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The Challenges of Implementing Greywater Recycling System in Residential Buildings

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Abstract: The growth of sustainable construction has encouraged construction players to implement green technologies such as water efficiency technology into their projects. Even though Malaysia is not a country that lack of water resources, but water supply problems always been an issue due to water pollution, leakages and others reason. Malaysian's daily freshwater consumption has over the standard set by WHO because they use potable water in gardening, and toilet flushing. This paper aims to identify the challenges and the readiness of Malaysian construction players in implementing greywater recycling systems in residential buildings as well as the strategies that should be used to increase the rate of implementation of this system. By achieving the objectives of this paper, a survey questionnaire been carried out among 91 out of 364 respondents with a 25% response rate in the construction industry such as developers, contractors, and construction authorities' organization. This research found that the agreement of respondents towards challenges and strategies is high while their readiness to implement greywater recycling systems is moderate-high. Respondents agreed that lack of awareness and knowledge is the biggest challenge to implement greywater recycling systems, clients' support readiness is low and construction industry authorities and government should implement strategies in education and certification to increase the implementation rate of these systems in Malaysia residential buildings. In conclusion, this research encourages construction players to understand the challenges and knowledge on greywater recycling systems and give more awareness to increase the implementation rate of these systems in future residential projects in Malaysia.

Keywords: Construction players, Greywater recycling systems, Residential buildings

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1. Introduction

The rapid growth of global urbanization had brought a lot of changes to technologies and economics world and one of the industries that have rapid growth is construction industry. Construction industry sector in Malaysia is the top five of sector that contribute the most to national income (Essay UK, 2019). But, the rapidly growth of urbanization had brought pro and cons to environmental and economic impact such as economic improvement, opening new markets or water pollution. Construction industries had introduced green technologies to reduce or minimize the damage that bring to global environment (Kamar & Hamid, 2012).

One of the main criteria in Green Building Index (GBI) is water efficiency, to fulfil the requirement and implementation of green technologies to achieve as certified green building in Malaysia. Water conservation and efficiency is an important part in supporting the growth of sustainable construction and environmental care. According to the Greywater Reuse Technical Report (2019), 50-70% of residential wastewater are made up from grey water. Although greywater recycling technologies has started use in Malaysia's construction industry, but the implementation of this technologies are still passive due to high implementation cost and ack of knowledge construction players.

This paper will be discussing the background and literature review of implementing greywater recycling systems in Malaysia based on research questions and objectives. Research methodology that carry out in this research is by distributing questionnaire to construction players in Malaysia to determine the challenges, readiness and strategies of implementing greywater recycling systems in residential buildings.

1.1 Research Background

Greywater recycling system is referring to recycling less polluted water such as laundry and toilet except urinals and faeces as it does not contain biological and chemical contaminant where it will make the sewage treatment easier and faster. Greywater recycling technologies are still very new and less implemented in our country due to lack of awareness and knowledge about green technologies. Although Malaysia's water resources are relatively high and adequate but in some rural areas water is still difficult to get to fulfil people life necessity. By implementing greywater recycling technologies could help to minimize the problem of water crisis.

In this research, we will emphasize on the challenges and readiness of construction players towards greywater recycling systems. Others than that, the strategies that could increase the rate of greywater recycling systems will be discussed in this paper too. This is because greywater is not dependent on Nature, where it is more reliable water resources than rainwater. It is environmentally friendly where it can help to reduce the load and requirement of building treatment plant, and could bring effective water purification (Brain *et al*., 2015). The uses of greywater can be divided into two categories which are indoor reuse for toilet flushing and outdoor reuse for irrigation purpose (AU Government, 2013).

1.2 Problem Statement

As a developing country, Malaysia is starting to develop and implementing green technology in construction industry. The growth of implementing green technology such as greywater recycling technology are still respectively slow because there are some barriers such as limited sources and management knowledge that affecting the growing process (Oh *et al.*, 2018). The barrier in implementing green technologies are because green building is not a common building practice in Malaysia where developers' awareness is still respectively low in implementing it (Abidin, 2010).

Malaysia has been rated as one of the highest water user in South East Asia region where Malaysian uses an average of 300 litres of water a day where WHO reported water requirement individually for daily basis is 165 litres (FMT, 2016) According to FOMCA (2010), a survey is conducted among 1792 Malaysian families where 70% of respondents are not likely or not very likely will reduce their water usage to helps the growth of sustainable development in our country and 43% of freshwater usage end up as greywater. As resulted, Malaysian is unaware of water savings and water efficiency as water supply can be obtained easily.

