REMOVAL OF AMMONIACAL NITROGEN AND SUSPENDED SOLIDS IN SEWAGE WASTEWATER BY USING FERROUS SULFATE IN COAGULATION PROCESS VIA ZETA POTENTIAL AND PARTICLES SIZE MEASUREMENTS

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ABSTRAK

Pencirian kumbahan yang komprehensif telah dijalankan untuk lebih memahami sifat kumbahan yang dijana di kawasan domestik dan komersil. Telah dinyatakan bahawa kumbahan ciri di kawasan tempatan menyerupai ciri-ciri sisa kumbahan biasa yang dilaporkan di seluruh dunia. Dalam fasa pertama kajian ini, untuk menentukan ciri-ciri awal air kumbahan bagi setiap sampel dan kualiti air kumbahan, kerja-kerja makmal telah dijalankan termasuklah ammoniacal nitrogen (NH_3-N), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS) dan *e.coli*. Seterusnya, bagi fasa kedua kajian ini, digunakan untuk menganalisis dan mengukur potensi zeta purata dan saiz zarah sebagai fungsi pH dilakukan secara berasingan untuk air sisa kumbahan dan koagulan yang terpilih iaitu daripada ferus sulfat terhidrat, $FeSO_4.7H_2O$. Berdasarkan analisa peringkat pertama, julat pH optimum telah ditentukan terlebih dahulu iaitu pH 2 dan pH 8. Ini kemudiannya diikuti melalui pemerhatian agregat dan perlakuan pembahagian zarah-zarah saiz dalam kotoran air kumbahan kerana interaksi dengan koagulan sebagai fungsi kepekatan koagulan. Akhir sekali, ujian balang dilakukan untuk mengesahkan penemuan awal dengan menilai penyingkiran pencemar yang dipilih dalam nilai peratusan (%). Telah dilaporkan bahawa pada pH 2, peratusan penyingkiran polutan bagi BOD_5, COD dan TSS masing-masing adalah 86.0%, 88.9% dan 73.5% iaitu lebih tinggi berbanding dengan pH 8 yang masing-masing mempunyai peratusan sebanyak 59.3%, 92.1% dan 66.7%. Walau bagaimanapun, untuk kepekatan NH_3-N dan *e.coli* untuk pH 2 masing-masing diperoleh 33.9% dan 66.1% manakala pH 8 masing-masing adalah 21.9% dan 64.1%. Oleh itu, objektif untuk mengira peratusan pembuangan pencemar berdasarkan julat optimum pH iaitu pH 2 dan pH8 serta koagulan yang telah ditetapkan telah dicapai.

ABSTRACT

A comprehensive sewage characterization was conducted to further understand the nature of sewage generated in domestic and commercial areas. It was revealed that the characteristic sewage in domestic areas resembled the typical sewage characteristic reported globally. In the first phase of this study, to characterize the initial wastewater characteristics for each sample and wastewater quality, laboratory work were carried out included ammoniacal nitrogen (NH_3-N), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS) and *e.coli*. Next in the second phase of this study, to analysis and measurements of the average zeta potential and particles size as a function of pH were carried out separately for the sewage wastewater and the selected coagulant which is the selected of coagulant was ferrous sulfate hydrated, $FeSO_4.7H_2O$. Based on the results, the optimum pH range was predetermined which is pH 2 and pH 8. This is subsequently followed through by observing the aggregation and disaggregation behaviour of the size particles in the sewage wastewater due to the interaction with the coagulant as the function of the coagulant concentration. Finally, a jar test was conducted to validate the preliminary findings by evaluating selected pollutant removal in percentage values (%). It was reported that for pH 2, percentage of pollutant removal for BOD_5, COD and TSS were 86.0%, 88.9% and 73.5% respectively which higher compared to pH 8 that obtained of 59.3%, 92.1% and 66.7% respectively. However, for concentration of NH_3 –N and *e.coli* at pH 2 were obtained of 33.9% and 66.1% respectively while pH 8 is about 21.9% and 64.1% respectively. Hence, the objective to calculate the percentage of pollutant removal based on the predetermined optimum pH which is pH 2 and pH8 and coagulant dosage range has been achieved.

