0.017 X= 109.90 mg / L 10 000 mg / L = 1% 109.90 mg / L = % Concentration Uptake = 0.0110%
	Flowers	Absorbance= 2.075 y= 0.0198x – 0.017 2.075= 0.0198x – 0.017 X= 105.66 mg / L 10 000 mg / L = 1% 105.66 mg / L = % Concentration Uptake = 0.0106%
	Leaves	Absorbance= 2.147 y= 0.0198x – 0.017 2.147= 0.0198x – 0.017 X= 109.29 mg / L 10 000 mg / L = 1% 109.29 mg / L = % Concentration Uptake = 0.0109%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
5% (Plant B)	**Root**	Absorbance= 3.108 y= 0.0198x – 0.017 3.108= 0.0198x – 0.017 X= 157.83 mg / L 10 000 mg / L = 1% 157.83 mg / L = % Concentration Uptake = 0.0158%
	Stem	Absorbance= 2.106 y= 0.0198x – 0.017 2.106= 0.0198x – 0.017 X= 107.22 mg / L 10 000 mg / L = 1% 107.22 mg / L = % Concentration Uptake = 0.0107%
	Flowers	Absorbance= 2.862 y= 0.0198x – 0.017 2.862= 0.0198x – 0.017 X= 145.40 mg / L 10 000 mg / L = 1% 145.40 mg / L = % Concentration Uptake = 0.0145%
	Leaves	Absorbance= 2.649 y= 0.0198x – 0.017 2.649= 0.0198x – 0.017 X= 134.65 mg / L 10 000 mg / L = 1% 134.65 mg / L = % Concentration Uptake = 0.0135%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
7% (Plant A)	**Root**	Absorbance= 2.863 y= 0.0198x – 0.017 2.863= 0.0198x – 0.017 X= 145.45 mg / L 10 000 mg / L = 1% 145.45 mg / L = % Concentration Uptake = 0.0145%
	Stem	Absorbance= 2.097 y= 0.0198x – 0.017 2.097= 0.0198x – 0.017 X= 106.77 mg / L 10 000 mg / L = 1% 106.77 mg / L = % Concentration Uptake = 0.0107%
7% (Plant B)	**Root**	Absorbance= 2.779 y= 0.0198x – 0.017 2.779= 0.0198x – 0.017 X= 141.21 mg / L 10 000 mg / L = 1% 141.21 mg / L = % Concentration Uptake = 0.0141%
	Stem	Absorbance= 2.758 y= 0.0198x – 0.017 2.758= 0.0198x – 0.017 X= 140.15 mg / L 10 000 mg / L = 1% 140.15 mg / L = % Concentration Uptake = 0.0140%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
14% (Plant A)	**Root**	Absorbance= 3.115 y= 0.0198x – 0.017 3.115= 0.0198x – 0.017 X= 158.18 mg / L 10 000 mg / L = 1% 158.18 mg / L = % Concentration Uptake = 0.0158%
	Stem	Absorbance= 2.225 y= 0.0198x – 0.017 2.225= 0.0198x – 0.017 X= 113.23 mg / L 10 000 mg / L = 1% 113.23 mg / L = % Concentration Uptake = 0.0113%
14% (Plant B)	**Root**	Absorbance= 2.929 y= 0.0198x – 0.017 2.929= 0.0198x – 0.017 X= 148.79 mg / L 10 000 mg / L = 1% 148.79 mg / L = % Concentration Uptake = 0.0149%
	Stem	Absorbance= 2.584 y= 0.0198x – 0.017 2.584= 0.0198x – 0.017 X= 131.36 mg / L 10 000 mg / L = 1% 131.36 mg / L = % Concentration Uptake = 0.0131%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
21% (Plant A)	**Root**	Absorbance= 2.964 y= 0.0198x – 0.017 2.964= 0.0198x – 0.017 X= 150.56 mg / L 10 000 mg / L = 1% 150.56 mg / L = % Concentration Uptake = 0.0151%
	Stem	Absorbance= 2.842 y= 0.0198x – 0.017 2.842= 0.0198x – 0.017 X= 144.39 mg / L 10 000 mg / L = 1% 144.39 mg / L = % Concentration Uptake = 0.0144%
21% (Plant B)	**Root**	Absorbance= 2.925 y= 0.0198x – 0.017 2.925= 0.0198x – 0.017 X= 148.59 mg / L 10 000 mg / L = 1% 148.59 mg / L = % Concentration Uptake = 0.0149%
	Stem	Absorbance= 2.038 y= 0.0198x – 0.017 2.038= 0.0198x – 0.017 X= 103.79 mg / L 10 000 mg / L = 1% 103.79 mg / L = % Concentration Uptake = 0.0104%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
28% (Plant A)	**Root**	Absorbance= 2.987 y= 0.0198x – 0.017 2.987= 0.0198x – 0.017 X= 151.72 mg / L 10 000 mg / L = 1% 151.72 mg / L = % Concentration Uptake = 0.0152%
	Stem	Absorbance= 2.734 y= 0.0198x – 0.017 2.734= 0.0198x – 0.017 X= 138.94 mg / L 10 000 mg / L = 1% 138.94 mg / L = % Concentration Uptake = 0.0139%
28% (Plant B)	**Root**	Absorbance= 3.007 y= 0.0198x – 0.017 3.007= 0.0198x – 0.017 X= 152.73 mg / L 10 000 mg / L = 1% 152.73 mg / L = % Concentration Uptake = 0.0153%
	Stem	Absorbance= 2.825 y= 0.0198x – 0.017 2.825= 0.0198x – 0.017 X= 143.54 mg / L 10 000 mg / L = 1% 143.54 mg / L = % Concentration Uptake = 0.0144%

