TREATMENT OF TOILET ODOR USING HORIZONTALLY PLACED ODOR REMOVAL MEMBRANE

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TREATMENT OF TOILET ODOR USING HORIZONTALLY PLACED ODOR REMOVAL MEMBRANE

By

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I hereby declare that all corrections and comments made by the supervisor(s) and examiner have been taken into consideration and rectified accordingly.

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With that, thank you.

ABSTRAK

Tandas merupakan tempat yang paling kerap dilawati di rumah atau di tempat awam. Kekerapan tandas digunakan dan aktiviti yang dijalankan di dalamnya membawa kepada keadaan yang buruk di mana terdapat bau yang tidak menyenangkan dan keadaan ini sering menjadi kebimbangan terhadap penggunanya. Terdapat beberapa kaedah yang digunakan dalam menangani isu bau di dalam tandas seperti meningkatkan kekerapan tandas itu dibasuh, penggunaan pewangi tandas dan juga reka bentuk pengudaraan tandas yang baik. Kajian ini bertempat di tandas asrama perempuan di Desasiswa Lembaran, dijalankan untuk memberi tumpuan kepada rawatan bau tandas menggunakan membran penyingkiran bau, iaitu Deodoratex. Kecekapan pengendalian bau kedua-dua jenis kain ini iaitu Deodoratex, Jenis 03 dan Jenis 32 yang digunakan dalam kajian ini dinilai dengan mengukur kepekatan unit bau (OU / m^3) dan intensiti bau di dalam tandas sebelum dan selepas pemasangan kain . Penyingkiran ammonia dan hidrogen sulfida yang tidak menentu juga diukur dan dibandingkan dengan kedua-dua fabrik dalam kedua-dua keadaan (sebelum dan selepas pemasangan). Ujian penyerapan ammonia juga dilakukan pada fabrik untuk menentukan keupayaan kain untuk benar-benar menyerap kepekatan ammonia. Kedua-dua jenis kain ini menunjukkan kecekapan kawalan bau yang bagus di dalam tandas walaupun bau bervariasi dan bau intensiti dari semasa ke semasa. Fabrik ini juga memberikan keputusan yang positif dalam ujian kecekapan penyingkiran bau di mana Jenis 32 menunjukkan peratusan yang lebih besar dalam penghapusan ammonia dan hidrogen sulfida. Dalam ujian penyerapan ammonia, fabrik menunjukkan kesan yang ketara ke atas ammonia kerana jumlah ammonia selepas ujian lebih rendah jika dibandingkan dengan jumlah ammonia yang tidak dirawat. Fabrik Jenis 32 mempunyai jumlah ammonia-nitrogen yang lebih tinggi apabila air basuhannya diuji menggunakan Hach Spectrophotometer

ABSTRACT

Toilet is considered the most visited place in a home or in public. The frequency of the toilet being used and the activity conducted in it led to a bad condition where it can have offensive smell and the odorous condition of the toilet often be a concern towards its users. There are several methods applied in dealing with odor in the toilet such increasing the frequency of the toilet being washed, the application of fragrance and also a wise toilet's ventilation design. This study that took place in toilet located in girl's hostel at Desasiswa Lembaran, was conducted to focus on treatment of the toilet's odor using odor removal membrane, which is Deodoratex. The odor control efficiency of the both type of Deodoratex fabrics, Type 03 and Type 32 that are used in this study are evaluated by measuring the odor unit concentration (OU/m^3) and odor intensity in the toilet before and after the installation of the fabrics. The removal of ammonia and hydrogen sulfide also being measured and compared for both fabrics in both situation (before and after installation). Ammonia adsorption test also conducted on the fabrics to determine the capability of the fabrics to really adsorb ammonia concentration. Both fabrics shows a great odor control efficiency in the toilet even the odor intensity and odor character varies from time to time. These fabrics also have a positive values of odour removal efficiency where fabric Type 32 shows a greater percentage in removal of ammonia and hydrogen sulfide. In the ammonia adsorption test, the fabrics showed significant effects on ammonia gas as the concentration of ammonia after the test was lower compared to the concentration of untreated ammonia. Type 32 fabrics have higher amounts of ammonia-nitrogen when the washing water is tested using the Hach Spectrophotometer.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

TAC	**T**oxic **A**ir **C**ontaminants

NOMENCLATURES

NH_3	Ammonia
NH_3-N	Ammonia-Nitrogen
H_2S	Hydrogen Sulphide

CHAPTER 1

INTRODUCTION

1.1 General Background

Recently, concerns for the indoor environment have significantly increased due to demands for a better quality of life. The toilet has the poorest air quality in a building; nevertheless, it usually requires the best cleanliness (Seo and Seouk Park, 2013). Even though regular cleaning certainly reduces toilet odor, there is still a way that our toilet is leaking noxious fumes despite the best cleaning routines.

Offensive toilet odor can cause the entire home or building's area to smell like a sewer and most contamination sources in a bathroom are the unpleasant odor and bacteria due to urine and faeces. An offensive smell in the toilet is more often caused by a lack of cleaning beside some possible causes, burst pipe below the toilet or leaking at the base of the toilet itself. Unfortunately this is often the case with public toilets and visiting them can be an unpleasant experience.

Generally, toilet in food centers can be used by about 100 to 150 people an hour; with up to 300 people an hour uses shopping malls' restrooms (Teng, 2016). Toilet odor are actually quite complex and consist of more than 200 different chemical compounds arising from faeces and urine that change over time and vary depending on the health and diet (Weller, 2016). By targeting specific compounds e.g. ammonia and hydrogen sulfide, the odorous compound can be reverse-engineered using Deodoratex, an odor eliminating mesh that reduces odor by adsorbing various odor chemically which targeted to remove 4 major gases that generate bad smell including ammonia, hydrogen sulfide. methanethiol, trimethylamine and acetaldehyde.

