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Aerobic treatment of kitchen wastewater using sequence batch reactor (SBR) and reuse for irrigation landscape purposes.

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ABSTRACT**:** *The trend towards reuse of effluent for landscape irrigation from kitchen is driven by the need to maximise limited water resources and benefit from the plant nutrients available in the effluent. The significant impact upon the value of the wastewater for reuse is its chemical properties as well as biochemical oxygen demand and suspended solids. While treatment plant is expected to treat all wastewater received to a minimum environmental standard, not much effort are given for wastewater reuse in Malaysia due to the fact that Malaysia is not experiencing shortage in portable water yet but as population increases water availability will be more scares according to WHO prediction. The improvement in effluent quality will have significant beneficial effects upon land application and human health. This study investigate the performance of SBR on treating kitchen wastewater and the possible reuse for irrigation purposes with hydraulic retention time (HRT) 5 hours varying the aeration time at 15 minute interval for 12 cycles. The operation volume of the rectors was 20 litres which comprises of 13 litres of kitchen wastewater and 7 litres of sludge in every cycle for treatment. Wastewater used was taken from University Tun Hussein Onn Malaysia (UTHM) cafeteria and the sludge used is from a pond inside the campus. Laboratory analyses were carried out in influent and effluent in order to achieve maximum efficiency reduction in effluent. Parameters tested for both in influent and effluent are pH, DO, COD, BOD, PO4, NH_4, NO_3 and TSS. Total percentage removal obtained for COD, BOD, PO_4, NH_4 and NO_3 are: 63, 67, 78, 85 and 86% respectively which are all in compliance with the standard A and B regulation for effluent discharge or reuse. The data were analysed using Microsoft excel.*

KEYWORDS*: Aerobic, Effluent, HRT, Influent, SBR and Wastewater.*

I. INTRODUCTION

In the past, wastewater treatment has been widely adopted as the major control measure in controlled effluent use schemes, with crop restriction being used in a few notable cases. A more integrated approach to the planning of wastewater use in agriculture and landscape irrigation will take advantage of the optimal combination of the health protection measures available and allow for any soil/plant constraints in arriving at an economic system suited to the local socio-cultural and institutional conditions. In the growing number of conflicts between agricultural and domestic use of scarce water resources, an increased use of treated wastewater for irrigation purposes is vital. The degree of wastewater treatment varies in most developing countries. In some cases industrial wastewater is discharged directly into bodies of water, while major industrial facilities may have comprehensive in-plant treatment. Domestic wastewater is treated in centralized plants, pit latrines, septic systems or disposed of in unmanaged lagoons or waterways, via open or closed sewers. In some coastal cities domestic wastewater is discharged directly into the ocean. Pit latrines are lined or unlined holes of up to several meters deep, which may be fitted with a toilet for convenience

Wastewater is composed of over 99% water. In a developing urban society, the wastewater generation is usually approximately 30-70 m^3 per person per year. In a city of one million people, the wastewater generated would be sufficient to irrigate approximately 1500-3500 hectare (SIDA, 2000). Innovative and appropriate technologies can contribute to urban wastewater treatment and reuse. To re-use the treated wastewater in irrigation purposes, the effluent quality must comply with the WHO guidelines for use of wastewater in agriculture and aquaculture, which were adopted in 1989 as a result of the consensus of a group of experts that met in 1985 in Engelberg, Switzerland.

The tremendous development of cafeteria premises restaurant, food courts and markets in Malaysia have contribute to the domestic wastewater in term of kitchen waste as it was directly discharge without proper treatment. Water supply and treatment often received more priority than wastewater collection, treatment. However, due to the increasing need wastewater treatment deserves greater emphasis. Currently there is a growing awareness of the impact of sewage contamination on rivers and lakes. Malaysia is facing an environmental problem especially in water pollution matter, the pollution is one of the critical matters that require a prompt action as the generation is increasing in a daily bases especially in university tun Hussein onn Malaysia (UTHM) campus. The increment of food business and lack of awareness of restaurant owners has contribute to the significant impact to the environment as many of the waste are convey to the water course or river without any appropriate treatment, some of the wastewater are also disposed to landfill site resulting to an overburdened of decomposition capacity