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Table 4.4: (Continued)

Plants	Parts of Plant	Concentration Uptake (%)
35% (Plant A)	**Root**	Absorbance= 2.933 y= 0.0198x – 0.017 2.933= 0.0198x – 0.017 X= 148.99 mg / L 10 000 mg / L = 1% 148.99 mg / L = % Concentration Uptake = 0.0149%
	Stem	Absorbance= 2.800 y= 0.0198x – 0.017 2.800= 0.0198x – 0.017 X= 142.27 mg / L 10 000 mg / L = 1% 142.27 mg / L = % Concentration Uptake = 0.0142%
35% (Plant B)	**Root**	Absorbance= 3.197 y= 0.0198x – 0.017 3.197= 0.0198x – 0.017 X= 162.32 mg / L 10 000 mg / L = 1% 162.32 mg / L = % Concentration Uptake = 0.0162%
	Stem	Absorbance= 3.122 y= 0.0198x – 0.017 3.122= 0.0198x – 0.017 X= 158.54 mg / L 10 000 mg / L = 1% 158.54 mg / L = % Concentration Uptake = 0.0159%

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In addition, the total formaldehyde content for the Control Plant D was in the following order leaves>root>flowers>stem. Table 4.4 illustrates the total concentration of formaldehyde in Control Plant D. From the results obtained, formaldehyde with total concentration 0.0018% was the most abundant concentration found in the leaves compared to the other parts of plant. The part of plant with the second highest concentration was root with a concentration of 0.0016% followed by flowers with a value of 0.0014%. The lowest content of formaldehyde with a total concentration of 0.0011% was found in the stem.

Furthermore, the total formaldehyde for 0.5% and 3% (Plant A) were same in the following order root>leaves>flowers>stem. It can be seen in the 0.5% (Plant A). Root is the most abundant concentration with total value 0.0176%, followed by leaves with total concentration 0.0173% and next in the flowers with total concentration 0.0118%. Stem is the least concentration found in the 0.5% (Plant A) with total amount only 0.0094%.

Moreover, the total formaldehyde for 0.5% and 3% (Plant B) were same in the following order root>leaves>stem>flowers. For example the concentrations of total formaldehyde found in the 0.5% (Plant B) were varied in each parts of plant. As shown in Table 4.4, the highest concentration of formaldehyde is in root which contributing 0.0158%, followed by leaves with the amount of 0.119%, then followed by stem with 0.110% while flowers has the lowest amount of total formaldehyde, 0.0108% which was less than root, leaves and stem.