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LIST OF ABBREVIATIONS

BOD	**B**iochemical **O**xygen **Demand**
COD	**C**hemical **O**xygen **D**emand
Cd	**C**admium
Cu	**C**opper
DO	**D**issolved **O**xygen
Fe	**I**ron
Hg	**M**ercury
Mn	**M**anganese
Ni	**N**ickel
Pb	**L**ead
PE	**P**opulation **E**quivalent
POPs	**P**ersistent **O**rganic **P**ollutants
STP	**S**ewage **T**reatment **P**lant
TSS	**T**otal **S**uspended **S**olid
UWS	**U**rban **W**astewater **S**ystem
WWTP	**W**astewater **T**reatment **P**lant
Zn	**Z**inc

NOMENCLATURES

$FeSO_4.7H_2O$	Ferrous sulfate
HCI	Hydrochloric acid
H_2S	Hydrogen sulphide
NaOH	Sodium hydroxide
NH_3-N	Ammoniacal nitrogen

CHAPTER 1

INTRODUCTION

1.1 Background Study

Malaysia has undergone fast economic growth from the 1960s (Guan *et al.*, 2002). In many cases, rapid economic growth can lead to unjustifiable exploitation of natural resources, fast rate of industrialization without proper environmental pollution control will result in environmental degradation. Access to safe water and sanitation are one of the important elements in maintaining the good quality of people.

The population census data collected for every ten year and the latest data have been showed that the level of urbanization in Malaysia is on the rise. The urban population in Malaysia increased by 11% point from 51% in 1991 to 62% in 2000 (Jaafar, 2004). The rapid growth will definitely exert pressure on the provision of adequate housing, sanitary facilities and amenities, proper drainage, garbage disposal health, and educational facilities as well as infrastructure. However, the need of proper management regarding the environmental issues such as water pollution must be done judiciously.

Wastewater management has become focus for many countries. However, an effective sewerage system management must to ensure sewage being treated and disposed in a safe manner (Rakesh *et al.*, 2016). Generally, sewage includes human waste, urine and wastewater from kitchens, bathrooms and laundries. Sewerage systems are designed to collect, transfer, treat and dispose of human waste and wastewater (Sutherland *et al.*, 2007). Hence, effective and small wastewater management systems are crucial for the protection of public health and environment.

In some countries such as China and Japan, the sewerage systems are designed to treat commercial and industrial sewage, toxic waste and manufacturing waste. However, Malaysia's sewerage system only treats human waste and household wastewater. Industrial and trade waste is treated separately by on site industrial waste treatment plant. None of the industrial waste or trade effluent is allowed to be discharged into existing sewerage system.

The growing environmental pollution needs for decontaminating wastewater result in the study of characterization of waste water, especially domestic sewage. Recently, increasing pollution in the waste water leads to developing and implementing new treatment techniques to control nitrogen and other priority pollutants (Trivedi *et al.,* 2008). Degradation of water quality is the unfavourable alteration in chemical, physical and biological characteristics of water that prevents domestic, commercial, industry, agricultural, and other beneficial uses of water (Rakesh *et al.,* 2016).

The regulation on the standard of discharge quality for both sewage and industrial effluent which are known as Environmental Quality (Sewage and Industrial Effluents) was enacted in 1979 and become part of Environmental Quality Act (EQA) 1974. The EQA 1974 was used to control and measure water pollution in Malaysia (EQA, 2000). Instead of that, the national policy on the environment aims at continued economic, social and cultural progress of Malaysia and enhancement the quality of public life through environmentally sound and sustainable development.

1.2 Problem Statement

Protection of the receiving waters from pollution by harmful waste is the primary goal for the treatment of municipal wastewater treatment plants (WWTPs). The effluent discharge of BOD, COD and suspended solid from WWTPs is regulated by national and local authorities in Malaysia. However, non-regulated parameter such as total mineral oils, persistent organic pollutant and surfactants are regularly measured in effluent. As mentioned by Mariani and Norhafizah (2015), despite these developments of sewage treatment systems, still need to be concerned about the removal of suspended and floatable materials, the treatment of biodegradable organic and in some cases relate with the elimination of pathogenic organisms. Hence, it was recognized that the problem of human waste needed a proper management.

At presence, domestic sewage contributed to almost half of organic pollutant in Malaysian aquatic environment (DOE, 2007). As in Penang only, about 58% of the sources of pollutant load to the rivers are coming from the effluent from IWK sewage treatment plant (DOE Penang, 2008).

As in Malaysia, the municipal wastewater treatment systems that are being used such as oxidation pond, aerated lagoon and rotating biological contractor. The treatment efficiency seems good enough in term of BOD, COD and SS reduction. However, the effectiveness of trace priority of ammoniacal nitrogen and growth of bacteria which is *e.coli* in sewage and uses of dynamic light scattering technique by zeta potential and particles size have neither been studied nor only detected sporadically, which should be of great value considering their potential toxicity and environmental risk.