In experimental phase, laboratory scale aerobic sequence batch reactor was installed to treat grey water, grey wastewater was used as feed for the experiment to investigate the re-use of wastewater after treatment in contributing to the sustainability of the environment by conserving water usage there by reducing the effect of global warming. This experimental research is focused on re-using treated waste water for landscape irrigation purpose by using aerobic SBR reactor to treat grey water (kitchen waste) in other to achieve partial or full treatment of the wastewater. Generally, 70% of kitchen waste can be considered as organic.

II. Methodology

Eutrophication of an enclosed water area is caused by contaminants, especially BOD, nitrogen and phosphorus. Long-term accumulation of nutrients will cause eutrophication and influence the quality of water resource. In this study, wastewater influent from the UTHM cafeteria was used to a sequencing batch reactor SBR to determine the removal efficiency of BOD, COD, N-NO_3, N-NH_4, P-PO_4, SS, pH, DO, and TSS of the system and to determine it re-use for landscape irrigation. In recent year, sequencing batch reactors (SBR) has great interest for wastewater treatment, because of their simple configuration. SBR could achieve nutrient removal using alternation of anoxic and aerobic periods; nitrification and denitrification are achieved in a SBR by mentioned periods, while the separation of treated wastewater and microorganisms is accomplished by ceasing aeration and/or mixing at the end of process cycle. Due to its operational flexibility, it is quite simple to increase its efficiency in treating wastewater by changing the duration of each phase rather than adding or removing tanks in SBR. In such systems raw wastewater is used as source, while in SBR this source is interrupt during phases. Removing the mentioned disadvantages and to achieve nitrogen removal an experimental study using SBR with 5 hours hydraulic retention time (HRT) has been performed. The purpose of this research is to determine the capability of the system in removing BOD, COD, N-NO_3, N-NH_4, P-PO_4, SS, and TSS from raw wastewater. In experimental phase, laboratory scale aerobic sequence batch reactor was installed to treat grey water; grey wastewater was used as feed for the experiment to investigate the re-use of wastewater after treatment in contributing to the sustainability of the environment by conserving water usage there by reducing the effect of global warming. This experimental research is focused on re-using treated waste water for landscape irrigation purpose by using aerobic SBR reactor to treat grey water (kitchen waste) in other to achieve partial or full treatment of the wastewater.

2.1 Sample Collection

In this study, the kitchen waste is used as the sample of domestic wastewater where this sample is collected at the effluent of UTHM school cafeteria during peak hour (lunch hour). This period was selected since the wastewater generated from this café is more concentrated and fresh. Furthermore, the location has been chosen because until now, there is no prior treatment of wastewater before been discharge to body of water, which mean there is no even pre-treatment available.

A standard procedure has been followed to ensure the sampling is free from any contaminants. In order to minimize the contamination effect, sample was preserved and analysed via APHA (1995) manuals. Several important factors should also be taking into account during sampling period, which are described as follows

- Bottle for sampling storage must be rinse with water sample to avoid a chemical-biological reaction in the bottle.
- DO and pH metre should be rinse with distilled water to avoid error reading during sampling period.
- Sample in the bottle must leave at least a quarter to full to allow uniform blending
- A label must be provided on the bottles
- Experiment in the laboratory must be made immediately after sampling