1.2 Problem Statement

Toilet is usually known as one of the most odorous place in a building since it is being frequently used. Without proper ventilation, the toilet will, without a doubt, begin to accumulate unwanted odors of all kinds (Tung et al., 2009). Despite all those cleaning activities that are carried out in the toilet, the odor seems like not going anywhere.

Odor in toilet that are produced during the excretion of faecal material (Andreev et al., 2017) from the human body or existed due to the conditions of the toilet itself are often offensive and disturbing. Also, too much exposure to the odor can result in adverse health effects to the toilet users (Brancher et al., 2017).

Fresheners are commonly placed in toilets to mask toilet odor as they are designed to impart an aroma to the air environment or to mask odors, with the intent of creating a pleasing indoor space. However, despite the intent, air fresheners can emit and generate a range of potentially hazardous air pollutants that can impair air quality (Steinemann, 2017). This situation could lead to unsafe ambient in the toilet.

Over the years, several treatment process are developed to treat taste and odor in drinking water and this includes method by Bruchet and M Laîné (2005) and DiToro (2012) that focus on the potential of membrane process in removal of taste and odor causing compounds. However, least information is available in the literature on the use of membrane for odor removal in toilet. In conjunction with that, a study is needed to evaluate the performance of the membrane in removal of odor in the toilet.

1.3 Objectives

This ultimate aim of this project is to establish the potential of Deodoratex in the control of odor at public toilet. To achieve the above aim, the following project objectives are proposed:

1. To determine odor control efficiency of Deodoratex membrane in horizontal application at Desasiswa Lembaran.

2. To determine the hydrogen sulfide and ammonia removal in hostel's toilet using Deodoratex in horizontal application.

3. To establish ammonia absorption capability of Deodoratex.

1.4 Scope of Study

The study is conducted in toilet located in girls' hostel at Desasiswa Lembaran, Universiti Sains Malaysia, Engineering Campus, Pulau Pinang. The scope of works focused on collecting odor data in the toilet before and the installation of odor removal membrane, Deodoratex Type 03 and Type 32. Before the first installation of fabric, the odor concentration (OU/m^3), hydrogen sulfide and ammonia levels (ppm) will be assessed three times a day, tentatively in the morning at 9 am, in the afternoon at 3.00 pm and in the evening at 9 pm for 5 days. During the data recording time, concurrent observations of the toilet condition and usage e.g. cleaning time, blocked toilets etc. will be recorded. The data recording processes is repeated once the fabric has been installed.

The determination of odor is based on the use of a dilution instrument, called olfactometer, which presents the odor sample diluted with odor-free air at precise ratios, to a panel of human assessors. Apart from that, the hydrogen sulfide and ammonia level of the toilet will be assessed using portable gas sensors OdoTracker TR8 (Scentroid, Canada). Scentroid OdoTracker is a multisensor device that measures the concentrations of two chemicals in ambient air (or sample bag) at the same time. All data would be recorded and justification would be made regarding the odor condition of the toilet. The rest of the day are laboratory works that include adsorption test on the fabric.

1.5 Justification of Research

The study of odor treatment in the toilet helps to improve the odorous condition of the toilet in many ways. The use of odor removal membrane would help in reducing odor in the toilet since it is able to remove compound that are believe to contribute to odor such as ammonia and hydrogen sulfide. Not just that, the use of toilet fresheners can be cut down since it is believe to bring more harm than good when the usage is excessive.

1.6 Dissertation Outline

In this dissertation, Chapter One provides an introduction to the topic of the research. This chapter involve general description of study that includes problem statement, objectives to achieve and scope of work to be carried out and the justification of the research. This is followed by Chapter Two which consists of literature review which discussing about previous research that are related to the use of removal membrane and treatment of odor in the toilet. Chapter Three provides the method of which this research is conducted followed by result and discussion in Chapter Four. The results of the study are discussed in this chapter including the level of ammonia and hydrogen sulfide in the toilet before and after installation of the odor removal membrane, Deodoratex. Apart from that, survey data from toilet's users also been discussed in this chapter before further discussion on the ammonia adsorption test on the fabrics is carried out. At the end, Chapter Five which is conclusion and recommendation, concludes the findings in this study and provides suggestion to mitigate the environmental problem

CHAPTER 2

LITERATURE REVIEW

2.1 Odor

Odor is perceived by our brains in response to chemicals present in the air we breathe. Odor is the effect that those chemicals have upon us. Humans have sensitive sense of smell and can detect odor even when chemicals are present in very low concentrations.

Most odors are a mixture of many chemicals that interact to produce what we detect as an odor. Odor-free air contains no odorous chemicals. Fresh air is usually perceived as being air that contains no chemicals or contaminants that could cause harm, or air that smells ‘clean’. Fresh air may contain some odor, but these odors will usually be pleasant in character or below the human detection limit (Hayes et al., 2017).

According to Son et al. (2017), different life experiences and natural variation in the population can result in different sensations and emotional responses by individuals to the same odorous compounds. Because the response to odor is synthesised in our brains, other senses such as sight and taste, and even our upbringing can influence our perception of odor and whether we find it acceptable or objectionable and offensive.

2.2 Odor Characteristics and Attributes

From first detection, the need to describe odors is essential and this requires reference to a number of different attributes of smell, described and summarized in Table 2.1.