Research is required to chart the broad spectrum of pollutant specifically in Malaysian's sewage generated which to provide fundamental knowledge before formulating certain rules and regulation. There are several vague area in understanding of our own sewage behaviour and how its effect the environment. Even now, we still tend to adopt the technologies based on advanced countries to suit with our local condition by evaluate zeta potential and particles size. It is the goal of this research to provide meaningful data and information to justify the treatment methodology that can be put into practice, hence, more efficient treatment systems could be developed and employed.

1.3 Objectives

The principal objective of the wastewater treatment is generally to allow human and industrial effluents to be disposed of without endangering to human health or lead to unacceptable damage to the natural

I. To characterize the major types of pollutant that constitute in sewage wastewater.

II. To measure the average zeta potential and corresponding particle size for both wastewater sample and coagulant type as a function of pH (pH 2- 12).

III. To evaluate the level of interaction between the wastewater suspension and coagulant as a function of coagulant concentration.

IV. To calculate the percentage of pollutant removal coagulant based on the predetermined optimum pH and coagulant dosage range.

1.4 Scope of Study

The study on sewage can be very broad and cover various aspects. However, this research emphasizes on the sewage generated at Sewage Treatment Plants (STPs) Nibong Tebal – Transkrian, Penang only.

I. The characterization of sewage was done based on parameter specified in the Environmental Quality Act (EQA) 1974, under Sewage Regulations 2009 for standard B.

II. Also, in this study were focus on determining the optimum pH and coagulant dosage range for coagulation and flocculation process of both wastewater sample and coagulant type. The graphing for zeta potential and particles size was done by using Nano Zetasizer ZS (Malvern) only.

III. For characterization of sewage, we also carried out the test of parameters tested in laboratory include ammoniacal nitrogen (NH_3-N), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and *e coli.* The samplings of sewage in sewerage network were done on dry weather and diurnal basis within three month period.

IV. The treatability studies were done on laboratory work and simulate the current condition of sewage wastewater at particular time by calculate the percentage of pollutant removal based on predetermined optimum pH and coagulant dosage range.

1.5 Significance of the Study

The outcome of the research will be necessary in providing our local and national authorities with the fundamental knowledge on the background chemical pollutant before proposing regulation on specific domestic discharge. It is also the aim of the research to provide information and knowledge on optimizing the current treatment design system and sewerage network employed by IWK and propose further modification to improve treatment efficiency particularly dealing with chemical pollutant. Hence, the aim of this study is to investigate percentage of the removal for suspended solids and NH_3-N in sewage wastewater by using Dynamic Light Scattering Technique. For the in- sewer rate of degradation of several pollutants parameter such as COD, TSS, NH_3-N and *e.coli* will definitely help the authority to design and develop more effective treatment which will serve as sewage treatment plant. It is important to continuously find a better method or system to treat our sewage wastewater due to increasing of population that lead to large amount of wastewater.

1.6 Dissertation Outline

These dissertations consist of five chapters which are organized in the following manner:

Chapter 1 explains briefly about the background of the study, problem statement, objective, scope and benefit of this study for Civil Engineering. **Chapter 2** presents the literature review which covers the general introduction, sources of municipal wastewater, current quality condition, and sewage wastewater treatment studies. While, for **Chapter 3** presents the procedures, materials and methods of the research undertaken. Its include sewage wastewater sampling, sewage wastewater characteristic study, zeta potential and particles size for both sample and coagulant and lastly for jar test. **Chapter 4** describes the results and discussion of the experiments. The results are presented in graphical form and analysis and discussion are made in detail. **Chapter 5** gives the conclusions and recommendations based on the results obtained for improvement in future studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The increase in population, industrial and economic activities has led to the large amounts of wastewater to be generated. If the wastewaters are not properly managed, it can cause a lot of problems especially to our environment. According to Rakesh *et al.*, (2016), sewage can be characterized in terms of its physical, chemical and biological characteristics. The main physical, chemical and biological constituents of domestic sewage may be summarized as; (i) the physical properties including colour, odour, solids and temperature, (ii) chemical characteristic including pH value, nitrogen and chloride content, toxic, solid and dissolved oxygen, (iii) biological properties which are containing bacteria, algae, fungi, and protozoa.

A wastewater treatment plants (WWTPs) is a central unit of an urban wastewater system (UWS). The treatment of municipal sewage is one of the few processes in commercial life where it receives polluted wastewater from the urban area, originated from several sources (depending on the sewer design) including domestic, industrial, commercial, hospital, agricultural that contain a wide range of impurities, human excreta, personal care products, detergents, disinfectants, pharmaceuticals, and sediments (Carlos *et al.*, 2016). WWTPs are an important initiative which has to be taken more seriously for the betterment of the society and our future. The treatment plant must therefore be able to cope with a wide range of flows that containing a wide range of impurities.

