REUSE OF SEWAGE TREATMENT PLANT EFFLUENT AND DOMESTIC WASTEWATER AS A SUSTAINABLE ALTERNATIVE WATER SUPPLY FOR LANDSCAPE IRRIGATION USING DRIP IRRIGATION SYSTEM

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ABSTRACT

The main purpose of this study was to reuse of sewage treatment plants effluent and domestic wastewater as a sustainable water supply to landscape irrigation using drip irrigation. Generally, reuse of freshwater consumption is devoted to agricultural activities that caused critical water demand. Wastewater reuse can provide an alternative solution to these problems by supplying the water and nutrients needed for landscape irrigation. Nitrogen, phosphorus and potassium are the major nutrients for plant growth, thus, the sewage treatment plants effluent and domestic wastewater are sustainable to be used as an alternative water supply for landscape irrigation as all of these nutrients can also be found in these two alternatives. However, the safe use of wastewater for irrigation purpose should be determined. Therefore, a test was done in environmental laboratory in order to test the water quality of sewage treatment plant effluent, domestic wastewater and tap water. Besides, this study also was done to determine the effectiveness of using these types of wastewater in contributing in the plant growth. In an effort to test it effectiveness, the wastewater was irrigated to three gardens which were planted with the same types of plant in the same quantity where garden A was irrigated with tap water, garden B irrigated with domestic wastewater while garden C was irrigated with sewage treatment plant effluent. The plants used in this study are '*Corrilair Yellow*', '*Ixora*', '*Licuala Grandis*', *Loropetalum*' and '*Spider Lily*' which are measured based on their overall height, canopy opening, leaves size and leaves height. The drip irrigation was used to irrigate the water supply to each garden as it is the most effective way to reduce water consumption and the pollutants that will be produced. Sewage treatment plants, domestic wastewater and tap water are safe to be used for landscape irrigation based on the results shown by the growths of the plant. Moreover, all the plants that were planted in garden C shown a more blooming growth compared to garden A and garden B.

ABSTRAK

Tujuan utama kajian ini adalah untuk menguji samada air daripada loji rawatan kumbahan dan juga air sisa domestik adalah sesuai digunakan untuk tanaman landskap atau sebaliknya. Penggunaan air bersih untuk tanaman menyebabkan permasalahan air bersih yang serius. Penggunaan semula air terbuang ini adalah salah satu penyelesaian kepada permasalahan ini kerana, air terbuang ini akan membekalkan nutrisi kepada tumbuhan. Nitrogen, fosforus dan kalium merupakan kandungan asas untuk pertumbuhan tumbuhan landskap. Oleh itu, air daripada loji rawatan kumbahan dan air sisa domestic adalah sesuai digunakan sebagai salah satu cara penyiraman air kepada tumbuhan landskap. Walaubagaimanapun, kesesuaian penggunaan air terbuang ini dari segi kesan buruk penggunaanya perlu diambil kira. Kajian telah dijalankan di makmal untuk menguji kualiti air daripada loji rawatan kumbahan, air sisa domestik dan air paip . Dalam usaha untuk menentukan keberkesananya, air terbuang ini akan diairi sebagai air siraman terhadap tiga tapak tanaman dengan pokok yang sama species dan dlama kuantiti yang sama di mana, tapa tanaman A diari dengan air paip, tapak tanaman B diari dengan air sisa domestic dan tanaman C diairi dengan air daripada loji raatan kumbahan. Selain itu, pokok-pokok yang digunakan dalam projek ini ialah '*Corrilair Yellow'*, *Licuala Grandis, Ixora*, *Lolopetalum* and *Spider Lily*. Semua pokok ini akan diukur dan diambil bacaan berdasarkan ketinggian keseluruhan pokok, lebar pembukaan poko, lebar daun dan ketinggian daun. Kajian ini juga mengguankan kaedah penyiraman secara titisan dala system guna semula air yang merupakan cara paling selamat, paling kurang pencemaran dan menjimatkan air. Berdasarkan keputusan yang diperolehi, didapati air daripada loji rawatan kumbahan adalah paling sesuai digunakan untuk tanaman landskap berdasarkan kepada kesuburan pokok.Tambahan lagi, pokok-pokok yang ditanam di tapak tanaman C menunjukkan pertumbuhan paling subur berbanding tapak tanaman B dan tapak tanaman A.