Table 2.1: Basic Sensory Properties of Odour (Kaeppler and Mueller, 2013)

Detection (at Threshold)	Concentration of odor when first detectable
Recognition	Human ability to differentiate between odors, e.g. wine or vinegar
Intensity	Perceived strength at differing concentrations, e.g. faint, district, strong
Hedonic Tone	Pleasantness/ offensiveness, e.g. pleasant, unpleasant, offensive
Odor Quality or Character	Association & complexity, e.g. the many tones and associations we have with an odor such as flowers, coffee, waste, sewage, etc

2.3 Toilet's Air Quality

Bathrooms are one of the most frequently used rooms in the house. Consequently, bathroom design is a high priority for many homeowners. Without proper ventilation, the bathroom will, without a doubt, begin to accumulate unwanted odors of all kinds. Dols et al. (2014) and Chung et al. (2017) reported that indoor air quality has a great impact on the health of human inhabitants.

Boor et al (2017) revealed that indoor air pollutants are normally found at higher concentrations than their outdoor counterparts. However, effective ventilation systems are able to improve the indoor air quality and solve the embarrassing problems of toilet odors and moist air.

2.4 Odor Contributor in Toilet

Urine is the main contributors towards the bad odorous condition in the toilet. Liu, et al. (2017) conducted a study that investigated the odorous compounds that emitted from source-separated human urine under different hydrolysis conditions. Batch experiments were conducted to investigate the effect of temperature, stale/fresh urine ratio and urine dilution on odor emissions. It was found that ammonia, dimethyl disulfide, allyl methyl sulfide and 4-heptanone were the main odorous compounds generated from human urine, with headspace concentrations hundreds of times higher than their respective odor threshold. According to Harvard Women's Health Watch (2013), a surprising number of things can affect the odor of urine. The most common ones are harmless and temporary, including foods, vitamins, and certain medications. But sometimes changes in urine signal a medical problem, which may range from relatively benign (a urinary tract infection) to serious (kidney or bladder cancer).

2.4.1 Odorous Compounds

The inevitable gas emission from the toilet, which indirectly reflects the composting process, is another important concern. Also, due to evaporation and aeration of the composting tank, precious nutrients, mainly ammonia gas, can be lost (Tsang, 2012). Based on a study conducted by Wu et al. (2017) in Fujian, humans and waste disposal are two important sources of ammonia emissions, accounting for 4.9% and 4.2% of the total ammonia emissions in 2015. Within the sub-categories of humans, human excretion was the major contributor, sharing 51.2%–79.3% of the total humans' emissions. Considering the high coverage rate of flushing toilet in urban families, part of ammonia emission from urban resident excretion may be double counted in the estimate of ammonia from sewage treatment, which might overestimate contribution in the urban areas.

Occasionally, an electric water heater is a source of hydrogen sulfide odor. The magnesium corrosion control rod present in many water heaters can chemically reduce naturally occurring sulfates to hydrogen sulfide. Hydrogen sulfide gas produces an offensive "rotten egg" or "sulfur water" odor and taste in the water. In some cases, the odor may be noticeable only when the water is initially turned on or when hot water is run in the toilet. Heat forces the gas into the air which may cause the odor to be especially offensive in a shower (Oram, 2014). Also according to Malone Rubright et al.,(2017), hydrogen sulfide is produced from sewage sludge through breakdown of organic materials that probably take place in the pipe (hence, its common name, "sewer gas"), liquid manure, sulfur hot springs, and natural gas.

2.5 Methods in Dealing with Toilet Odor

Many researchers have studied the state of indoor air contamination or its sources during the last few decades. Also, numerous practical studies have been conducted to eliminate unwanted odor and bacteria in toilet. The polluted air stream from toilet might not cause any harm to people, but increases the uncomfortable sensation of the people who use the toilet.

2.5.1 Toilet's Ventilation Design

The inappropriate ventilation design of toilet will result in the odors from excreta flowing to other nearby spaces. Most methodologies focused on how to design ventilation systems in toilet effectively so that the unwanted materials would not contaminate rooms. Other than that, instead of an air ventilation system that circulates all of the bathroom air, study investigate numerically and experimentally a system that entrains the source from a toilet bowl and blocks the source's outflow. The system is simply installed inside the toilet seat. The effects of the suction flow rate, the suction hole size, and the number of suction holes are tested. The flow and concentration in the toilet bowl are numerically visualized. In addition, experimental results are in good agreement with the numerical results (Seo and Seouk Park, 2013).

Chung et al. (1997) simulated the airflow numerically and the flow path of contaminant particles in the bathroom with floor exhaust ventilation. Tung et al. (2009) conducted an experimental study in a mock-up bathroom with a typical ceiling ventilation system. They utilized Sulfur hexafluoride (SF6) trace gas to verify the concentration at each sampling point. Their results showed that the removal efficiency of odors became more effective with higher ventilation rates and shorter distances between the toilet and the exhaust air vent, which reflects common sense. However, these two studies did not suggest an ultimate methodology for people to be safe from unwanted odor and bacteria.

2.5.2 Air Fresheners

Even so-called green and organic air fresheners can emit hazardous air pollutants. Air freshener ingredients are largely unknown and undisclosed, owing to regulatory protections on consumer product ingredients and on fragrance formulations. In studies, fewer than ten percent of all volatile ingredients are typically disclosed on air freshener labels or material safety data sheets.

From an indoor air quality perspective, air fresheners have been indicated as a primary source of volatile organic compounds within buildings. From a health perspective, air fresheners have been associated with adverse effects, such as migraine headaches, asthma attacks, mucosal symptoms, infant illness, and breathing difficulties (Steinemann, 2017). Apart from that, more than two dozen research articles present evidence of adverse health effects from inhalation exposure associated with cleaning or cleaning products.