Generally, wastewater or sewage is defined as the discharge of effluent containing wastewater that comes from domestic and commercial areas. Activities for household uses such as showering, dishwashing, laundry and, of course, include flushing of the toilet. Furthermore, municipal sewage treatment means the purification of wastewaters coming from domestic, institutional, and commercial activities, which carried with the sewage system and delivered to the treatment work. So our final result it can convert the mixed waste into the treated liquid effluent that safely returned to the natural environment (Sutherland *et al.,* 2007).

The impurities that contain in wastewater will be suspended and dissolved, which become toxic that include organic and inorganic matter. Thus, the treatment works must have in place on decontamination processes that can reduce all these impurities to below a set of limits defined by national and local regulatory bodies (Carlos *et al.,* 2016). Otherwise, there are regulation that have been stated in Environmental Quality Act 1974 (Act 127) (EQA) and Environmental Quality (Sewage) Regulations 2009 which is need to be followed that specialized for sewage wastewater treatment plant. Sewage treatment plant is quite necessary to receive the domestic and commercial wastes and removes the materials which pose harm for general public. Its objective is to produce an environmental safe effluent and used to control water pollution in Malaysia (Ramya *et al.,* 2015).

The World Health Organisation (WHO) in 2014 estimated that every year 1.8 million people die due to suffer from waterborne diseases. A large part of these deaths can be indirectly attributed to improper sanitation. Harlina (2010) has stated few damages due to sewage pollution. The damage included direct health damage in the form of increased of illness or mortality due to the ingestion of or skin contact with the contaminated water which led to rose on health care cost and loss of tourism income.

2.1.1 Sources of Municipal Wastewater

Wastewater is defined as any storm of water runoff, as well as industrial, domestic or commercial sewage or any combination thereof carried by water. The type and volume of wastewater generated is determined by both, population numbers and the combination of surrounding domestic, recreational and industrial activities, and all of which affect the discharge patterns as well as the chemical status of the treated effluent (Harlina, 2010). Sewage consists of various residential, public and industrial mixtures of wastewater, which contain organic and inorganic materials in dissolved or suspended or colloidal form as well as various microorganisms useful and harmful to human life. Hence, need to further understand about the characteristics of sewage before designing any sewage treatment system to work efficiently.

Four main types of wastewater have been identified, namely domestic, industrial, agricultural and urban (Harlina, 2010). Urban wastewater is defined as a combination of domestic and industrial wastewater as well as surrounding sewage infiltration and rain water whilst agricultural wastewater consists of wastewater generated through processes from surrounding farms, agricultural activities and sometimes contaminated groundwater (Hamdy *et al.,* 2013). However, the focus of this research is mainly on domestic and industrial sewage as a source of plant influent and contamination which now becoming increasingly important to design a proper treatment.

Domestic wastewater is defined as sewage which generally consists of black water composed of fecal matter (human and animal wastes) together with grey water sources composed of various wastewater constituents. These components originate from a range of household activities such as washing and bathing. Initially, this water is used for drinking, food preparation, hot water systems, bathing, personal hygiene, washing, and gardening and may ultimately form part of the domestic wastewater being excreted into the environment (Hamdy *et al.,* 2013).

Within a household individual domestic wastewater, however, industrial wastes containing such as pulp, paper, petrochemical runoff as well as various chemicals, salts and acids. All these sources were widely in composition and often required special treatments in order to comply with discharge regulations based on the Environmental Quality Act, 1979 (EQA,2001).

The composition of industrial wastewater varies based on the type of surrounding industry together with respective contaminant and pollutant composition with general classification into inorganic and organic industrial wastewater (Rosenwinkel, 2007). Instead of that, the sewage flow rate and composition vary considerably from place to place, basically depending on economic aspects, social behaviour, type and number of industries located in the collection area, climatic conditions, water consumption, type and conditions of the sewer system. However, domestic wastewater is usually the main component of sewage, and is often used as a synonym.

2.1.2 Characteristics of Municipal Wastewater

To further understand about the nature of sewage pollution, one cannot be avoid to briefly understanding the common characteristic of sewage. According to Harlina (2010), raw sewage composes of more than 99% water and 1% solids. About 70% of solid is organic matter and the rest about 30% is inorganic compounds. However, characterization of wastes is essential for an effective and economical waste management programme. It can helps in the choice of suitable treatment methods deciding the extent of treatment, assessing the beneficial uses of wastes and utilizing the waste purification capacity of water in planned and controlled manner. Hence, the characteristics of sewage include the physical, chemical and biological parameters are discussed below.