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CHAPTER 1

INTRODUCTION

1.1 General

We are now entering an era where abundant of clean freshwater is no longer guaranteed. In many part of the world, water is one of the most significant challenges to human health and environmental integrity. We know that, every year increasing on the world population grows so, water demand increase and multiply without the possibility for an increase in supply. Increasing with population grows; mean that increasing with useful of freshwater. So the useful of freshwater need to limited. Wastewater reuse is one such strategy, and its usefulness to fulfill non-portable water needs should be thoroughly investigated.

In 1995, over 65 percent of the total global water withdrawal for human uses was for irrigation which includes both agricultural and nonresidential landscape applications. Depending on the technology and management, consumptive use associated with irrigation can range from 30 to 90 percent of the total water withdrawn.

In many developing countries, particularly those where there is a water shortage, access to fresh water for irrigation is limited and instead both treated and untreated wastewater is used. Wastewater is important health implications when used improperly, has huge potential as a source of water. Even when untreated, there is a growing body of evidence that proves that farmers will use wastewater to increase their crop yields and lower their water costs.

1.2 Problem Statement

Globally, over 70% of freshwater consumption is devoted to agricultural activities (FAO 2008). Wastewater treatment and reuse at the individual level can provide a combined solution to these problems by supplying the water and nutrients needed for household food production. Indeed, this strategic is already in use by millions of farmers worldwide and it is estimated that 10% of the world's population consumes foods irrigated with wastewater. Wastewater treatment and reuse for irrigation may well hold the key to easing demand on limited of freshwater reserves while improving the food or plants production capacity of households and farms.

We know that, all the activities like agriculture; industry activities growing plant either hobby or as a means to reinforce food security are heavily dependent on a cheap and abundant freshwater supply. As water levels drop and pollution increases, prices are rising and efficient use of water is becoming more important to business, farmers and homeowners alike. So, interest in wastewater reuse technologies is growing rapidly.

The problem is about the safety of wastewater reuse for irrigation purposes. The key issue involved is the potential for damaging effects of poor-quality water on soil, plants and humans. The microbial population of untreated water is very diverse and dangerous organisms can be present. Microorganisms that can cause illness or disease, collectively known as pathogens, are usually associated with human or animal fecal matter present in wastewater and surface water sources. Irrigation water contaminated with pathogens has often been blamed for outbreaks of forborne illness. So, it is important to carefully manage the risk when promoting the reuse of non-portable water sources to fulfill water demand of agricultural irrigation activities.

However, there is a need to us to reuse wastewater for multiply purpose either treated or untreated to reduce the total usage of fresh water. In this case, we propose domestic wastewater reuse as alternative water supply for landscape irrigation.

1.3 Objective

The objectives of study are:

i) To test the water quality of sewage treatment plant and domestic wastewater.

ii) To determine the effectiveness of using sewage treatment plant and untreated domestic wastewater as water reuse for landscape irrigation.

iii) To compare the performance of plants using sewage treatment plant, untreated domestic wastewater and tab water

1.4 Scope of Study

The sample of water used for the testing would be taken from sewage treatment plant at KK2, untreated domestic wastewater at KK3, and tab water. Comparison of water quality would be done among the 10 water sample. The sample will be taken from site at University Malaysia Pahang (UMP) and the sample of tab water at UMP.

1.5 Significant of Study

The research is to provide a feasibility study of landscape irrigation using sewage treatment plant and untreated domestic wastewater so that it can be widely used later as it is to minimize the usage of water for irrigation to solve fresh water source crisis in year to come. Besides that, it also to make sure the wastewater instead of letting it to become a source of pollution. So this research will be a contribution to the wastewater reuse technology in our country that will be essential for years to come.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Wastewater

Wastewater is the water that comes into contact with any of a variety of contaminants and is not fit for human consumption. Wastewater also is water that has come into contact with any of a variety of contaminants and is not fit for human consumption. It has variety types of wastewater such as domestic wastewater, industrial wastewater, and municipal wastewater and so on. This kind of wastewater has different of water quality. The domestic wastewater is wastewater from household. The industrial wastewater means process and non-process wastewater from manufacturing, commercial, mining and civil cultural activities including runoff and leachate from areas that receive pollutants associated with industrial or processing. Then the municipal wastewater mean that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources.