In developing country, where huge segment of the population lacks ability for investing in green housing because largely green buildings prices are unaffordable to an average income family. The cost of implementing green technologies is still respectively high where construction players are afraid to invest on it because the benefits towards them is low (Zahir, 2014).

In oversea studies, Tianxiu Garden Project in Beijing, China had implemented both rainwater harvesting systems and greywater recycling system. The result showed that the cost of implementing greywater recycling system is higher than rainwater harvesting system. But, the greywater recycling system could purify 10000 litres of greywater daily for residential uses and greywater recycling system does not depends on seasonal variation in water volume (Zhang *et al*., 2009). However, Ghisi and Mengotti (2007) found that a greywater system in Brazil was not cost-effective, given the length of the payback period (>17 years). This is because the maintenance cost of greywater recycling plant is high to maintain the quality of greywater reuse to be free of suspended substances (He *et al.*, 2008).

Therefore, based on the statement this research attempt to identify the challenges and the readiness among construction players of greywater water recycling system in residential building.

1.3 Research Questions

Based on the problem statement, the research question for this research are:

(i) What are the challenges of implementing greywater recycling system in Malaysia's residential buildings?

(ii) Are construction players in Malaysia ready for greywater Recycling systems being introduced?

(iii) What are the strategies to increase the implementation of greywater recycling system in Malaysia's residential buildings?

1.4 Research Objectives

Based on the research question. this research will main focus on the following objectives:

(i) To identify the challenges of implementing greywater recycling system in Malaysia's residential buildings

(ii) To investigate the readiness of construction players about implementing greywater recycling system

(iii) To investigate the strategies to increase the implementation of greywater recycling system in Malaysia's residential buildings.

1.5 Scope of the Study

In this research, the focus will be on residential buildings that implemented greywater recycling system in Kuala Lumpur. According to Ismail *et al*., (2011) stated that, 67 % of water consumption in Malaysia is domestic usage where greywater recycling for toilet flushing could help to reduce up 30% of water demand. The application of greywater recycling system could help to minimise water shortage when happening water disruption.

The aiming respondents for this research are construction players such as contractor and developers through quantitative methods by distributing survey questionnaire to guarantee result accuracy and meet with the research objectives. This group of respondents could help us to identify the barriers and readiness of construction players and strategies to increase the implementation rate in Malaysia

1.6 Significance of the Study

This research being carry out is to emphasize the importance of the study of greywater recycling systems towards developers and contractors, construction industry and academics. This research could raise the awareness and knowledge of greywater recycling systems to developer and contractors so that they will implement this system in their future project to achieve sustainable construction. Next, the implementation of greywater recycling system could solve the issue of water disruption by reviewing and made any correction if needed on current sustainable standards for construction industry. This research is important to academic because it can be a reference for other researchers to improve and identify better solutions in implementing greywater recycling system in residential buildings. In the future, researcher hopes this research could be a reference and as an academic support to universities students.

2. Literature Review

This section will be reviewing literatures that related to the challenges that affect the implementation rate of greywater recycling system and the strategies to increase the rate of implementation of greywater recycling system in Malaysia's residential buildings.

2.1 Greywater Recycling Systems

According to Casanova *et al*. (2001), greywater is defined as a household's water wastage that does not included with black water such as faeces and urine. Greywater is including with waste water from washing machine, hand washing, showering and kitchen sink where they can be treated easily onsite and reuse for flushing toilet and gardening uses (Alaziz & Al-Saqer, 2014). However, sometimes kitchen sink wastage is not classified into greywater because it may contain high level of oil and food remainders (Al-Jayyousi, 2003).

(a) Advantages and Disadvantages of Greywater Recycling Systems

Greywater recycling systems has helps green building to achieve water efficiency as it's one of the criteria to achieve as certified green building in Malaysia. However, this technology has brought advantages and disadvantages to construction industry and environmental impact.

Alaziz and Al-sager (2014) documented that the main advantages of greywater recycling are reduce consumption of drinking water, reduce burden and cost on wastewater treatment plant, and reduce household water bills. Misra *et al.* (2010) resulted that using greywater to plant tomatoes, where it potentially could grow greater quantity of tomatoes compared with tap water irrigated plants. Others than that, Racek (2020) documented large amount of greywater produced by household or others residential building maybe increasing in their operating cost for greywater recycling systems but it could also help to save water bills. Matos *et. al* (2012) stated that greywater recycling could enhance environmental situation and increase water saving.

The main disadvantages for implementing greywater recycling systems are high implementation cost, high maintenance cost and risk of environment pollution Alaziz and Al-Sager (2014).Next, Misra and Sivongxay (2009) documented that greywater contain of high amount of chemical such as boron and sodium that could diminished the quality of soil and caused plants grows negatively.