2.2 Hydraulic Retention Time (HRT)

Performance of the SBR system was investigated for kitchen waste water by varying HRT in 12 different cycles as shown in Table 1, aeration time was adjusted in each cycle at 15 minute interval 135, 150, 165, 180, 195, 210, 225, 240, 255, 270, 285and 300 minutes, to maintain the HRT values. Settling time and withdrawer time were kept constant at 55 minutes. The SBR was operated with HRT 5 hours (300 minutes), a settling phase (60 min), and a draw phase of (55 min) with aeration time different in interval of 15 min for each cycle feeding (5min) was done by gravity. During filling the reactor was always under anoxic conditions in order to enhance biological denitrification. The first cycle was operated for 135 min with kitchen wastewater and sludge from UTHM pond 7 litres of sludge and 13 litres of kitchen wastewater from cafeteria in UTHM which make it a total of 20 litres for each cycle and 12 litres was withdrawn as effluent for further measurement of the parameters mention earlier. Oil and grease was extracted from the kitchen wastewater by storing the influent in a storage tank and allow it to settle for a while, the influent was withdrawn from the bottom since the oil and grease float above the sample with this has able to reduce or eliminate oil content in the sample. At the start-up of SBR operation the HRT was fixed at 135 min. Total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonium and Nitrogen compounds, nitrates, phosphate parameters and total suspended solid was analysed according to standard methods. MLSS for every cycle was measure and they are within the range of 2120- 2330. For the whole operation period a constant air pressure of 60 kg/cm^2 was use throughout the experiment.

2.3 System Configuration

The SBR reactor were fabricated from a transparent Plexiglas cylinder (19.0 cm in diameter), with a total volume of 25 L and a working volume of 20 L. The reactor was equipped with two peristaltic pumps in charge of influent feeding and effluent discharging, respectively. In this study feeding was done by gravity while pump is use to withdraw the effluent after settlement. Typically, SBR operations are divided into five phases: filling, reaction, settling and effluent discharge as shown in table 1 below.

Table 1: Summary of Design Operation

Cycle	Filling	Aeration time (min)	Settling time (min)	Withdrawer time (min)	HRT (min)
1	5	15	60	55	135
2	5	30	60	55	150
3	5	45	60	55	165
4	5	60	60	55	180
5	5	75	60	55	195
6	5	90	60	55	210
7	5	105	60	55	225
8	5	120	60	55	240
9	5	135	60	55	255
10	5	150	60	55	270
11	5	165	60	55	285
12	5	180	60	55	300

2.4 Influent Characteristics

There was a need to establish the characteristics of the influent wastewater used in this study; Table 2 shows the wastewater characteristics. The influent used in the SBR was real kitchen wastewater taken from a UTHM school cafeteria. The characteristics of the influent are listed in Table 2. COD and NH_4 -N in the raw wastewater was 180–220 mg/L and 40–60 mg/L, respectively.

Table 2. Characteristics of the influent

Parameter	Range (mg/L)
COD	205-230
BOD	45-120
TSS	260-490
NH_4	0.180-0.250
NO_3	5.0-11
PO_4	2.30-3.50
SS	450-530
pH	6.15-6.20
Temperature	23̊c-25̊c
DO	1.02-3.8

III. RESULTS AND DISCUSSION

A characterization of several of the wastewaters used in this study was performed. The wastewaters studied include two raw wastewaters from different source. The trend towards reuse of treated wastewater is driven by the need to maximise limited water resources and to benefit from the nutrients such as phosphorus available in the wastewater. Improvements in aeration devices and controls have allowed SBRs to be successfully compete with conventional activated sludge systems (USEPA 1999).

3.1 SBR Start-up

3.1.1 Performance of SBR Aerobics

The SBR performance was initially evaluated by measuring COD, TSS, BOD_5, PO_4-P, SS, NO_3, and ammonium nitrogen compounds in influent and effluent. During the total operational period, low COD removal was achieved in the reactor and the effluent COD was nearly 90 mg/L at 5h HRTs. Hydraulic retention time (HRT) variations affected the nitrification rate. BOD effluent total removal was achieved at HRT 285 minutes which are at cycle 11 of the experiment at 78% which is similar to results obtained from other researcher. At cycle 1 the No_3 concentration in effluent was relativity high at 4.6 mg/L. At cycle 3,5,7,9 and 11 it was notice that there was rise and fall in the removal of NO_3. NO_3-N concentrations in the effluent varied between 1.5 and 4.6mg/L with about 86% total removal at HRT 5h. At HRT of 5h, the effluent concentration of the PO_4-P was 78% and the effluent value varied between 0.77 and 1.56 mg/L, but at HRT of 255 min it is lower than 1.56 mg/L.