2.1.2.1 Physical Parameters

2.1.2.1.1 Solids

All the contaminants of water, with the exception of dissolved gases, contributed to the solid load. Table 2.1 classified the solid present in wastewater according to their sizes (suspended solids and dissolved solids), chemical characteristics (fixed solids or volatile solids).

Table 2.1: Classification of solids (Von Sperling, 2007)

Physical Parameter	Description
Total Solids	Contain organic and inorganic: suspended, dissolved and settle able.
Suspended Solids i. Fixed Solids ii. Volatile Solids	Part of organic and inorganic that are non-filterable. Mineral compounds, not oxidisable by heat. Organic compound, oxidisable by heat.
Dissolved Solids i. Fixed Solids ii. Volatile Solids	Part of organic and inorganic that is filterable and normally considered having dimension less than 10^{-3}μm. Organic compound of the dissolved solids.
Settleable Solids	Part of organic and inorganic solids that settle in 1 hour in an Imhoff cone. Approximate indication of the settling in sedimentation tank.

2.1.2.1.2 Odour

Odour abatement and control is a major issue of sewerage work operator. Since our understanding of the sense of small in incomplete, there is no single measure that will directly relate to the like hood of complaint. Odour measurement technique fall into two classes; sensory measurement which employ human nose and measure the effect of odour by an observer and analytical measurement characterize odour in term of chemical composition that quantify odorant present (Gostelow and Stuetz, 2001). Stuetz *et al.*, (1999) had demonstrated the ability of electronic nose based on non-specific conducting polymer array to respond to sewage odour in range of odour measurement (125-781066 odour units/m^3). For odour control in sewers, addition of nitrate favour which can give advantages due to high solubility, low nitrate consumption rate and low operational cost compared to addition of oxygen (Zhang *et al.*, 2008).

2.1.2.2 Other Physical and Chemical Parameter

Other physical and chemical parameters of sewage characterization which are important include alkalinity, turbidity, color and pH. The alkalinity of water has little public health significance. Highly alkaline water is usually unpalatable. Chemical treated wastewaters sometimes have rather high pH values (Haslina, 2010). Moreover, turbidity of sewage indicated the presence of suspended materials such as silts, clays, sediments and organic matter (Zhang *et al.,* 2008). Practically, turbidity is the phenomenon of resistance offered by water to passage of lights. Study has been conducted by using zeolite that act as heteroagglomerate sediment which can remove turbidity in clarification process (Gostelow and Stuetz, 2001).

The color indicated the nature of sewage whether it is fresh or septic. The light brown indicates fresh sewage while black or dark color indicates septic. Generally, color can easily to be identified by naked eyes, however, the platinum cobalt scale is designed to indicate the color scale (Basak, 2003). The pH value is used to determine whether the sewage is acidic or alkaline. Firstly, the sewage is alkaline but it is converted to acidic nature after few hours. In biological process of wastewater treatment, pH must be controlled within range favourable to particular organisms involved. While for chemical process used to coagulate wastewater, dewater sludge or oxidize certain substances such as cyanide ion, which required pH to be controlled within narrow limits (Sawyer *et al.,* 2003).

2.1.2.3 Toxic Compounds

The sewage effluent is considered to be a sources of organic matter and plant nutrients and among these much emphasis has been placed on the value of its nitrogen and phosphorus contents, yet on the other hand it also contain considerable amount of soluble salts and varying amount of harmful substances including heavy metals like iron, manganese, copper, zinc, lead, pathogen and nickel (Shah and Riazullah, 2003).

Heavy metals and their compounds, both organic and inorganic are released to the environment as a result of anthropogenic activities (Karvelas *et al.,* 2003). Many heavy metal and their compounds found in wastewater are toxic while some are also subjected to bio magnifications (Shah and Riazullah, 2003). Shrivastava *et al., (*2003) had reported that significant concentration of Iron (Fe), Manganese (Mn), Copper (Cu), Nickel (Ni), Zinc (Zn) and Lead (Pb) were detected in fishes, planktons and sediment of lakes that received from untreated domestic sewage of residential areas in Bhopal city.