Recycled greywater used in irrigation will be affect the pH value of soil and if the soil pH value goes up to 9 will slow down the transpiration rate of plants and destroying flora and fauna (Eriksson *et al*., 2009)..

2.2 The Challenges of Greywater Recycling Systems

To implement a new water sustainability technology in Malaysia, it requires balancing between environment sustainability with economics viability, politics and construction industry but it is hard to achieve the balancing (Oh *et al*., 2018). But it is hard to achieve the balancing between all of this element because there are few challenges that faced by construction players in implementing greywater recycling systems.

The main challenge of implementing greywater recycling systems is financial contraint which is implementation cost. To design or implementing this technology in an existing building, it requires a lot of works and design to revise the current piping systems and installing cost will be high too due to need to create a new piping system for the existing building (Khatun and Amin, 2011). Arumugam *et al*. (2017) resulted that cost for only a simple greywater filtration system for housing is 1425.63USD where it could be a financial burden to construction players and public to installing it in their houses.

Next, lack of construction players' awareness and knowledge is also one of the challenges. Due to Malaysia does not have a standard for greywater recycling, construction players have no knowledge on treating greywater and eliminating contaminants in greywater to ensure the effectiveness of greywater recycling system (Allen *et al*., 2010). Samari *et al.* (2013) reviewed that developing countries often facing the mutual challenge which is lack of knowledge to implement high-performance green building technologies which lead to construction players have to employ expertise that will lead to increases cost of implementing it.

Legal limitation has consistently been a challenges for upscaling greywater recycling systems (Rescke,2013). In Malaysia, water supply is under authority of state government but the focus of sustainability of construction industries is still under the authorities of Malaysian government (Lim, 2011; Oh *et al*. 2018). Mah *et al*. (2009) documented that approval of implementing greywater recycling system in each state is under control of Malaysian government but Malaysian government is lack of experience in implementing and maintaining greywater recycling system.

Public perception towards greywater recycling system is also a challenge in implementing it because publics think that recycled greywater is unsafe and unhealthy and might harm their health. Allen *et al*. (2010) stated that a study in Spain found that the level of acceptance of greywater in public is because of perceived health risk, perceived cost and environmental awareness. Publics also concerned that tank of storing greywater for recycling purposes might be a habitat for mosquitoes and causes health problems such as Dengue fever (Jeppesen, 1996).

2.3 Readiness of Construction Players in Implementing Greywater Recycling Systems

Readiness can be defined as the ability of an organisation to adopt or implement new ideas, processes or products (Yusof, 2011). According to Ibrahim *et al.* (2013) stated that the readiness of construction players are determined by four (4) dimensions which are optimism, innovativess, discomfort and insecurity. Ibrahim *et al.* (2014) also documeted construction players are ready to implement green housing technology if they could get support from government and mature housing market readiness towards green housing technology.

A study of green building technology in Malaysia resulted that 85% of respondent agreed that the demand and readiness of green building technology is in the low to respectively low level in construction industry (Zainordin *et al*., 2018). In additon, the level of readiness of implementing green development in Malaysia has an average of 88% of developer is in low-medium level of readiness

where the lowest level of readiness indicated by respondent are financial security due to sustainble housing require higher cost of implementation(Gomez and Gordon,2018, Goh *et al.*, 2013). Oteng *et al.* (2020) stated that the readiness of household in implementing greywater recycleing systems in developing is low due to lack of financial support and knowledge about the system.

2.4 Strategies of Implementing Greywater Recycling Systems

The strategies reviewed from literatures showed that to encourage the implementation of greywater recycling, financial intensives and subsidies provided by government and public sector to stakeholders to who installing the systems could increase the rate of implementation (Boyjoo *et al*., 2013).Allen *et al.* (2010) documented that in in Australia the government has introduced $500 for household that purchase and installed new greywater recycling system since year 2009 and it helped to increase the rate of implementation. While in Malaysia, Malaysian government had introduced Green Technology Financing Scheme (GTFS) in 2010 as a loan incentive to attract construction players to investing in green technology in Malaysia construction industry (GTFS, 2018).Next, education and certification play critical role in building public knowledge and support for recycling systems. Samari *et al*. (2013) documented that efficient way to eliminate the challenges of implementing greywater recycling system is to launch factual information and long term studies about the benefits of green building. In addition, Green Building certifier could motivate construction players by awarding green certification and recognition where these could enhance construction players' public images and competitiveness in industry and proving they have achieved the environmental standards and performance (Afandi and Abidin, 2013).