4.1 Dissolve Oxygen and pH

The wastewater was slightly alkaline in nature due to presence of detergents, soaps etc. It was observed that during the treatment, the reactor had developed acidic conditions causing a drop in pH values of the reactor content and the treated effluent. During the study period the pH values of the influent were used to be in the range of 6.15-6.55, but after aeration, the pH value drop to range of 4.38-4.69. DO and temperature in both influent and effluent were measured in every cycle. DO in effluent was significantly decreased while increasing HRT, it varied in between 0.5 mg/L – 6.8 mg/L. At the beginning of the first cycle DO level was 6.8 mg/L and it was gradually decreased while moving to the second cycle. However, there was a sudden decrease in DO level in SBR while moving to the third run with HRT 165 min. Further, it could be observed that DO level dropped from 3.14 mg/L to 0.5 mg/L. This rapid variation may be due to higher consumption of oxygen because of high HRT. In fact, consequently, air flow rate was constant at 6o kg/cm^2 in order to maintain aerobic condition in the system. DO levels fluctuate seasonally and over a 24-hour period. They vary with water temperature and altitude. Cold water holds more oxygen than warm water and water holds less oxygen at higher altitudes. Thermal discharges, such as water used to cool machinery in a manufacturing plant or a power plant, raise the temperature of water and lower its oxygen content.

4.2 NUTRIENT REMOVAL

4.3.1 Carbon Oxygen Demand (COD)

COD in feed and effluent were followed throughout the experiment. Influent total COD was about 230 mg/L. Removal of COD in cycle 1, 2 and 3 were 26, 49 and 54 % respectively shows system capability in COD removal in different cycle. COD removal was rapid during the initial phase of sequence operation. With an increase of sequence time a relatively slow removal was noticed at the end of the reaction phase. For SBR treatment, kitchen wastewater and sludge were mixed in the batch reactor. The removal efficiency of COD was analysed. The removal efficiency of COD increases with reaction time. In the SBR process the maximum of

COD removal was 63%. When the reaction time was more than 180minute, the removal efficiency of COD was not obvious**.** In this study the SBR was operated at low HRT of 135minute after the sludge had been added to the wastewater in the reactor, after 12 cycles of SBR aeration, settle and decant of HRT 300minute. The experiment result with SBR system indicate that removal efficiency of COD are similar to those obtained by Dorota et al, 2006 on COD removal in SBR which varied from 83% to 76% on shortening the hydraulic retention time (HRT) from 12 to 2 days. The condition for discharge according to standard A and B is 120 and 200 mg/L respectively which means is within the range for viability.

4.3.2 Biology Oxygen Demand (BOD)

One of the most commonly measured constituents of wastewater is the biochemical oxygen demand (BOD). Wastewater is composed of a variety of inorganic and organic substances. Organic substances refer to molecules that are based on carbon and include faecal matter as well as detergents, soaps, fats, greases and food particles (especially where garbage grinders are used). These large organic molecules are easily decomposed by bacteria in the septic system. However, oxygen is required for this process of breaking large molecules into smaller molecules and eventually into carbon dioxide and water. The amount of oxygen required for this process is known as the biochemical oxygen demand or BOD. High BOD5 in effluent means a large quantity of oxygen was needed to break down the organic matter. This identifies a large amount of organic matter in the effluent and indicates inadequate treatment (Peavey *et al*., 1985). In this study BOD in feed and effluent were measured throughout the experiment, Influent total BOD was about 120 mg/L. removal of BOD in cycle 1, 2 and 3 were 24, 30 and 35 % respectively. In this system BOD removal is more than other processes, it shows system capability in BOD removal in different cycles with increase in HRT. The BOD like the other parameters also decreased along the various treatment units with increase in HRT. The overall percentage efficiency removal in BOD was 67% where effluent is 15 mg/L which is within the standard for reuse according to Standard A and B which set 20 mg/L and 50 mg/L respectively. The result obtained is low compared to those obtain by Umble and Ketchum 1997, who used a SBR to biological treatment from municipal wastewater. At 12 hours cycle time, BOD removal was at 98%. This shows that if the HRT is been increase from 5 hours as used in this study to 12 hours is possible to obtain same or even better result in BOD removal. BOD removal in SBR is more than 90%, while conventional modifications of activated sludge are capable to remove 60-95% of BOD (Metcalf and Eddy, 1991)