Besides, the total formaldehyde for 7%, 14%, 21%, 28% and 35% (Plant A and B) were same in the following order root>stem. It can be seen in the 35% (Plant B) as an example. From the results obtained, formaldehyde with total concentration 0.0162% was the most abundant concentration found in the root compared to the other parts of plant. The lowest content of formaldehyde with a total concentration of 0.0159% was found in the stem.

The absorbance from each part of plants sample was calculated from the different formaldehyde concentration and was recorded using UV-Vis Spectrophotometer. Standard curve graph was obtained from the reading. Then, each part of the plants sample was compared with the standard curve of formaldehyde.

The uptake of formaldehyde was higher at the plants that treated with formaldehyde compared to the control plant (Figure 4.9). Even though the control plants do not treated with formaldehyde, however it still absorb small amount of formaldehyde in the plants. The uptake of formaldehyde for the control plants was higher in the leaves about 0.001%. The control plants were slightly affected because it was placed beside the plants that treated with formaldehyde. Formaldehyde is a volatile organic compound and it will release quickly in the atmosphere after being poured on the plant (N.D, 2018). Leaves absorb the highest amount of formaldehyde compared to the other parts of plants because it located at the external part of the plant.

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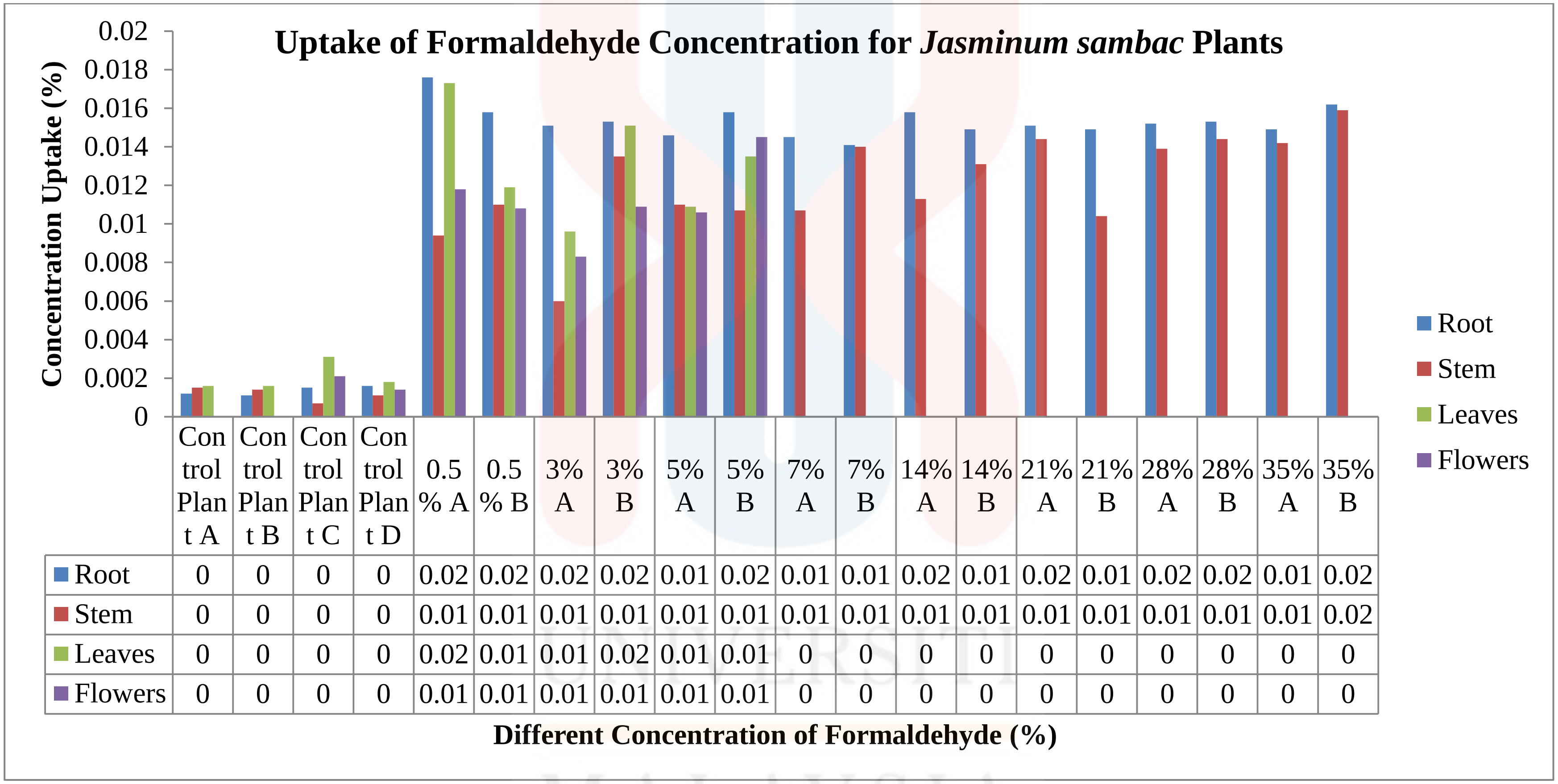