Lastly, standard and regulations could encourage the rate to implementing greywater recycling systems because it can be a guideline for constructions players when installing the system. Oh *et al.* (2018) stated that a fixed design of a greywater recycling system for different size of housing could be guideline and details of water quality to ensure the design having appropriate and efficiency treatment method for greywater. Next, Domenech and Sauri (2010) reviewed that greywater recycling systems in Spain are used widely in Spain due to Spain government command all new buildings must install the systems. WHO had proposed guidelines of water recycling for partially filtered could only be adopted in specific uses that minimise the contact of greywater with human body and health (Dixon *et al*., 2007).

3. Research Methodology

This research uses quantitative research design where researcher distributed survey questionnaire through google form for the data collection. Data collection in this research used primary data and secondary data. The primary data from this research achieved from questionnaire distribution via online platform such as google form while collecting secondary data from journals, articles and other related resources to ease the writing in literature review and analysis report as a factual and theoretical support in validity of primary data and reliability of this research.

3.1 Sampling Methods

The sampling methods that will be adopted in this research is random sampling on developers and construction firms that involved in Klang Valley development. Klang Valley being choose as the research location is because it is the largest city in Malaysia and has the largest amount of green buildings located in it. The population of this research will made up from G5-G7 contractors, developer firms and construction authorities in Klang Valley. According to CIDB (2015), it recommends contractor G5-G7 to implement green technologies because these contractors has financial strength, mind-set and willingness to implement it. According to Krejcie and Morgan (1970), in this research the registered G5-G7 contractors under CIDB in Klang Valley over 7000, so

for the sample size for this research need to have 364 respondents to represent the whole contractors in Klang Valley

3.2 Research Process

Researcher has designed an appropriate research process for this research to find the solution based on research questions (shown in Figure 1)

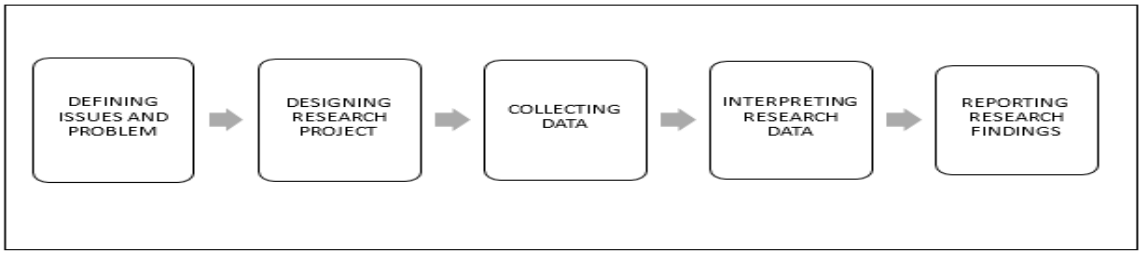

Figure 1: The 5 steps in research process

The 5 steps of this research process which are defining issue and problem, designing research projects, collecting data, interpreting research data and reporting research findings. In step 1, researcher will produce research titles, objectives and problem statement after topic discussion. Next, researchers will be doing literature review by reading, citing and collecting primary data that relevant to research title from others authors. In data collection steps, there are 2 types of data been collected in this research which are primary data and secondary data. Then, researcher will be distributing questionnaire to construction players in Klang Valley for data collection that meet with research objectives. After data collection, the data is analysed and interpreted into technical writing where it is easy to understand and achieve research objectives. Lastly, conclusion and recommendation will be made to improve and solve topic's issue to achieve a successful research.

3.3 Data Analysis

The data collected from quantitative methods had been analysed and presented using the SPSS version 25 for demographic and questionnaire analysis while Microsoft Words is used as the software to analyse data in words and table. In order to answer the research questions and objective, descriptive analysis is requiring in this research to compare to with other recent findings in Malaysia.

4. Results and Discussion

Researcher had designed a questionnaire that consist of four (4) section which is Section A: demographic data, Section B: Challenges Related Questions, Section C; Readiness related questions and Sections D: strategies related questions on greywater recycling systems that is related to implementation of greywater recycling systems in Malaysia's residential buildings. In section A, researcher will be using frequency analysis to determine the frequency of respondents. While in Section B, C, and D, researcher will be using descriptive analysis which analyse the mean score of each statement in questionnaire. Wahab *et. al*. (2013) stated that the level of respondents' agreement on questionnaire is tested by using Jamil Mean Score (see Table 1).