4.3.3 Determination of kinetic constants

Removal coefficient of COD and BOD was obtained using the following formula (So – Se) versus t. Figure 1 presents the kinetic model similar to monod rate for the double reciprocating rate and the substrate that is based on a double reciprocated form of equation for the linearized model. From Figure 1 the experimental data were fitted with the equation. The value obtained for the correlation coefficient (R^2) was 0.2357. The rate constant (K) was -4.4351 d-1 Ks was 47.081 mg/L. The large value of Ks shows that either the biomass grown on the wastewater has a low affinity for the substrate or that the rate expression can be simplified and may lead to the first order (Naja, et al 2007). Figure 1 is determined by the raw wastewater BOD concentration and the hydraulic retention time (d) or wastewater flow rate. After determining the kinetic constant K, using experimental data at different operational conditions (e.g. flow rate, temperature, and wastewater strength), the reactor effluent BOD (Se) and BOD removal (So) can be calculated. The value obtained is lower than most literatures values for domestic wastewater, which typically are between 0.46 and 0.69 (Grady et al, 1999). In figure 2 the experimental data were fitted with the equation. The value obtained for the correlation coefficient (R^2) was 0.1825 the rate constant (K) was 0.998d-1 and Ks was 4.09mg/L. the estimated and measured values of effluent BOD and BOD removal are presented. It is evident that using the first order kinetic model it is possible to predict reactor performance in term of substrate removal. Furthermore, these values are significantly higher than those reported by Borja and Banks (19994) (0.9d-1) and this can be attributed to different testing.