	Control Plant A	Control Plant B	Control Plant C	Control Plant D	0.5% A	0.5% B	3% A	3% B	5% A	5% B	7% A	7% B	14% A	14% B	21% A	21% B	28% A	28% B	35% A	35% B
Root	0	0	0	0	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.02
Stem	0	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Leaves	0	0	0	0	0.02	0.01	0.01	0.02	0.01	0.01	0	0	0	0	0	0	0	0	0	0
Flowers	0	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0	0	0	0	0	0

Figure 4.9: The uptake of formaldehyde concentration for *Jasminum sambac* plants in the root, stem, leaves and flowers

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In this study, the plants that treated with formaldehyde has higher uptake of formaldehyde in the roots than in the green part of the plant. The average uptake of formaldehyde for the plants that treated with formaldehyde was only 0.02% from the actual concentration that applied to the plants. The rest of the formaldehyde was absorbed by the atmosphere because of its characteristics which was volatile. The root absorbs most of the formaldehyde because normally plant root that will absorb any metal or excess nutrients.

According to Tangahu et al (2011), the pollutants absorb into the roots of the plant and surround the plant root area. Other than that, it also will cause damage to the root. The microorganisms found in the soil are nourished by natural substances produced by plant roots. In addition, plant roots can provide a surface for the process of absorption and precipitation of metal pollutants. The interplay between soil types, root zone and plant type will influence the composition of the bacterial community (Tangahu et al., 2011). Previous research works by Yabanli, Yozukmaz & Sel (2014) have shown that higher formaldehyde concentration uptake was in the roots than in the green parts of the plant, same as this study. Most of the plant that treated with formaldehyde was in this order of root>stem>flowers>leaves. This might be because formaldehyde showed low mobility ability in its transport from the root to green parts of the plant (Yabanli et al., 2014).

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CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Study on the formaldehyde uptake by *Jasminum sambac* had been undertaken in this work. The growth of plant at the biological waste disposal site located in Kampung Demit, Kubang Kerian, Kelantan cemetery and the physical changes of *Jasminum sambac* plant between the control plant and the treated plants with formaldehyde were observed very well. The plant at the formalin treated plot become brownish and were found not growing well during the site visit. There were also found not many plants growing at the formalin treated plot.

Meanwhile, the physical characteristics of *Jasminum sambac* plant such as the surface area of leaf, number of leaves and flowers and chlorophyll content of leaves were decreased after treated with formaldehyde while plant height recorded vice versa. One of the significant observations is that the leaves for the treated plant changed in color from dark green to brown and became wilt on the last day of observation. Moreover, the fresh weight, dry weight and turgid weight were measured to obtain the relative water content of leaves. The relative water content in leaves decreases as the concentration of formaldehyde increases.

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The highest formaldehyde concentration uptakes were found in the root with 0.02% from the actual concentration that applied to the plants. The evidence provided by this study demonstrated that the formaldehyde uptake followed the order of root>stem>flowers>leaves. In conclusion, formaldehyde application destroyed the plant and cause the physical characteristic of the plants does not grow well even with the lower concentration.

5.2 Recommendations

For the better result, it is recommended to plant the *Jasminum sambac* at the biological waste disposal site so that the effect of formalin can be obtained. Therefore, the results can show the accurate condition and observation on plant growth of the *Jasminum sambac* can be indicated.