2.1.2.4 Biological Parameter

Generally for the biological parameter in mainly related with the microorganism that come from various types of animal and plant. The sewage contains many microorganisms like bacteria, algae, fungi, protozoa, etc. Basically, bacteria are the most predominant in microorganism. But most of the bacteria found in the sewage are harmless non-pathogenic bacteria. They are helpful in oxidation and decomposition of sewage. A little number of bacteria, however, is disease producing pathogens, which are the real danger to the health of the public. In case of sewage samples, the routine bacteriological tests, as performed for water samples, are generally not performed because of the high concentration of bacteria present in it. But at the time of outbreak of epidemics, certain tests may be done to find the type of pathogens (Kharagpur, 2015).

Domestic sewage has the obvious high potential of carriage of pathogens from human wastes, dishwashing, laundry, bathing facilities and miscellaneous substances that get flushed down toilets or drain into sinks (Sinclair *et al.,* 2008). The types of pathogens that are likely to be present in untreated sewage will depend on the input to the sewerage systems. The pathogens concern will vary from region to region depending on the nature and prevalence on endemic infectious intestinal diseases within indigenous population (Mara and Horan, 2003).

2.1.3 Common Problems Associated with Sewage Wastewater

Sewage pollution is one of the largest water pollution issues throughout the world. According to Akhtar (2009), sewage can affect various substrates which include i) Public health and other living organisms; ii) Soil resources; iii) Crops; iv) Groundwater resources; v) Property values; vi) Social and economic impact. However, the biggest concern associated with microbial pollution is the risk of human and livestock related illnesses after exposure to contaminated water sources. Often the discharge of improperly treated effluent from wastewater treatment plants results in the deposition of large amounts of organic matter and nutrients which have major effects on the health for these surrounding environments as well as micro- and macro-fauna present.

By exposure to microbiologically contaminated surface water may have adverse health effects which result in gastroenteritis that can cause fever, skin, ear, and eye complaint or severe illness such as hepatitis and meningitis (Muisa *et al.,* 2015). In Europe, protozoan parasites have frequently been the cause of water borne outbreaks.

But in Netherland, it has been demonstrated that pathogenic microorganisms may enter surface waters through discharges of raw and treated sewage and manure run off from agriculture land (Lodder and de Husman, 2005).

Furthermore, communities that are situated downstream or near to municipal sewage plant or contaminated water sources are at the highest risk of illness due to increased microbial pathogens and deteriorating physico-chemical parameters (Shalinee and Ademola, 2014). In this journal also state that often the discharge of extremely turbid effluent in conjunction with dense algal blooms results in poor visibility within these water bodies and can creating dangerous situations for recreational users. In addition, water bodies used for full contact recreational activities may serve as a source of various infectious diseases which may be contracted either by ingestion of contaminated water or through full body contact. Other than that, a variety of skin and ear infections may arise as a result of contaminated water coming into contact with broken skin or penetration of the ear. Furthermore, discharge of improperly treated effluent often results in an increased number of bacterial, viral and protozoan pathogens which may result in a range of waterborne related diseases such as giardiasis and gastroenteritis (Okoh *et al.,* 2010, Shalinee and Ademola, 2014).

For domestic sewage, the main pollutant that contained including suspended solids, biodegradable organic matter, nutrients and pathogenic organisms. Other, domestic waste streams carry pharmaceuticals metabolites excreted by human body in urine and fecal matter. Generally, these compounds are not effectively removed by conventional sewage treatment and consequently discharged into water body (Brun *et al.,* 2005).

The solution to most of these problem especially the biodegradable organic matter and pathogens has been reached in many developed region, which a now concentrated on the removal nutrients and micro pollutant together with substantial attention to the pollution caused by storm water drainage (Marcos,2007). Water bodies in their natural form contain small amounts of chemical compounds like bicarbonates, nitrates, chlorides, sulfates, etc. Rise in the amount of such compounds may cause many problems. For example, water becomes unsuitable for drinking and irrigation. The Total Dissolved Solids (TDS) present in water should be less than 500 mg/gram for water to be considered potable. Saline water is not considered suitable for irrigation either. By using of such kind of water for agricultural purpose leads to salinization of soil, which can turn causes soil erosion (Shivaraju, 2011).

Heavy metal contamination of soil resulting from wastewater irrigation is a cause of serious concern due to the potential health impact of consuming contaminated produce. As stated by Sharma *et al.,* (2007), it concluded that the use of treated and untreated wastewater for irrigation has increased the contamination of Cd, Pb and Ni in edible portion of vegetable causing potential health risk in the long term from this practice. The study also point that the fact of adherence to standard for heavy metal contamination of soil and irrigation water does not ensure safe food. Wang *et al.,* (2008) proved that the nutrient content of soil was increased after sewage sludge was applied, however at the same time the concentration of heavy metal especially Cd also was increased.