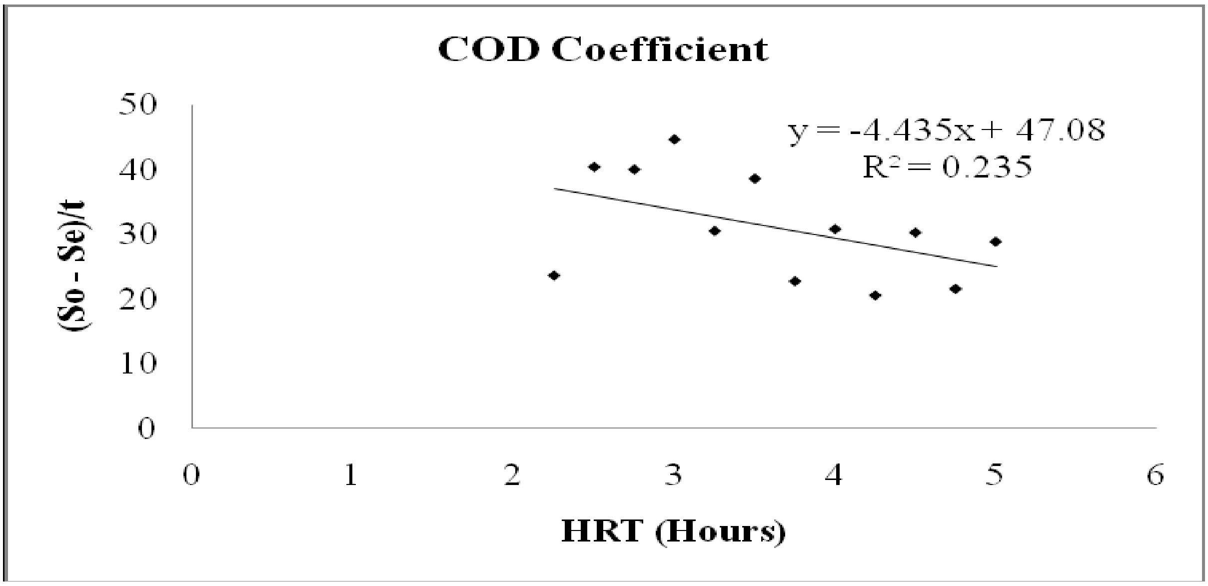

Figure 1: COD Removal Coefficient

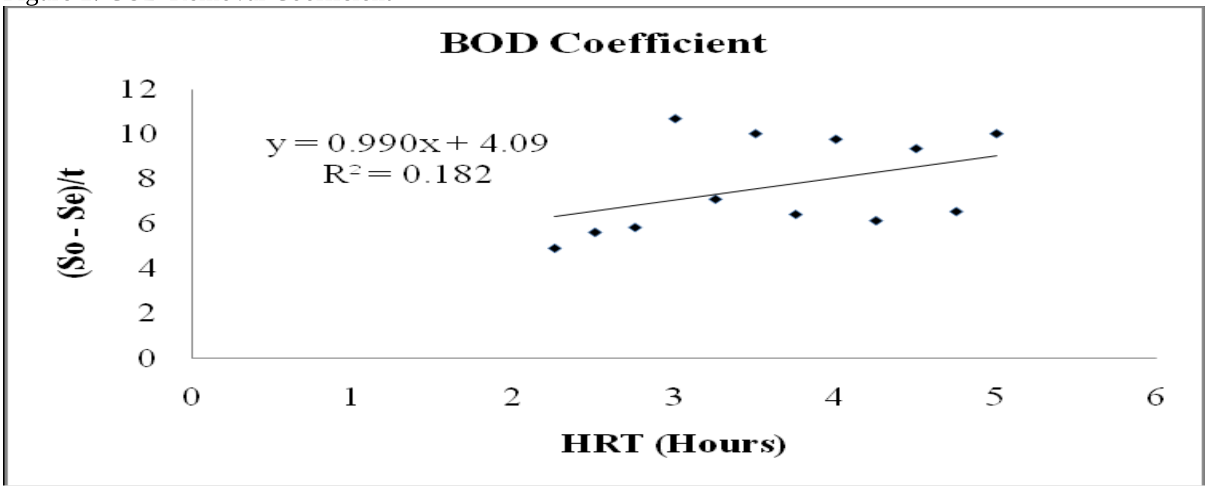

Figure 2: BOD Removal Coefficient

4.3.4 Nitrate (NO_3)

Nitrates are a form of nitrogen, which is found in several different forms. These forms of nitrogen include ammonia (NH_3), nitrates (NO_3), and nitrites (NO_2). Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L) or higher under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L. Nitrates themselves are relatively nontoxic. In this study high nitrate was not present in the effluent, it was produced as a result of nitrification of NH_4-N during the anoxic (aerobic) phase and converted to N_2 during the anoxic phase, and there were slight increase in the values recorded in cycle 4 and 5 from 2.8 mg/L to 5.0 mg/L. Decreases in nitrate were recorded in the 6th cycle from 5.0 mg/L to 2.9 mg/L (representing 73 % decrease), which further decreases to 1.5 mg/L at the 10th and 12th cycle. The overall percentage efficiency removal change in the parameter was 86% and is way below the value set for standard A and B which is 10mg/L. The result is similar to the one obtained by Lin and Cheng (2001) who investigated treatment of municipal sewage wastewater for possible irrigation reuse. The total nutrient removal was recorded at 89%. The treatment method consisted of HRT 6 hours and sequencing batch reactor (SBR) system. Acceptable condition for nitrate discharge is 10.0 mg/L which is within the range for viable discharge or re-use.