Few studies have directly addressed the indoor concentrations of toxic air contaminants (TACs) that might result from primary emissions or secondary pollutant formation following the use of cleaning agents and air fresheners. In the study conducted by Nazaroff and Weschler (2004), they combine direct empirical evidence with the basic principles of indoor pollutant behaviour and with information from relevant studies, to analyse and critically assess air pollutant exposures resulting from the use of cleaning products and air fresheners. Exposure to primary and secondary pollutants depends on the complex interplay of many sets of factors and processes, including cleaning product composition, usage, building occupancy, emission dynamics, transport and mixing, building ventilation, sorptive interactions with building surfaces, and reactive chemistry.

2.6 Application of Membrane in Odor Treatment

Odor treatment technologies can be classified into three categories, namely ones employing chemical (thermal oxidation, catalytic oxidation, ozonation), physical (condensation, adsorption, absorption) and biological (using biofilters, biotrickling filters, bioscrubbers and other bioreactor types) treatment methods (Barbusinski et al., 2017). The application of membrane in dealing with odor treatment can be categorized as either physical or biological method since sorption and filtrating process respectively take place in most cases.

Research on membrane technologies has grown exponentially to treat wastewater, recycle polluted water and provide more freshwater (Liao et al., 2018). Membrane Bioreactors (MBRs) that broadly defined as systems integrating biological degradation of waste products with membrane filtration have proven quite effective in removing organic and inorganic contaminants as well as biological entities from wastewater (Cicek, 2003).

In treatment of off-gas emissions, according to Estrada et al. (2013), biotechnologies are nowadays recognized as the best available technologies for odor treatment due to their lower environmental impact and operating costs compared to their physical-chemical counterparts. Among conventional biotechnologies, biofiltration and biotrickling filtration are by far the most commonly implemented technologies for odor abatement likely due to their ease of operation and the extensive design and operation experience (Iranpour et al., 2005). However, these biotechnologies are claimed to support low removal efficiencies for the hydrophobic fraction of malodorous emissions, whose elimination is mandatory for an efficient odor abatement (Liu et al., 2009, Iranpour et al., 2005).

2.7 Summary

The concentration of ammonia and hydrogen sulfide in the toilet have been reported and studied. Several methods that are suggested to deal with toilet odor are somehow proven not to be the best technique. The use of membrane in treatment of odor gas as physical method also has not been widely used yet and the existing study regarding the application membrane in odor treatment are all focusing on the biological treatment. However, its effectiveness in reducing toilet odor has yet to be proven and thus a research needs to be conducted to prove it.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter explains the method used to carry out the research and collecting odor data in the toilet before analysis of data can be made. Several steps have been taken in preparing and implementing the scope of works in order for the research to be conducted in good performance. The steps involve in achieving all of the objectives of the study as shown in the flow chart (Figure 3.1). The study is then performed based on the steps and the laboratory work is repeated to get an average results.

3.2 Location of Study

The proposed study location is in the toilet of girls' hostel located in Wing A, First Floor, Blok 2, Desasiswa Lembaran as shown in Figure 3.2. Desasiswa Lembaran is a students' hostel, located in Engineering Campus, Universiti Sains Malaysia. Consists of three hostel's blocks, two blocks populated female students and one block populated by male students. In Blok 2, the building comprises of approximately 469 students which divided into three main wings. Number of students that stay in first floor, wing A around 40 people and the amount of users in the studied toilet is about 17 people. This site is chosen due to reported odor complaints of the toilet as well as its easy access for the purpose of this study.