Sewer leakage which leads to the occurrence of infiltration or exfiltration is a chronic problem in sewer system for many cities worldwide. Exfiltration can result in deterioration of groundwater quality and serious public health risks if groundwater is used for potable supply. Throughout the world there is evidence of contaminated groundwater leading to outbreaks of waterborne diseases (Chisala and Lerner, 2008). Okoh *et al.,* 2010 has summarized the component of wastewater and their effect towards the environment as shown in Table 2.2.

Table 2.2: Component of wastewater and their environmental effect (Okoh *et al.,* 2010).

Components	**Special interest**	**Environmental effect**
Micro organisms	Pathogenic bacteria, virus and worms, eggs	Risk when bathing and eating shellfish
Biodegradable organic matter	Oxygen depletion in rivers, lakes and estuaries.	Depletion of dissolved oxygen
Other organic matter	Detergents, pesticides, fats, oil and grease, colouring, phenol and cyanides.	Toxic effect, aesthetic inconveniences, bioaccumulation
Nutrients	Nitrogen, phosphorus, and ammonia	Eutrophication, oxygen depletion, toxic effect
Metals	Hg, Pb, Cd, Cr, Cu, Ni	Toxic effect and bioaccumulation.
Other inorganic matter	Acids, eg, hydrogen sulphide, bases	Corrosion and toxic effect
Thermal effect	Hot water	Changing living conditions for flora and fauna
Odour and taste	Hydrogen sulphide	Aesthetic inconvenience, toxic effect

In the events where wastewater collection and treatment systems did not keep the pace with population growth and economic development in the past, the discharge of wastewater from domestic and industrial sources led to the deterioration of aquatic and marine ecological systems, the closure of beaches, the occurrence of red tides, the bioaccumulation and contamination of seafood (Hua *et al.,* 2008).

2.1.4 Water Quality Issues

Wastewater can only be disposed of as permitted by a licence under the Environmental Quality Act 1974, administered by the department. This usually means wastewater has to be treated or contaminants removed before it can be discharged to waterways. Most wastewater flows into the sewerage system. The primary federal legislative instrument governing efforts to improve and maintain water quality in Malaysia is the Environmental Quality Act 1974 (Act 127) (EQA). The EQA is considered as the most comprehensive legislation that deals with environmental protection and pollution control in the country. Section 25 of the EQA prohibits any person to discharge or deposit of any environmentally hazardous substances, pollutants or wastes in contravention of standards specified by the Minister responsible for the environment into Malaysian inland waters without a license (Mariani *et al.*, 2015).

Otherwise, same goes to sewage, such standards are set in the Environmental Quality (Sewage) Regulations 2009. The 2009 Regulations is applicable to any premises which discharge sewage into any inland waters or Malaysian waters, except for housing or commercial development with a population equivalent (PE) of less than 150. Any discharge of sewage into any inland waters or Malaysian waters requires prior written notification to the Director General of Environmental Quality.

Sewage discharged should not contain substances in concentration greater than the limits set in the Second Schedule of the 2009 Regulations. Among the parameters included in the standards are temperature, pH value, BOD, COD, suspended solids, oil and grease as well as NH_3-N. The standards set different limit for new and old sewage treatment systems which is for those systems which were approved before the date of the coming into operation of the 2009 Regulations. In general, the standards for the new sewage treatment systems are stricter in terms of concentration limit and number of parameters regulated.

In addition, there are also stated from Environmental Quality (Sewage) Regulation 2009 for second schedule that is specified for the acceptable condition of sewage discharge of Standard A and Standard B in the Table 2.3. Basically, Standard A is applicable to discharges into any inland waters within catchment areas listed in the Third Schedule, while Standard B is applicable to any other inland waters or Malaysian waters.

Table 2.3: Acceptable condition of sewage discharge of Standard A and Standard B based on Environmental Quality (Sewage) Regulation 2009.