4.3.5 Ammoniacal-Nitrogen (NH4-N)

Ammoniacal-nitrogen (NH_4-N) has a major effect on the growth rate of bacteria. When the NH4-N concentration increases, much more carbon will be diverted for growth, while the storage process will be lowered or less efficient (Serafim *et al*., 2004). Discharging of N-containing surface waters result in problems like decrease of the dissolved oxygen concentration, presence of the toxic compound ammonia (NH_3) and growth of algae in natural environment. Therefore, under aerobic condition, the NH_4-N should be reduced significantly in a fast pace. However, the NH_4-N removal in this study values varies from 0.039 mg/L – 0.231 mg/L. At HRT 135 minutes efficiency removal tend to be at 2% with increase in HRT it was observed that the efficiency increase, at the third cycle 28% was recorded with a decrease in efficiency in the fourth cycle in which 6% was recorded. It was further observed in the sixth cycle where the efficiency improves tremendously to 79%. The total efficient removal was obtained at 85% in the seventh cycle and subsequently as HRT increases the efficiency removal decreases to about 30% at HRT 285 minutes. This circumstance is lower compared to other studies (Beun *et al*., 2002). In an aerobic system, NH4-N removal is due nitrification process. Nitrification is the oxidation of NH4+ to NO3-, and is carried out by autotrophic microorganism (Beun *et al*., 2002). In an experiment by Chang and Hao (1996) studied nutrient removal for identifying process variables affecting performance of SBR system efficiency for NH4-N removal was 98% for HRT 15 hours (Chang and Hao, 1996). While Study carried out in a similar condition by Umble and Ketchum (1997), using SBR to biological treatment from municipal wastewater at HRT of 12h obtain total efficiency removal of NH4-N to be 89% (Umble and Ketchum, 1997). As more stringent effluent quality standards are imposed, advanced and cost effective techniques for nitrogen removal from wastewater become more and more important. Many modifications and novel processes have been developed and implemented for nitrogen removal from wastewater (Tchobanoglous et al. 2003). Several reuse standards have been developed, based on the type of application. Based on previous experiences in Germany, Japan, China, UK and Australia, a set of reuse standards have been proposed (Li et al., 2009) but for Malaysia, Standard A and B for acceptable condition of sewage discharge for nitrogen ammonium is set at 5 mg/L which means the result obtained is within the Malaysia standard for re-use.

4.3.6 Phosphorus (PO4)

Phosphorus, in the forms to be found in waste water, is neither poisonous nor a health hazard. On the contrary, phosphorus is a component of many cell structures and the metabolism of animals and plants. Phosphorus occurs in sewage in its most highly oxidized forms and is therefore not an oxygen consuming substance. Nevertheless, phosphorus is a “problem” because in an aquatic environment, it is generally a limiting factor for the development of organisms. Which means the concentration of phosphates determines the extent to which e.g. algae (Phytoplankton) can develop or known as eutrophication (Kaschka, 1999). Phosphorus concentration in feed and effluent were measure throughout this study. Only total phosphorus was measured. Influent total phosphorus was about 2.36 - 3.43 mg/L with effluent ranging from 0.77 – 2.02 mg/L. Efficiency removal of total phosphorus in cycle no 1, 2and 3 was 34, 43, and 52% respectively, from the result phosphorus effluent removal decreases with increase in HRT except in cycle 8 and 9 where there was slight decrease which later increases in the 10th cycle and in the 12th cycle. Total removal of about 78% obtained where effluent was recorded to be 0.77mg/L which is within the level measurement for discharge in Asia especially in Malaysia. This result is relatively high compared to results obtained by other researchers (Mino *et al*., 1998) on enhanced biological phosphate removal (EPBR) process at HRT 6 hours, which reported at least 40% removal.

Many countries set 1 mg/L and 2 mg/L as the limit for total phosphorus concentrations in discharges of wastewater treatment plants. One of the reasons for this low limit is that phosphorus concentrations below 0.5 mg/l have been shown to be the limiting value for algal growth (Dryden, 1968). For Asian country such as Malaysia, the level measurement to discharge phosphorus is 5.0 mg/L; this is based on Department of Environment in national water quality standard in Malaysia. Biological phosphorus removal from wastewater has received much attention in the recent years (Beun *et al*., 2001; Mino *et al*., 1998). However, the P-removal process is a complex process (Beun *et al*., 2002).