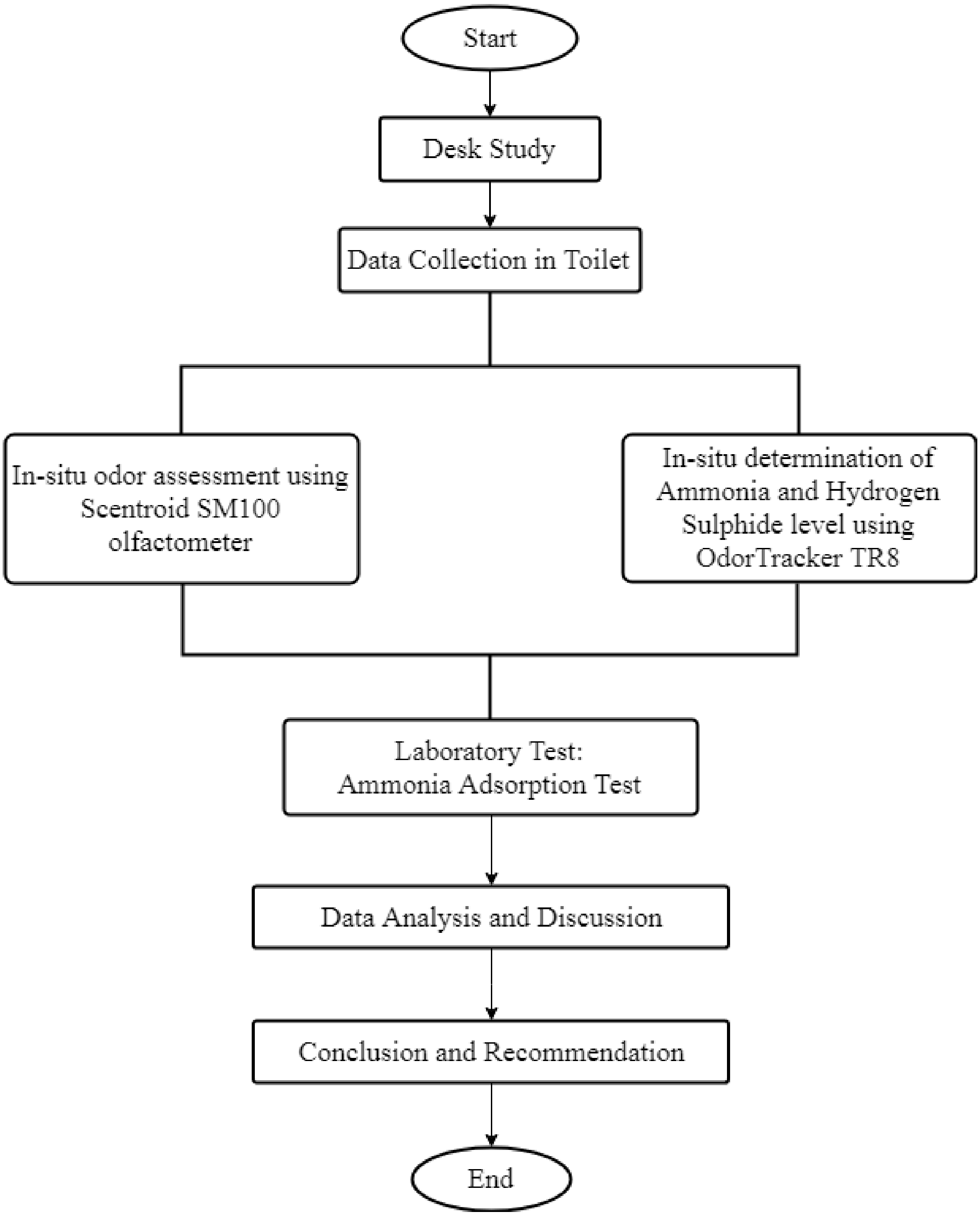

Figure 3.1: Flow chart of the research methodology

Figure 3.2: Toilet in Desasiswa Lembaran

3.3 Deodoratex

Deodoratex is an odor eliminating mesh that reduces odor by adsorbing various odor chemically, both acidic and basic odorants. It is hypothesized that the “stinky sewage, sweat, and ripe cheese” smell of public toilet can be brought to more acceptable and less pungent smell using Deodoratex. The Deodoratex membrane is made from inorganic system deodorizer (Silicon Dioxide, Zinc Oxide and Aluminiumsilicate). The Deodoratex helps to improve air quality by adsorbing various odour chemically. It absorbs both acid and base materials because it has both adsorption sites (Hiraoka & Co LTD., 2015).

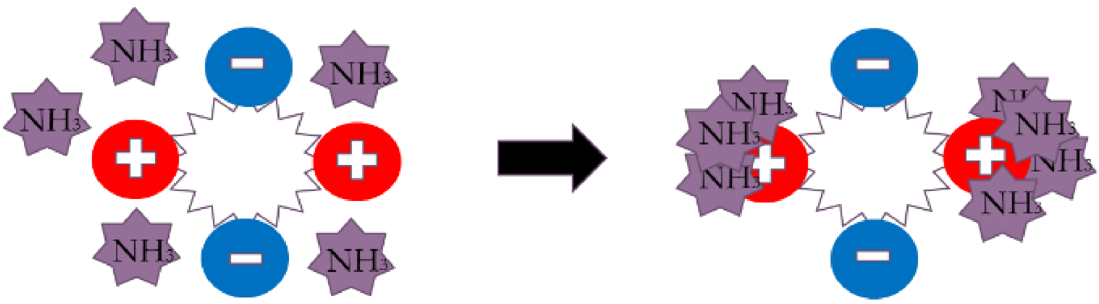

Figure 3.3: The Deodoratex can capture the basic and acidic deodorants

The Deodoratex target to remove 4 major gases that generate bad smell such as ammonia that yield strong and pungent odor, hydrogen sulfide that has rotten-egg smell, methanethiol that could produce rotten cabbage or rotten-eggs smell, trimethylamine that often associated with rotting fish smell and acetaldehyde that has green apple-like smell. The Deodoratex is effective for many months. The duration will depend on the concentration of odorant. The Deodoratex can be simply washed with water and mild detergent to release trapped odour molecules. The washing process renews the performance properties of the Deodoratex to allow re-use (Hiraoka & Co LTD., 2015).

There are two types of Deodoratex fabric that are used in the study which are Deodoratex Type 03 and Deodoratex Type 32. The average measurement value of the fabrics are as tabulated below:

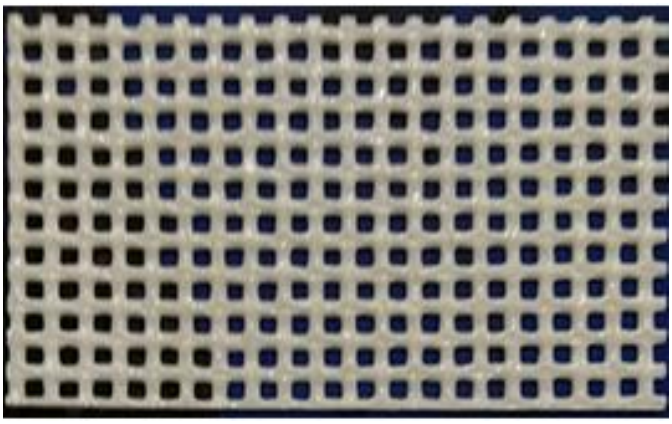

Figure 3.4: Fabric Type 03

Table 3.1: Metric Count of Fabric Type 03

Type 03 (cm)		
Width × Length / Roll	ASTM D-751	189cm × 50m
Weight	ASTM D-751	450g / m^2
Tensile Strength	ASTM D-751	1,600 × 1,600N / 3cm
Breaking Elongation	ASTM D-751	25 × 25%
Tear Strength (Trapezoid)	ASTM D-751	550 × 550N