2.2 Wastewater Reuse for Landscape

Landscape or agricultural irrigation is the major application of water reuse. Wastewater reuse is an attractive alternative with good potential to supplement freshwater supplies. Wastewater reuse of untreated wastewater in agriculture knows to cause an excess transmission of certain excreta- related disease. So, it can give bad impact to environment and public health. Reuse of untreated wastewater in agriculture is a reality in much of the world, especially in areas where poverty restricts farmers that access to freshwater and fertilizer suppliers. For this reason, much attention has been given to the health and environmental implications of raw and treated wastewater reuse in agricultural irrigation (Rosas, I., 1984).That why, using treated wastewater for landscape irrigation is a very sensible thing to do. However, it must not cause any excess transmission of excreta-related disease, and therefore the wastewater need to treat to an appropriate microbiological quality.

2.3 Literatures on Wastewater Reuse

2.3.1 Wastewater Reuse in Canada

Canadians are the second largest per capita consumers of freshwater in the world, surpassed only by its neighbors to the south it is estimated that each Canadian consumes an average of 335 liters of fresh, treated water every day This number is especially egregious when compare it to 140L/person/day in Europe, or under 40L/person/day in parts of Africa and Asia. The consumption rate of Canadian households increases considerably in summer, when garden irrigation accounts for a large part of our water debit. Most Canadian homes incorporate at least a small yard or flower patch, and consume thousands of liters of 3 water each week to keep them green. An increasing number of Canadians are also engaged in urban agriculture activities, growing food plants either as a hobby or as a means to reinforce food security. All of these activities are heavily dependent on a cheap and abundant freshwater supply. Today there are signs that Canadians' historically privileged access to fresh water may be changing. As water levels in Canadian waterways drop and pollution increases, prices are rising and efficient use of water is becoming more important to businesses, farmers and homeowners alike. As a result, interest in wastewater reuse technologies is growing rapidly.

2.3.2 Wastewater Reuse in Australia

Over 30% of the total potable water supplied to homes in metropolitan cities such as Sydney is used for irrigation of gardens and lawns around homes (Maheshwari, 2010). Such as, the reuse of domestic wastewater for irrigation around homes offers an excellent opportunity to save potable water supplies. The domestic wastewater reuse practice is becoming increasingly common in many households around the country with more than half of all Australian households reusing domestic wastewater in some form. However, to provide effective support to homeowners who want to reuse domestic wastewater, we need to understand people's views on water issues, their motivation for the reuse, impactsof reuse on soil, plant and human health in the long term and factor that affect the adoption of widespread reuse practices.

2.3.3 Wastewater Reuse in California

Figure 2.1 show reuse wastewater for the landscape irrigation which has been practiced in California since 1890s which more than0.899 Mm3/d of wastewater (7-8% of the production) were being used for the applications indicated in the figure below.(California State Water Resources Control Board, 1990).