Other than that, it is suggested to use new chemical which is the Nash Reagent rather than chromotropic acid to determine the uptake of formaldehyde. The new chemical used can compare the amount of formaldehyde uptake when using the Nash Reagent and the chromotropic acid. The comparison will obtained the best chemical that can be used to determine the uptake of formaldehyde in the future research.

Furthermore, the additional of parameter to measure the plant growth can be added for the future research. For example, the amount of carotenoid can be measured to know the plant condition and growth. Then, the uptake of formaldehyde must be measured not only in the root, stem, flowers and leaves but in the soil as well. It is the soil that located in the pot of *Jasminum sambac* plants.

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APPENDIX A

Table 4.2: The data measurement for *Jasminum sambac* plants that treated with different concentration of formaldehyde

Plants	**Control Plant A**								**Control Plant B**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	38.1	39.4	40.6	41.1	41.7	41.9	42.7	43.1	34.3	34.3	38.1	38.1	38.4	38.6	38.9	40.6
Surface area of leaf	12	12.5	13	14	14.5	15	17	18	10	12	13	14	15	16	18	20
Number of leaves	9	11	17	22	24	28	29	31	7	7	10	11	11	12	16	19
Number of flowers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colors of leaves	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Chlorophyll content of leaves	29.5	-	-	-	-	-	-	103.8	25.9	-	-	-	-	-	-	101.5
Plants	**Control Plant C**								**Control Plant D**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	35.6	36.8	38.1	39.4	40.6	43.1	-	-	39.4	40.6	41.4	41.9	43.2	48.3	-	-
Surface area of leaf	12	14	14.5	15	17	20	-	-	19	20	21	22	24	26	-	-
Number of leaves	45	47	49	55	57	60	-	-	43	45	54	60	62	68	-	-
Number of flowers	10	18	20	22	23	24	-	-	12	14	15	17	19	20	-	-
Colors of leaves	DG	DG	DG	DG	DG	DG	-	-	DG	DG	DG	DG	DG	DG	-	-

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Table 4.2: (Continued)

Plants	**Control Plant C**								**Control Plant D**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Chlorophyll content of leaves	36.0	-	-	-	-	87.9	-	-	47.2	-	-	-	-	96.8	-	-
Plants	**0.5% (Plant A)**								**0.5% (Plant B)**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	35.6	36.8	36.8	36.8	37.3	37.3	-	-	36.8	38.1	39.4	39.4	40.4	40.6	-	-
Surface area of leaf	14	13	12	10	10	9	-	-	17	16	15	11	11	9	-	-
Number of leaves	52	50	42	26	20	19	-	-	45	45	40	33	30	30	-	-
Number of flowers	9	7	4	3	0	0	-	-	9	7	7	7	2	0	-	-
Colors of leaves	DG	DG	LG	LG	YB	YB	-	-	DG	DG	LG	LG	YB	YB	-	-
Chlorophyll content of leaves	47.7	-	-	-	-	18.4	-	-	47.5	-	-	-	-	23.1	-	-
Plants	**3% (Plant A)**								**3% (Plant B)**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	34.3	35.6	35.6	35.6	38.1	38.1	-	-	29.2	30.5	30.5	30.5	31.2	31.2	-	-
Surface area of leaf	13	11	9	7	6	5	-	-	15	14	12	10	9	8	-	-

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Table 4.2: (Continued)

Plants				**3% (Plant A)**									**3% (Plant B)**			
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Number of leaves	48	48	45	31	25	25	-	-	38	38	38	30	29	29	-	-
Number of flowers	4	2	1	0	0	0	-	-	10	8	4	4	0	0	-	-
Colors of leaves	DG	LG	Y	YB	DB	DB	-	-	DG	LG	Y	YB	DB	DB	-	-
Chlorophyll content of leaves	15	-	-	-	-	2.1	-	-	11.5	-	-	-	-	5.3	-	-
Plants				**5% (Plant A)**									**5% (Plant B)**			
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	35.1	35.1	35.6	35.6	35.6	35.6	-	-	33	33	34.3	34.3	34.3	34.3	-	-
Surface area of leaf	15	12	9	7	5	4	-	-	11	10	8	6	5	4	-	-
Number of leaves	34	34	34	33	31	31	-	-	53	53	52	44	40	40	-	-
Number of flowers	4	3	0	0	0	0	-	-	4	2	0	0	0	0	-	-
Colors of leaves	DG	LG	Y	LB	DB	DB	-	-	DG	LG	Y	LB	DB	DB	-	-
Chlorophyll content of leaves	11	-	-	-	-	1.9	-	-	12	-	-	-	-	0.9	-	-