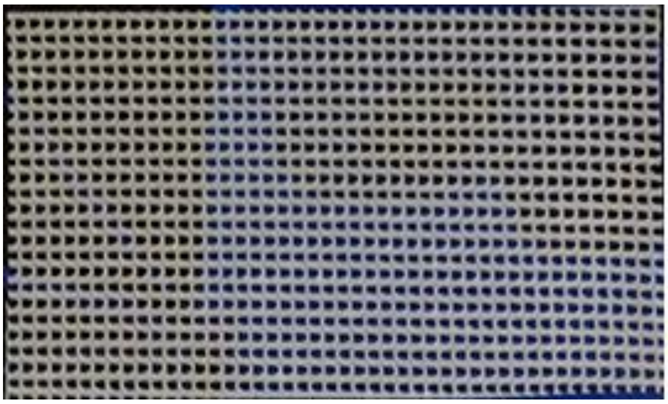

Figure 3.5: Fabric Type 32

Table 3.2: Metric Count of Fabric Type 32

Type 32 (cm)		
Width × Length / Roll	ASTM D-751	189cm × 50m
Weight	ASTM D-751	220g / m^2
Tensile Strength	ASTM D-751	680 × 550N / 3cm
Breaking Elongation	ASTM D-751	12 × 12%
Tear Strength (Trapezoid)	ASTM D-751	130 × 100N

Briefly, Type 03 Deodoratex has a bigger pore size, higher tensile strength, higher breaking elongation and higher tear strength compared to Type 32 Deodoratex. Technically, these fabrics have been use in critical applications to reduce ammonia gas in poultry and pig sheds. This improves animal health and has a direct correlation with improved productivity and weight gain. Deodoratex from Hiroaka chemically adsorbs odours therefore improving ambient conditions which has been proven to reduce livestock stress and mortality birthing rates in livestock sheds. The efficiency of the material dealing with ammonia and hydrogen sulfide also the performance of the fabric after washing can be seen in the following Figure. 3.6 to Figure 3.8.

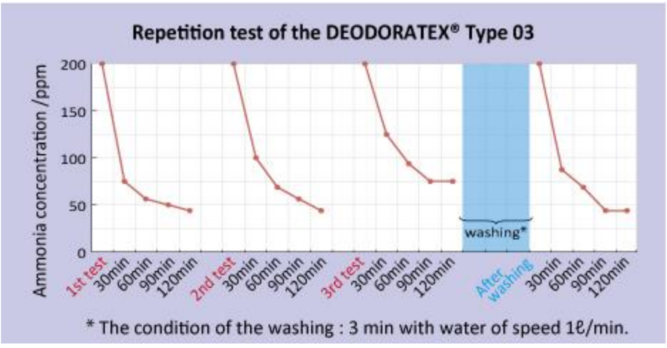

Figure 3.6: Deodoratex Performance with Ammonia (Hiraoka & Co LTD., 2015)

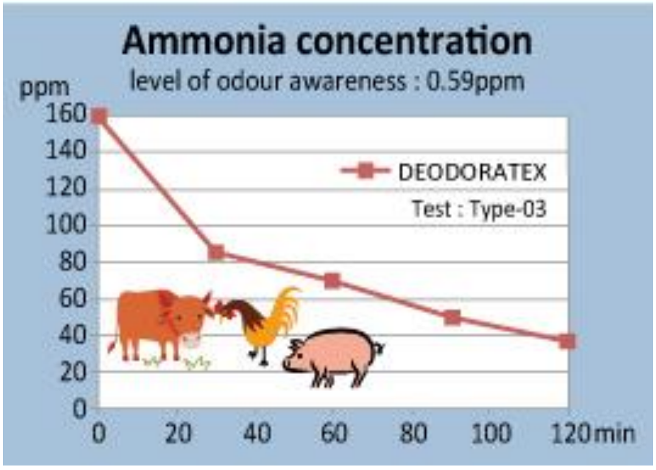

Figure 3.7: Level of Ammonia Concentration with the use of Deodoratex (Hiraoka & Co LTD., 2015)

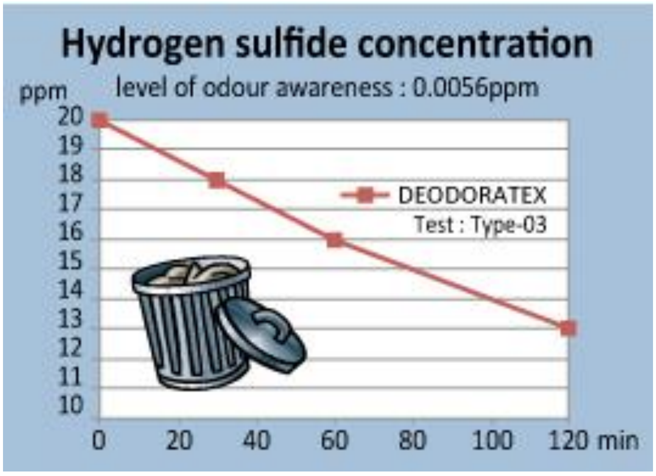

Figure 3.8: Level of Hydrogen Sulphide Concentration with the use of Deodoratex (Hiraoka & Co LTD., 2015)

3.4 Experimental Design

The effectiveness of the Deodoratex in odor control will be investigated in terms of its odor, hydrogen sulfide, and ammonia removal. Three test conditions will be studied; (i) without Deodoratex, (ii) Type 03 Deodoratex and (iii) Type 32 Deodoratex. For all three conditions, testing will be performed for 5 days at the same toilet with all data collected in-situ.