Table 1: Jamil Mean Score (Source: Wahab *et. al*., 2013)

Mean Score	Mean Score Interpretation
3.67-5.00	High
2.34-3.66	Moderate
1.00-2.33	Low

4.1 Discussion

Researcher had used Cronbach's Alpha to test the multiple choices question such as Likert Scale survey in questionnaire section B, section C and section D to determine if the questionnaire is reliable. As shown in Table 2, the Cronbach's Alpha that obtained in all three sections is acceptable as its already exceed Alpha=0.70 (Shemwell *et. al.,* 2015). Therefore, all the questions in survey questionnaire is acceptable and levels of reliability are satisfactory because they fall in the range of higher than 0.70. The data in this research is valid and reliable.

Table 2: Cronbach's Alpha Value of each objectives

Number of item	Study Variable	Cronbach's Alpha	Remarks
17	Section B: Challenges related questions	0.874	Good
11	Section C: Readiness related questions	0.841	Good
11	Section D: Strategies related questions	0.888	Good

(a) Frequency Analysis on Demographic Data

A total sample size in the research is 364 respondents while the response rate is only 25% of the total sample size. According to Ananth (2016), the acceptable response rate for questionnaire that distributed through electronic methods such as email and online survey form is between 25% to 30%. The 91 respondents (25%) is being analysed and tested for the research to ensure the researched questions is solved. Frequency analysis is used to determine the demographic data of respondents which include current job position, company types and also year of experience in Malaysia construction industry. The highest distribution of job position of respondents is project manager with 20 persons or 22% and contract manager is the least distribution which only made up of 7 persons or 7.7% in term of job position of respondent. There are 15 respondents that responded their job position as others which include GBI Facilitator, director of company, site supervisor, procurement executive and mechanical specialist. Next, the highest distribution of respondents' company type is contractor firm (G5-G7) with 31 persons or 34.1%. The least distribution of respondents' working industry is government agency with only 5 persons (5.5%). There is 7 respondent who responded their company types as others which it included private sector, water utility provider and also university. Last but not least, most of the respondents having 6-10 years of experience in Malaysia construction industry which consist of 31 persons or 34.1% while the respondents with more than 15 years of experience is the least with only 10 persons (11%) which showed that the data is valid where respondents having experience and given their opinions in current construction industry. In sum, the summary of frequency analysis is shown in Table 3.

Table 3: Demographic Characteristics of Respondent

Demographic		Frequency	Percentage
Job Position	Project Manager	20	22
	Quantity Surveyor	19	20.9
	Engineer	18	19.8
	Architect	12	13.2
	Contract Manager	7	7.7
	Others	15	16.4
Company Types	Contractor (G5-G7)	31	34.1
	Consultant Company	28	30.8
	Developer	14	15.4
	Sub-contractor	6	6.6
	Government Agency	5	5.5
	Others	7	7.7
Years of Experience	6-10 years	36	39.6
	1-5 years	34	37.4
	11-15 years	11	12.1
	> 15 years	10	11

(b) The Challenges in Implementation Greywater Recycling Systems In Malaysia's Residential Buildings

The highest rank among the four (4) categories of challenges is construction players awareness and knowledge. It had obtained 4.10 on its average mean score which is higher than others three (3) category of challenges. Respondents agreed that Malaysia construction industry is lack of expertise and knowledge in greywater recycling system which respectively obtained 4.21 and 4.12 mean score. According to Oh et. al. (2017), the limitation on available study case on greywater recycling system in Malaysia may lead to improper evaluation on greywater recycling information being introduced to construction players. In this challenge category, construction players least agreed on they refuse to change from traditional methods with mean score 4.02. By this we could assume that it is a positive scenario as some of the respondents are ready to adopt green building technologies.

Furthermore, policies and regulations is also one of the challenges that construction players are facing in implementation of water recycling system. The overall mean score for this category of challenges is 4.08 which showed high respondents' agreement on the statements in questionnaire. Respondents most strongly agree on the statement of Malaysia government still lack of information and experience in implementing greywater recycling systems which obtained 4.20 mean score. Mah *et al*. (2009) stated that Malaysian ministry ever refuse to approve implementing greywater recycling systems where we are still lack of experience in managing and maintaining the standard of recycled greywater. Others than that, unclear government policies on sustainable construction is second highly rated challenges by respondents. According to Goh *et al*. (2013), constructions players refuse to adopt sustainable construction due to government policies keep changing from them to time which causes them confusion and does not want to take the risk on their business.