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Table 4.2: (Continued)

Plants	**7% (Plant A)**								**7% (Plant B)**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	27.9	29.5	29.5	29.5	30	30	30	30.5	24	24	25.9	25.9	25.9	25.9	25.9	26.4
Surface area of leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of leaves	8	8	8	8	5	4	3	2	3	3	3	3	3	2	2	1
Number of flowers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colors of leaves	DG	LB	LB	LB	MB	MB	DB	DB	DG	DG	LG	LB	DB	DB	B	B
Chlorophyll content of leaves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plants	**14% (Plant A)**								**14% (Plant B)**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	24.1	24.1	24.1	24.1	24.4	24.4	24.4	24.6	22.9	22.9	22.9	22.9	22.9	22.9	23.4	23.9
Surface area of leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of leaves	10	9	8	7	5	3	2	1	6	6	6	4	4	4	3	2
Number of flowers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Color of leaves	DG	LG	LB	DB	DB	DB	B	B	DG	LG	LB	DB	DB	DB	B	B

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Table 4.2: (Continued)

Plants	**14% (Plant A)**								**14% (Plant B)**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Chlorophyll content of leaves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plants	**21% (Plant A)**								**21% (Plant B)**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	23.6	23.6	24.1	24.1	24.1	24.1	24.1	24.1	23.6	23.6	23.6	24.1	24.1	24.1	24.1	24.1
Surface area of leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of leaves	2	2	2	2	2	2	1	1	6	6	6	4	2	2	1	1
Number of flowers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colors of leaves	DG	LG	LB	LB	DB	DB	B	B	DG	LG	LB	LB	DB	DB	B	B
Chlorophyll content of leaves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plants	**28% (Plant A)**								**28% (Plant B)**							
Days	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**	**1st**	**4th**	**7th**	**10th**	**13th**	**16th**	**19th**	**22nd**
Plant height (cm)	34.3	34.3	34.3	34.3	34.3	34.3	34.8	34.8	22.9	22.9	22.9	22.9	24.1	24.1	24.1	24.1
Surface area of leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Table 4.2: (Continued)

Plants	28% (Plant A)								28% (Plant B)							
Days	**1^{st}**	**4^{th}**	**7^{th}**	**10^{th}**	**13^{th}**	**16^{th}**	**19^{th}**	**22^{nd}**	**1^{st}**	**4^{th}**	**7^{th}**	**10^{th}**	**13^{th}**	**16^{th}**	**19^{th}**	**22^{nd}**
Numbers of leaves	5	5	5	4	3	2	0	0	2	2	2	2	2	1	1	0
Numbers of flowers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colors of leaves	DG	LG	DB	DB	B	B	B	B	DG	LG	DB	DB	B	B	B	B
Chlorophyll content of leaves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plants	**35% (Plant A)**								**35% (Plant B)**							
Days	**1^{st}**	**4^{th}**	**7^{th}**	**10^{th}**	**13^{th}**	**16^{th}**	**19^{th}**	**22^{nd}**	**1^{st}**	**4^{th}**	**7^{th}**	**10^{th}**	**13^{th}**	**16^{th}**	**19^{th}**	**22^{nd}**
Plant height (cm)	28.7	28.7	29.2	29.2	29.2	29.2	29.2	29.2	28.7	28.7	30.5	30.5	33	33	33	33
Surface area of leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of leaves	8	8	7	6	5	5	4	3	7	7	7	5	3	2	2	1
Number of flowers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colors of leaves	DG	LG	DB	DB	B	B	B	B	DG	LG	DB	DB	B	B	B	B
Chlorophyll content of leaves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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APPENDIX B

Figure 4.10: The parts of plants in the powder form to determine the uptake of the formaldehyde concentration

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