3.4.1 Fabric Installation

A total of 26.80 m^2 fabric for each type is installed in a horizontal orientation in the toilet by attaching it on the plaster ceiling using screws end-to-end. The floor plan of the fabric installation is as shown in Figure 3.14. For each installation, each fabric has extra 50% length from its designed length space as it is set up in a horizontal-wavy orientation. The installation of the fabric in horizontal orientation is based on the technique adopted by Hiraoka & Co LTD (2015) in the animal housing environment and Tex Connex Pty Ltd that can be seen in Figure 3.9 and Figure 3.10.

Figure 3.9: Deodoratex is hung in horizontal orientation in chicken farm (Hiraoka & Co LTD., 2015)

Figure 3.10: Applications include reduction of solvent odours in printing houses (Tex Connex Pty Ltd.)

Figure 3.11: Fabric is installed in a wavy-horizontal orientation in the toilet

Figure 3.12: Fabric is set up on top of showers' and toilets' stalls

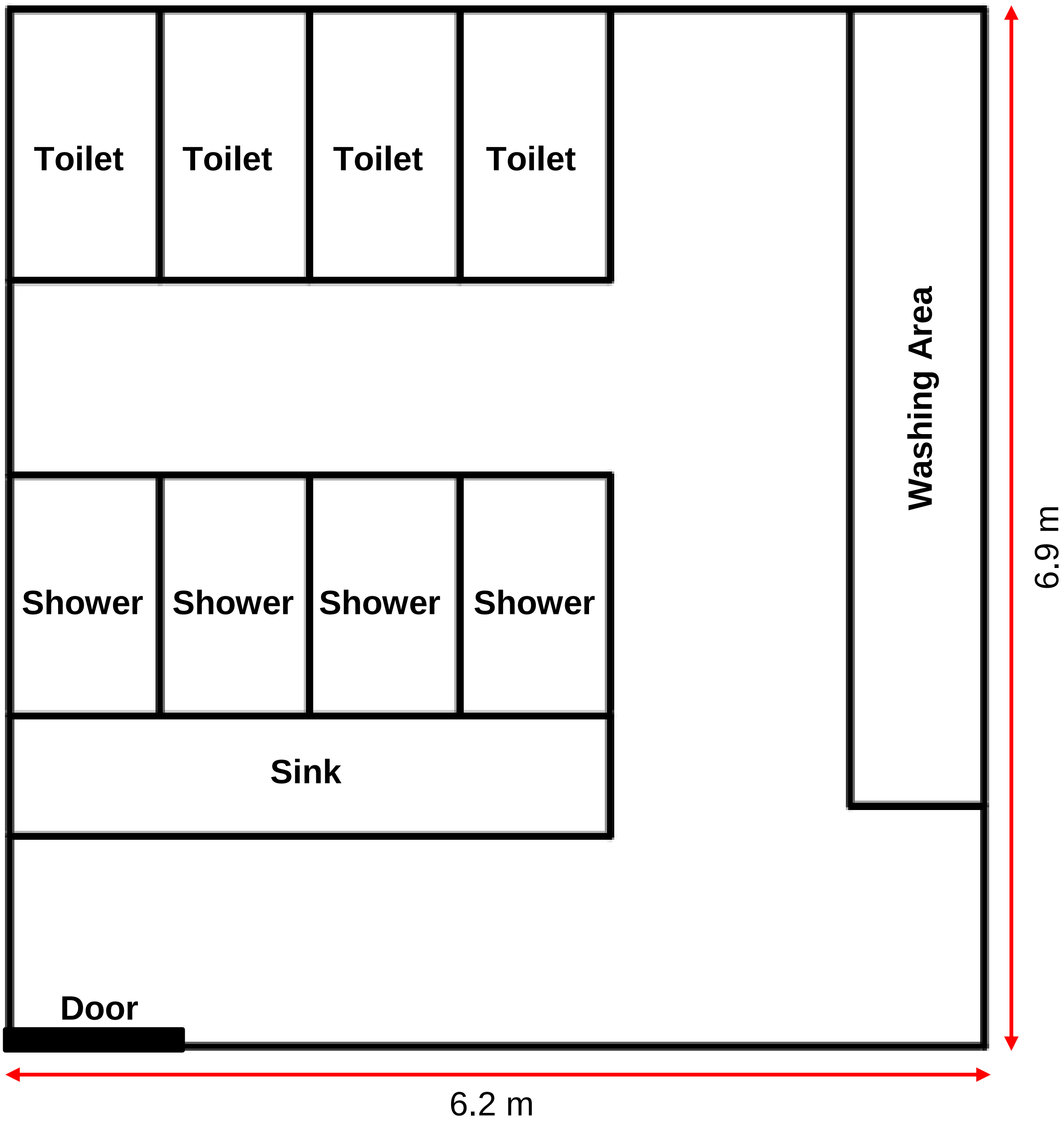

Figure 3.13: Desasiswa Lembaran's toilet floor plan

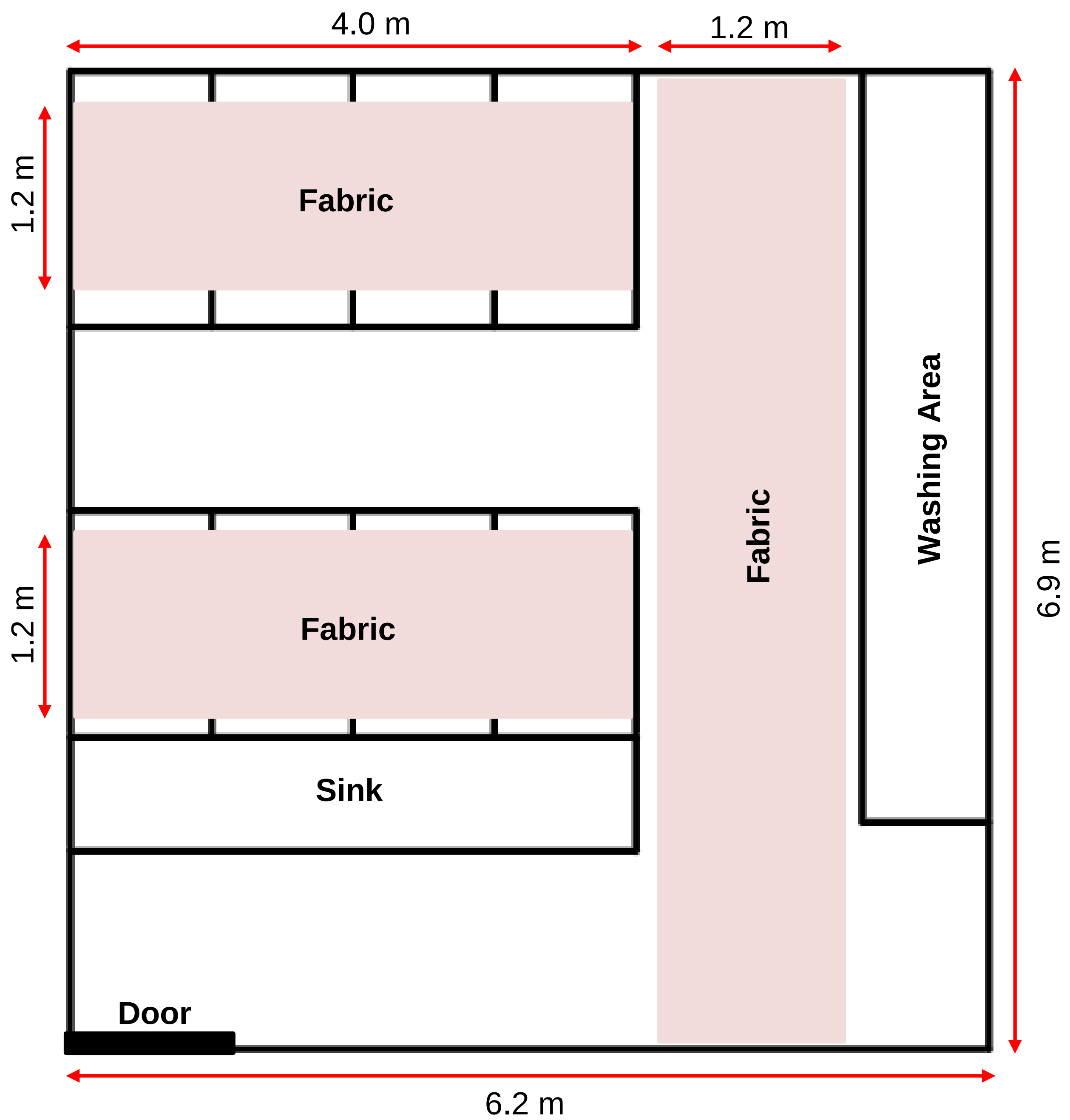

Figure 3.14: Horizontal installation of fabric in the respective toilet location

3.5 Sample and Data Collection

3.5.1 Determination of Odor, Hydrogen Sulfide and Ammonia Concentration

The odor concentration (OU/m^3), hydrogen sulfide and ammonia levels (ppm) was assessed three times a day, around at 9.00 am, 3.00 pm and 9.00 pm. During this time, concurrent observations of the toilet condition and usage e.g. cleaning time, blocked toilets etc. were recorded.