Financial constraint being in third rank among four categories of challenges with mean score 3.98. As compared to the higher-ranking position, financial constraint related challenges is falls on lower high interpretation in Jamil Mean Score because it is still in between of 3.0-4.0 mean score. Respondents responded that the statement of imported materials costs on greywater recycling systems is higher than normal water systems as the most challenges obstacle among 4 statements in the same category with mean score 4.08 which is higher than average mean score. In Malaysia, the previous studies on greywater recycling systems are mostly proposing greywater recycling systems models to minimise the cost of materials and cost of implementation as Malaysia still does not have greywater recycling systems supplier. However, according to Juan et. al. (2016) the cost of materials for implementing greywater recycling systems is 50% higher than normal water systems which will giving financial pressure to construction players for implementing it.

Based on Table 4, the last challenges in rank among others is public concern by obtaining mean score 3.95. Public is lack of knowledge and awareness on water savings and recycled water and it may cause the slow progress of implementing greywater recycling systems in Malaysia. IWA (2012) stated that low water cost countries such as Malaysia, the publics of these countries does not have high perspective on how important water saving and greywater recycling is which lead to worsening water problems and may face limited potable water in the future. There is one statement in public concerns related challenges falls on "moderate" in level of agreement which means that respondents are neutral towards the statement as a challenge that they are facing. Respondents pointed that they are moderate towards public's concern about greywater recycling systems may harm soil fertility and soil illness. Constructions players need to undergo environmental risk assessment before implementing sustainable constructions to ensure the recycled greywater will not cause any environmental issue (Chen et. al., 2012).

Table 4: The Mean Score Interpretation of the Challenges in Implementation Greywater Recycling Systems in Malaysia's Residential Buildings

No.	Statement	Mean	Level of Agreement	Ranking
A)	Financial Constraint	3.98	High	3
1	The implementation costs on greywater recycling systems is high	3.85	High	4
2	The imported materials costs on greywater recycling systems is higher than normal water systems.	4.08	High	1
3	The payback period of installing greywater recycling systems is long	3.98	High	3
4	Lack of water recycling incentives.	3.99	High	2
B)	Construction Player awareness and Knowledge	4.10	High	1
1	Construction players are resistance to change from their traditional practices.	4.02	High	5
2	Construction players are lack of the knowledge on greywater recycling technologies	4.12	High	2
3	Workers' unaware of the correct methods and procedures	4.09	High	3
4	Workers are lack of information and benefits on greywater recycling systems	4.04	High	4
5	Malaysia's construction industry is lack of expertise in greywater recycling systems	4.21	High	1
C)	Regulation and Policies	4.08	High	2
1	Malaysia do not have a specific standard on greywater recycling system.	4.00	High	4
2	Water management of each state is under different authority that causes confusion.	4.02	High	3
3	Malaysia government still lack of information and experience in implementing greywater recycling system.	4.20	High	1
4	Unclear of government policy on sustainable construction.	4.10	High	2
D)	Public Concern	3.95	High	4
1	Limited uses of recycled water in Malaysia's residential buildings.	3.88	High	3
2	Public are lack of knowledge and awareness on water saving and recycled water	4.14	High	1
3	Public concern that grey recycled water may harm soil fertility and cause soil illness	3.64	Moderate	4
4	Public concern that drinking recycled greywater will harm their health	4.12	High	2
	Overall Mean Score	4.03	High	

(c) The Readiness of Construction Players to implement Greywater Recycling Systems in Malaysia' Residential Buildings

Table 5 presents the result of questionnaire related to readiness aspect in implementing greywater recycling systems in Malaysia's residential buildings. In overall, the average mean score is 3.43 which falls on level of readiness among construction players towards implementing greywater recycling system in Malaysia's residential buildings is "moderate"

The regulation and policies is the highest rank for readiness of construction players where they are ready to implement greywater recycling systems when Malaysia's having a green development policies. There is a statement in readiness of policies and regulations scored a moderate-high level of readiness which obtained 3.65 mean score. The statement is regarding about construction players is ready to pay commitment on training their staff for green development in greywater recycling systems. This showed a positive scenario in implementing as greywater recycling systems as construction players are willing to learn about the knowledge of greywater recycling systems. From the result of 91 respondents, they are moderate in readiness to embrace green home developments in Malaysia. According to Nordin et. al. (2017), even though construction players are getting helps in term of finance however the higher rate of green certification requires higher cost where construction players need to pay more risk on the project. This may be the reason of why construction players is not so ready to embrace green home development in Malaysia.

Secondly, market readiness towards implementing greywater recycling systems is also moderate with overall 3.42 mean score among 4 statements in the category. The result showed that highest rank among four statements in market readiness is construction market is ready to provide more information to form a clear opinion about greywater recycling systems with high-moderate 3.51 mean score. Said *et al*. (2009) emphasize that education is very important to green home development as Malaysian is still not aware about the environmental issue which causes they are having low awareness and knowledge about greywater recycling systems and not ready to adopt this kind of lifestyle in them. In addition, the statement of construction market is ready to import greywater recycling material in Malaysia scored the lowest mean which representing Malaysia's construction players is not ready to import greywater recycling systems. According to Tey et. al (2014), green home materials such as greywater recycling systems is hard to achieve in local market where construction players need to import the technologies from overseas which will increase their total project cost and decrease their total revenue.