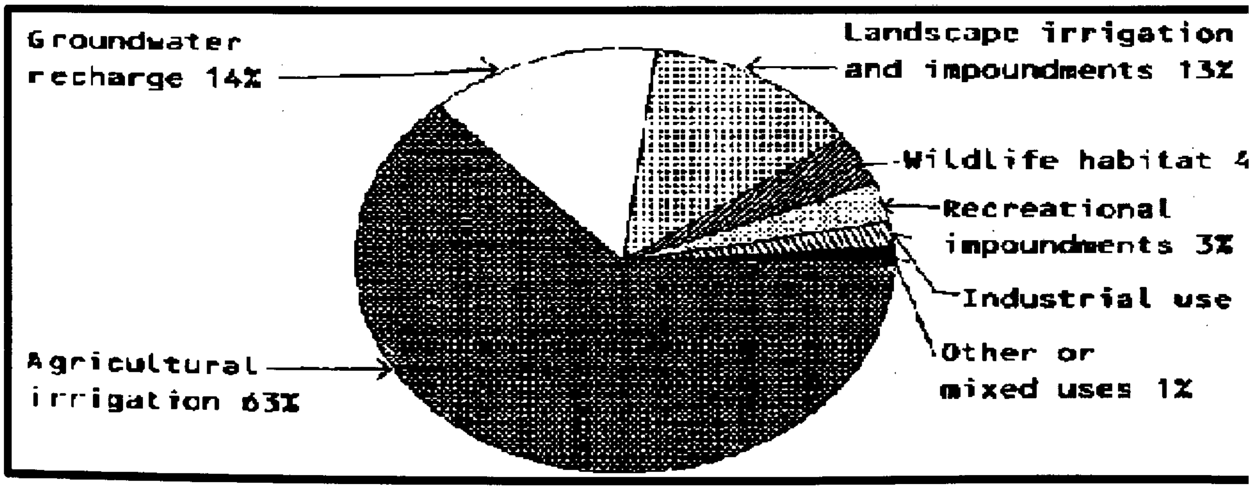

Figure 2.1 Reuse wastewater for the landscape irrigation and agricultural irrigation

Reclaimed wastewater has been increasingly used in California for the landscape irrigation in urban area and for groundwater recharge. Among 78 %, the wastewater used in the Central Valley and South Coastal regions of California.

2.3.4 Wastewater Reuse in Mexico

Irrigation is essential in this Irrigation District because rainfall is limited and poorly distributed over the year, most falling between July and September. Use of raw sewage for irrigation in the Mezquital Valley of the Tula River Basin began in 1886 (Duron.S., 1988). However, it was not until 1945 that the Ministry of Agriculture and Water Resources established the Number 03 Mezquital Irrigation District to manage the distribution of wastewater from Mexico City for irrigation purposes. Sewage from Mexico City mixed with variable proportions of surface water collected in reservoirs within the basin has enabled farmers in the Mezquital Valley to provide agricultural produce for the capital city, (Duron, S. 1988).

2.3.5 Wastewater Reuse in Israel

Reuse wastewater up to 1982 amounted to about 25% of the wastewater generated. Since that time, several large projects lead to a large increase in water reuse. About 72% was reused for irrigation, 42%). Or groundwater recharges 30%. Reuse constitutes approximately 10% of the water in Israel but by 2010 it is projected that reuse will account about 20% with about 33% of the water resources allocated to agricultural irrigation. This practice is generally recognized at the moment as an economically feasible strategy for developing a crucial water source for irrigation replacing freshwater to be reallocated for domestic use. About 80% of Israel's treated wastewater is reused in irrigation. (Argarnan, 1989).

2.3.6 Wastewater Reuse in Italy

In Italy, in the areas near the treatment plants of the town Castiglione, Cesena, Cesenatico an intensive programmed of reuse of treated wastewater has been carried out. Wastewater irrigation now covers an area of over 4000ha and very interesting results both in terms of the effects on the soil and on the irrigated crops. The first survey of Italian treatment plants estimated the total treated effluent now at 2400mm3/yr of usable water. This gives an estimate of the potential resources available for reuse.

2.4 The Benefit of Domestic Wastewater Reuse

Wastewater contains valuable nutrients needed for plant growth, and it has excellent fertilization potential for agricultural or landscape crops. Domestic wastewater contains the macronutrients nitrogen, phosphorous, and potassium, and micronutrients such as calcium and magnesium, all of which are vital to plant and soil health. Its use can supplement or even replace commercial fertilizer inputs, saving farmers money, provides significant savings in water use and also sewage disposal.In environment, it also allows these valuable nutrients to be diverted from the waste stream and recycled, instead of released into watercourses where they can become significant pollutants (Toze, S. 2006).