PARAMETER	**UNIT**	**STANDARD**	
		A	**B**
Temperature	°C	40	40
pH Value	-	6.0-9.0	5.5-9.0
BOD_5 at 20°C	mg/L	20	50
COD	mg/L	120	200
Suspended Solids	mg/L	50	100
Oil and Grease	mg/L	5.0	10.0
Ammoniacal Nitrogen (enclosed water body)	mg/L	5.0	5.0
Ammoniacal Nitrogen (river)	mg/L	10.0	20.0
Nitrate – Nitrogen (river)	mg/L	20.0	50.0
Nitrate – Nitrogen (enclosed water body)	mg/L	10.0	10.0
Phosphorous (enclosed water body)	mg/L	5.0	10.0

2.1.5 Sewage Wastewater Treatment Processes

Once the minimum effluent quality has been specified, for maximum allowable concentrations of solids (both suspended and dissolved), organic matter, nutrients, and pathogens, the objective of the treatment is to attain reliably the set standards (Kharagpur,2008; Rakesh *et al*., 2016) . The role of design engineer is to develop a process that will guarantee the technical feasibility of the treatment process, and taking into consideration for other factors such as construction and maintenance costs, the availability of construction materials and equipment, as well as specialized labour.

Wastewater management is very important to the environment. Thus, sewage treatment is the process of removing contaminants from wastewater and house hold sewage, both runoffs (effluents), domestic, commercial and institutional. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce an environmentally safe fluid waste stream and treated effluent and a solid waste or treated sludge suitable for disposal or reuse (Mariani *et al.,* 2015) .The treatment of waste water is not only important for our own health but also to keep our environment clean and healthy.

Wastewater treatment is usually classified according to the following levels including the preliminary process, primary process, secondary process and tertiary process (Marcos, 2008; Rakesh *et al.,* 2016). Otherwise, the objective of the preliminary treatment is only to remove a coarse solid while primary treatment aims at removing settle able solids and part of the organic matter. According to Rakesh *et al.,* (2016) had stated that physical pollutant removal mechanisms are predominant in both levels. In secondary treatment the aims is to remove the organic matter and possibly nutrients such as nitrogen and phosphorus by predominantly biological mechanisms.

The objective for tertiary treatment is the removal of specific pollutants which usually toxic and non-biodegradable compounds or the complementary removal of pollutant that were not sufficiently removed in the secondary treatment. But tertiary treatment is rare in developing countries (Marcos, 2008). In table 4 states the overview for wastewater treatment system according to preliminary, primary, secondary and tertiary process.

Table 2.4: Characteristics of the main wastewater treatment levels (Rakesh *et al.*, 2016).

Item	**Preliminary treatment**	**Primary treatment**	**Secondary treatment**
Pollutant removal	Corse solids	Settleable solids, particulate BOD	Non-settleable solids, fine particulate BOD, soluble BOD, nutrients, pathogens
Removal efficiency		SS: 60-70% BOD: 25-40% Coliforms: 30-40%	SS: 65-95% BOD: 60-99% Coliforms: 60-99%
Predominant treatment mechanisms	Physical	Physical	Biological
Complies with discharge standard	No	No	Usually yes
Application	Upstream of pumping station, initial treatment stage	Partial treatment, intermediate stage of a more complete treatment	More complete treatment

There is a large variety of treatment techniques designed to remove pollutants from wastewater. The objective of wastewater treatment is to separate wastes from water. There are physical, chemical and biological separation processes. Sedimentation and screening are examples of physical processes. Coagulation, ion exchange and pH adjustment are typical chemical processes, while various forms of biological digestion belong to the category of biological processes. In the biological processes living organisms, while in the physical and chemical processes physical and chemical properties are utilized for waste separation metabolizes organic wastes (Trivedi *et al.*, 2008).Generally, for the process of screening, clarifiers, grit chamber are includes in physical treatment unit because in all those units used as the removal of impurities and taking place due to physical processes like gravity settling, mechanical straining, and etc. For mechanical straining are takes place in screens but gravity settling takes place in clarifiers. Basically for the clarifiers are also known as the sedimentation basin or settling tanks (Marcos, 2008).

For chemical treatment of wastewater normally preferred when the wastewater discharge is very small like that produced by industries, which is contain of chemicals substances. Thus, chemical treatment takes place in units which is called as reactors. Also, for the chemical treatment of the industrial wastewaters can be achieved from one of the following methods including coagulation, precipitation, oxidation and reduction, neutralization and ion exchange.

Lastly, for the biological treatment is fully utilizes the microorganisms for treatment of the wastewater. Depending upon the type of microbes used, the biological treatment is classified as aerobic treatment and anaerobic treatment. The example of the treatment units for aerobic treatment using aerobic organisms includes activated sludge plant, trickling filter, rotating biological contactors, oxidation ponds, and etc. Otherwise for anaerobic treatment uses the aerobic microbes includes the treatment units of sludge digesters and etc. Generally, for treatment process of wastewater is mainly included of four basic stages which are preliminary treatment, primary treatment, secondary treatment and tertiary treatment. Basically, for each treatment has a specific function based on the process that is included in each stages.