Clients' support readiness was found to be the least readiness of construction players in implementing greywater recycling systems in Malaysia which interpreted as moderate readiness with 3.31 mean score. Based on the table resulted that construction players have the highest readiness of clients' support in clients' having green home designing could provide better information with 3.46 mean score. Green home developments is widely introduced in Malaysia in this few years, and some of the developers had embrace this development. Clients' with experience in green home development could help contractors to minimise their cost in professional fees as clients could provide consultation for them during implementing green technologies (Nordin et. al, 2017). The least readiness in client support readiness category is clients has knowledge of greywater recycling systems where it is also the lowest readiness among overall all statements in section C of questionnaire. Aliagha et. al. (2013) mentioned that sustainable construction in Malaysia is till in the early stage where construction players is still lack of knowledge and expertise among them and majority of site workers has no knowledge on sustainable development which causes them does not want to study about latest green technologies (e.g greywater recycling systems). to increase their project costing.

Table 5: The Mean Score Interpretation related to the Readiness of Construction Players to implement Greywater Recycling Systems in Malaysia' Residential Buildings

No.	Statement	Mean	Level of Agreement	Ranking
A)	Market Readiness	3.42	Moderate	2
1	Construction market is ready to import greywater recycling system material to Malaysia	3.27	Moderate	4
2	Construction market is ready to invest greywater recycling systems in Malaysia.	3.45	Moderate	3

3	Construction market should is ready to provide more information to form a clear opinion about greywater recycling system/.	3.51	Moderate	1
4	Construction market is ready to adopt greywater recycling systems in residential project	3.46	Moderate	2
B)	Client Support Readiness	3.31	Moderate	3
1	Clients' has knowledge on greywater recycling systems	3.16	Moderate	4
2	Clients' has experience on implementing green home projects.	3.42	Moderate	2
3	Clients' has high commitment in providing financial support in implementing greywater recycling systems in residential project.	3.25	Moderate	3
4	Clients has knowledge on green homes designing to provide better information.	3.43	Moderate	1
C)	Regulation and Policies	3.57	Moderate	1
1	My company is ready to embrace green homes development (e.g implementing greywater recycling systems) because the viability of projects make it easier to the company to secure loans from the financial institutions	3.54	Moderate	3
2	My company is ready to embrace green homes development (e.g implementing greywater recycling systems) because the government has promised to guarantee 60% of the financing under the Green Technology Financing Scheme (GTFS)	3.53	Moderate	2
3	My company is ready to pay commitment to train staff for green development in greywater recycling systems	3.65	Moderate	1
	Overall Mean Score:	3.43	Moderate	

(d) The Strategies of Increase the Implementation Rate Of Greywater Recycling Systems In Residential Building.

Based on the Table 6, there are 3 main strategies of increase the implementation rate of greywater recycling systems in residential building. They are financial incentives and subsidies related strategies, standard and regulation related strategies and education and certification related strategies. Within 91 respondent perspectives, most of the strategies were agreed and have high interpretation. The analysis shows that overall mean value is 4.01 among all the strategies.

Education and certification related strategies have recorded the highest mean value of 4.11 and ranked first among the 3 strategies. The interpretation is high as most of the respondents agree with the statements which mentioned education and certification is very important. In addition, one of the major factor that influences the success of greywater recycling in Malaysia would be the public acceptance of greywater reuse (Boyjoo *et al*., 2013). Then, the authorities should play their responsibility in educating the public and also the developers. Hence, the local society and government agencies should build up public awareness on the urgent issue of saving water and promote the benefits of reusing greywater to the Malaysian public (Harding, 2006). For example,

construction authorities such as PAM and CIDB shall introduce more publicity regarding about water recycling systems through media (e.g. print media, internet, and radio and television programs).

The second strategy which are less important is standard and regulation related strategies. The mean score is about 4.02 and the interpretation is high. There are several obstacles that limit the implementation of greywater recycling and reuse systems in Malaysia. Legal constraints have always been a challenge when upscaling greywater reuse systems (Reschke, 2013). The respondents believe that the authorities can increase the implementation rate of Greywater Recycling systems by proposing new standard and regulation. For example, government shall have proposed guideline on the specific use of recycled greywater in household.