2.5 The Benefit of Sewage Treatment Plant Effluent Reuse.

The reuse of water is just one source of water that has potential for use in an agricultural setting. Reused water does, however, have a major advantage in that it is usually a constant and reliable supply, particularly with sources such as treated sewage effluent. As well as being a constant source of water, many waters suitable for reuse are produced in large volumes, which if not used would be merely discharged into the environments.it is well known that discharge of effluents, treated or non-treated, into the environments can cause severe degradation of these water ways. The degradation is often related to the presence of organic and inorganic nutrients, which can cause problems such as alga blooms. Reusing these discharged effluents can have a significant impact on reducing or completely removing the impact of these effluents from receiving environments. In addition, the reuse of wastewater for purposes such as agricultural irrigation reduces the amount of water that needs to be extracted from environmental water sources.(U.S.EPA, 2004) Wastewater can often contain significant concentrations of organic and inorganic nutrients for example nitrogen and phosphate. These are potential for these nutrients present in recycled water to be used as a fertilizer source when the water is recycled as an irrigation source for agriculture. Soil microorganisms have been observed to have increase metabolic activity when sewage effluent is used for irrigation.

Table 2.1 : Factors driving further implementation of water reclamation and benefit.

Factors driving further implementation of water reclamation and reuse	Benefit
Dependability	Reclaimed water provides a reliable water source, even in drought years, as production of urban wastewater remains nearly constant
Competing demands for water resources	Increasing pressure on existing water resources due to population growth and increased agricultural demand
Public interest	Increasing awareness of the environmental impacts associated with overuse of water supplies, and community enthusiasm for the concept of water reclamation and reuse
Proven track record	The growing numbers of successful water reclamation and reuse projects throughout the world such as landscape irrigation

2.6 The Risk of Domestic Wastewater Reuse.

Domestic wastewater reuse for irrigation is not however without its hazards- the most prevalent risks identified are those associated with elevated pH, salinity, and Boron in domestic wastewater and the potential accumulation of pathogens, metals and organic chemicals in receiving soils (Toze.S.,2006). However, wastewater can also contain dangerous elements that could negatively impact environmental and public health. Reuse of untreated wastewater in agriculture is a reality in much of the world, especially in areas where poverty restricts farmers' access to freshwater and fertilizer supplies.

For this reason, much attention has been given to the health and environmental implications of raw and/or treated wastewater re-use in agricultural irrigation (Rosas.I., 1984).If untreated wastewater is discharged into rivers, lagoons or lakes, there is the danger of pollution of surface or groundwater sources of drinking water for downstream users, and the transmission of disease causing micro-organisms.

In addition, untreated wastewater discharged into the environment can cause serious ecological imbalances, oxygen depletion, odor nuisances and fish kills in the receiving bodies of water. The use of wastewater for irrigation triggers a psychological barrier for people. Irrigation with wastewater raises sanitary problems (risk of viral and bacterial infection both for farmers and crops) and problems of agronomic nature, due to the presence of toxic substances. To avoid health hazards and damage to the natural environment wastewater must be treated before it can be used for agricultural and landscape irrigation (Pereira et al., 2002).

2.7 The Risk of Sewage Treatment Plant Effluent Reuse.

Effluent reuse for landscape needs to be planned with attention to target crops and existing water delivery methods. Excess nitrogen may cause overgrowth, delayed maturity and poor quality of crops.

2.8 Wastewater Reuses Guidelines & Regulation

Table 2.2 shows, the guidelines in difference volume. World Health Organization (WHO) was published in 1989, these guidelines from the basis for the proposed increase in the use of wastewater for irrigation. Other important documents that reflect the WHO 1989 public health and microbial guidelines have beenpublished. The formulation of regulatory guidelines should be informed by thorough scientific study of wastewater contaminants and their relative risk. As pointed out by such guidelines should aim to balance calculated health and environmental risks with the potential benefits of wastewater reuse as an efficient use of a limited and vital resource. In 2006, the guidelines are further revised and WHO had come out with the idea of separated for different volume:

Based on the guidelines (WHO 2006) "Greywater", which refers to used water flowing from sources such as showers, washing machines, and bathroom sinks, often represents over 2/3 of household wastewater but is considered to be only weakly contaminated by pathogenic organisms and other potentially dangerous substances.