The determination of odor is based on the use of a dilution instrument, called olfactometer, which presents the odor sample diluted with odor-free air at precise ratios, to a panel of human assessors. The odor concentration is numerically equal to the dilution factor necessary to reach the odor threshold, which is the minimum concentration perceived by 50% of the population. Odor concentration is expressed as number of odor unit in a cubic meter of gas at standard conditions (OU/m^3). Figure 3.15 shows the SM100 Infield Olfactometer (Scentroid, Canada) to be used during the odor assessment and the detection limit of the instrument is 3.5 to 16,667 OU.

Figure 3.15 : In-situ odor assessment using Scentroid SM100 olfactometer

The hydrogen sulfide and ammonia level of the toilet were assessed using portable gas sensors OdoTracker TR8 (Scentroid, Canada), as shown in Figure 3.16.

Scentroid OdoTracker is a multisensor device that measures the concentrations of two chemicals in ambient air (or sample bag) at the same time. The following are the ammonia and hydrogen sulfide detection limits, available through a set of OdoTrackers TR8:

Table 3.3 : Detection Limits of Ammonia and Hydrogen Sulfide

Compound	Sensor Type	Highest Detection	Lowest Detection	Resolution
Ammonia	Electrochemical	100 ppm	0 ppm	0.3 ppm
Hydrogen Sulfide (high concentration)	Electrochemical	2000 ppm	1 ppm	1 ppm

Figure 3.16 : OdoTracker TR8 portable gas sensors for the in-situ determination of hydrogen sulfide and ammonia

The collected odor, H_2S and NH_3 data were reported in terms of its trend during the 5 days observation and its removal efficiency upon test completion. The removal efficiency will be calculated using Equation 1.

Removal efficiency (odor, H_2S or NH_3) %