The last strategy that the respondents think the less important is Financial Incentives and subsidies related strategies. The public will concern on reusing greywater would be the financial considerations (Prathapar *et al*., 2005). However, the interpretation is high and the mean score is 3.91. In financial and incentives and subsidies related strategies, due to high costing of the implementation for this technology, Government should imply the new scheme to support the implementation of greywater recycling. For example, to encourage the implementation of greywater recycling, subsidies or rebates could be provided by the government and public sector to stakeholders who install greywater recycling systems (Boyjoo *et al*., 2013; Hophmayer-Tokich, 2006).

Table 6: The Mean Score Interpretation related to the Strategies of Increase the Implementation Rate of Greywater Recycling Systems in Residential Building

No.	Statement	Mean	Level of Agreement	Ranking
A)	Financial Incentives and Subsidies Related Strategies	3.91	High	3
1	Government provide tax incentives for greywater recycling systems adopters	3.92	High	2
2	Government corporate with bank to provide low interest loans for greywater recycling system adopters.	3.81	High	3
3	Government provide discount and rebate on green residential project development application fees.	3.99	High	1
B).	Standard and Regulation Related strategies	4.02	High	2
1	Construction authorities such as PAM and CIDB to introduce an implementation standard and guideline on installing greywater recycling systems.	3.88	High	4
2	Greywater recycling systems adopter shall have minimum knowledge require on the systems.	4.04	High	2
3	Government shall proposed guideline on the specific use of recycled greywater in household.	4.16	High	1
4	Government shall include greywater recycling systems in Green Building Technology Road Map	4.01	High	3
C).	Education and certification related strategies	4.11	High	1
1	Public environment awareness creation through workshops, seminars, and conferences from time to time.	4.03	High	4

2	Construction authorities such as PAM and CIDB shall introduce more publicity regarding about water recycling systems through media (e.g. print media, internet, and radio and television programs)	4.18	High	1
3	Technology expertise shall offer educational programs for developers, contractors, and policy makers related to greywater recycling systems.	4.15	High	2
4	Researchers on construction industry shall strengthen research and communications on greywater recycling systems.	4.09	High	3
	Overall Mean Value	4.01	High	

5. Conclusion

A total of 91 out of 364 Klang Valley's respondents had completed the questionnaire which representing 25% of response rate of this research. All of the respondents are expertise in Malaysia construction industry which included project manager, architect, engineer and etc. so that their opinion on implementing greywater recycling systems in Malaysia's residential buildings would be valid. Researcher had undergone reliability analysis (Cronbach's Alpha) on the questionnaire where it tested with an average alpha=0.87 which higher than alpha=0.70 to prove that the data is valid and reliable.

This research indicates that the biggest challenges in implementing greywater recycling systems in Malaysia residential buildings is construction players lack of awareness and knowledge. Sustainable construction is still new to Malaysia and does not have a lot of expertise in this area had encourage the slowdown the implementation rate of greywater recycling systems in Malaysia. The others three challenges which are regulation and policies challenges, financial constraints, and public concerns challenges also result to be in high level of agreement from respondents towards the challenges that they are facing. The results of this result also show that the readiness of construction players towards implementing greywater recycling systems in Malaysia's residential buildings is fall in the range of "moderate-high". It shows that respondents agreed in they are ready to implement green home development and paying commitment in staff training if they have been given policies benefits. Respondents pointed out that clients' support readiness is low due to customers has no knowledge on greywater recycling systems. In addition, local market is not ready yet to import greywater recycling systems in Malaysia as its cost is higher than normal water systems and investment payback takes up long period. Malaysia government shall implement strategies not only on promoting sustainable construction but study detailly about element of sustainable construction to increase awareness and knowledge of construction players and publics on the importance of sustainable construction in the present and future.

Furthermore, researcher faced some limitation during conducting this research which is low response rate. Researcher could only send questionnaire to respondent through google form via email due to pandemic which had restricted researcher to handling questionnaire directly to targeted respondent. Others than that, the time limitation is also the limitation that researcher faced. As distributing survey questionnaire through email which causes a lot of email remain unread by targeted respondents. This causes researcher required longer time to follow up with targeted respondents and request them to respond to the survey questionnaire. In addition, this research only take place in

Klang Valley where researcher suggest the future study could take place in all round Malaysia so that having larger population can get a higher validity of research data.

This research had contributed knowledge and awareness on greywater recycling systems towards construction players in Malaysia for them to understand the challenges and strategies so that they could increase the implementation of this systems in Malaysia residential buildings. Researchers recommend extending this research in the future by studying more possible challenges and strategies of implementing greywater recycling systems in residential buildings to achieve water efficiency in Malaysia.

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