\ **Table 2.2:** The guidelines for different volume

Volume	Guidelines
I	Policy and Regulatory Aspects
II	Wastewater in Agriculture
III	Wastewater and Excreta Use in Aquaculture
IV	Excreta and greywater use in agriculture

2.9 Option for Domestic Wastewater Reuse.

Reuse of wastewater for domestic and agricultural purposes has been occurring since historical times. However, planned reuse is gained importance only two or three decades ago, as the demands for water dramatically increased due to technological advancement, population growth, and urbanization, which put great stress on the natural water cycle. Reuse of wastewater for water-demanding activities, which, so far consumed limited freshwater resources is, in effect, imitating the natural water cycle through engineered processes. Several pioneering studies have provided the technological confidence for the safe reuse of reclaimed water for beneficial uses. While initial emphasis was mainly on reuse for agricultural and non-potable reuses, the recent trends prove that there are direct reuse opportunities to applications closer to the point of generation. Domestic greywater can be categorized in two which greywater and also blackwater.

Domestic wastewater (greywater) is defined as the wastewater from hand wash basin, kitchen sink, laundry and this water is of lower quality than drinking water (Erikkson et al.2002). Greywater excludes foul black water from toilets, and soap and detergents are the major component of greywater (Jefferson et al. 1999). Greywater is usually high volume and low pollution while black water is low volume and highly polluted, and it is often reused for irrigation around homes and toilet flushing (Neal 1996).

Greywater which includes toilet wastes 60-70% of liquid waste flows should be technologically simpler and more space-efficient to treat or reuse at the household and community levels (Eriksson et al.2002). However when compared to raw wastewater, greywater has been found to be only mildly less contaminated (Casanova et al 2001; Jeferson et al 2004) and in some cases, more contaminated which hazardous agents, including pathogens and heavy metal. In all cases, it recommended treating wastewater before use it then; black water is water from toilet.

2.10 Option for Sewage Treatment Plant Effluent Reuse

Agricultural or landscape irrigation is crucial for improving the quality of production. Worldwide, agriculture is the largest user of water, the sector has accounted for 67% of total freshwater withdrawal in the world in 2000. Therefore more efficient use of agricultural water through wastewater reuse is essential for sustainable water management.

Effluent reuse for agriculture or landscape should be practiced with good management to reduce negative human health impacts that could be caused by uncontrolled use, so the effluent intended for reuse should be treated adequately and monitors to ensure that it is suitable for the intended use.

Main benefits of effluent reuse for agriculture and landscape irrigation are conservation and more rational allocation of freshwater resources. It also reduced requirements for artificial fertilizers and associated reduction in industrial discharge and energy expenditure. It also reduction of pollution loads to receiving water bodies.

2.11 Wastewater Quality Parameters

Other water quality parameters of concern in wastewater reuse have been toxic metal accumulation and salinity of wastewater. The availability of heavy metals to plants, their uptake and their accumulation depend on a number of soil, plant and other factors. The soil factors include, soil pH, organic matter content, cation exchange capacity, moisture, temperature and evaporation. Major plant factors are the species and variety, plant parts used for consumption, plant age and seasonal effects.

Dissolved salts causing salinity in wastewater exert an osmotic effect on plant growth. An increase in osmotic pressure of the soil solution increases the amount of energy which the plant must expend to take up water from the soil. As a result, respiration is increased and the growth and yield of plants decline. However, it has been found that not all plant species are susceptible. A wide variety of crops normally are tolerant to salinity. Salinity also affects the soil properties such as dispersion of particles, stability of aggregates, soil structure and permeability.

2.11.1 Water Quality Parameters

2.11.1.1 Biological Oxygen Demand (BOD)

BOD is a parameter which was analyzed using DR 2500 spectrophotometer. BOD is the measurement of the amount of oxygen consumed when all the biological organic matters in the water is degraded. If the BOD is too high the water will become anaerobic (no oxygen). (Weiner, 2008)

2.11.1.2 Chemical Oxygen Demand (COD)

COD also was analyzed using HACH method. COD is the measurement of the amount of oxygen consumed when all the organic matter is chemically oxidized to Carbon dioxide and Hyrdrogen (Weiner, 2008).

2.11.1.3 Odour and Taste

Taste in the water is commonly caused by the inorganic compound in the water while odour will most probably caused by the degration of organic matter (Peavy*et al.*, 1985).

2.11.1.4 Fecal Coliform

Pathogenic organisms of concern associated with greywater reuse include enterotoxigenic Escherichia Coli, Salmonella, Shigella, Legionella, and enteric