4.3.7 Total Suspended Solid (TSS)

Total suspended solids include all particles suspended in water which will not pass through a filter. Suspended solids are present in kitchen wastewater and many types of industrial wastewater. There are also nonpoint sources of suspended solids. As levels of TSS increase, a water body begins to lose its ability to support a diversity of life. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen. High TSS in a water body can often mean higher concentrations of bacteria, nutrients, pesticides, and metals in the water. High TSS can cause problems for industrial use, because the solids may clog or scour pipes and machinery (Mitchell and Stapp, 1992). In this study TSS in feed and effluent were measured throughout the experiment. Influent TSS was about 260 to 490 mg/L and effluent ranges from 20 to 110 mg/L. it was observed that effluent decrease with increase in HRT, from the third cycle to the fifth cycle a large amount of removal was obtained from 70 to 30 mg/L. Efficiency removal of TSS in cycle no. 1, no. 2 and no. 3 were 62, 69 and 73% respectively. This indicated that effluent removal percentage increases with increase in HRT. At HRT 5 hours a total of 94% total removal was achieved. The result obtained is low compared to the result obtained in a study by Umble and Ketchum (1997), investigated the effect of total cycle time on system performance, total suspended solids (TSS) 98% have been obtained, with a 12 hours cycle time. Several reuse standards have been developed, based on the type of application, based on previous experiences in Germany, Japan, China, UK and Australia, a set of reuse standards have been proposed (Li et al., 2009). However, many countries have individually produced their own guidelines depending on their needs. Because the main issue when using recycled water is the potential risk to human health, the standards are usually based on microbial content. The acceptable condition for effluent discharge of standard A and B for TSS is 50 mg/L and 100 mg/L respectively. From this study it is said to have comply with the Standard A and B condition for discharge.

4.3.8 Volatile Suspended Solid (VSS)

Volatile solids are more or less equivalent to the fraction of residue that is organic, while non-volatile solids approximate the inorganic fraction, because solids determinations are empirical in nature. The biomass solids in a biological waste water reactor are usually indicated as total suspended solids (TSS) and volatile suspended solids (VSS). The solids are comprised of biomass, non biodegradable volatile suspended solids and inert inorganic total suspended solids. In this However, very consistent VSS effluent concentrations were subsequently recorded and specifically continued until the fourth cycle (HRT of 3 hours) and the six cycle (HRT of 3.5 hours), where after this operation, VSS concentrations in the effluent have been increased towards the end of study from 48 to 60 mg/L and from 35 to 53 mg/L for the cycle four and cycle six, respectively. Besides, no such tendency has been observed in the cycle, but it was worthy to mention that every time the HRT was increase, the effluent was decreases (from 58 to 48 mg/L at HRT 135 minutes and from 32 to 20 mg/L at HRT of 5 hours) in the VSS values was recorded. According to these evidences, it can be noticed that HRT of 5 hours produce better removal efficiency result. Nevertheless, the overall reactors‟ abilities to retain the biomass were high at 83% removal efficiency for the SBR rector, while lower rate of only 42% was recorded in HRT of 135 minutes. This perfectly illustrates the positive role of SBR treatment to remove higher amount of sludge in the wastewater. Data points were obtained to assess the removability of solids in the reactor and were recorded at each HRT applied. The removal of solids was decreased after each new HRT applied, but rapidly recovered towards reaching the point of steady-state (stable operation). Results have indicated the high efficiency of the SBR reactor in removing solids, especially VSS, where 83% result was higher than previous studies. For instance, studies have been done using the SBR reactor have reported VSS removals of 72% Umble and Ketchum (1997).

4.3.9 Suspended Solid

It was observed that influent SS concentration varied in the range of 460 to 525 mg/L whereas, the effluent SS concentration was above 100 mg /L most times during the study period. The SS efficiency removal maximum was obtained at HRT 285 minutes to be 80%, and was around 60% at nearly all the lower HRTs considered in this study. During sequencing (cycle) operation, and also throughout the reactor operation, the variation of SS removal with the function of the cycle time is essential. The SS removal rate was slow during the initial phase of sequence operation. With an increase of sequence time a relatively rapid removal was noticed at the end of the reaction phase. Although fluctuation occur in cycle 4, 8, and 10 where it tend to decrease even with increase in HRT.

V CONCLUSION

Despite abundant freshwater resources in Malaysia on the whole, there are regions where demand exceeds supply. Within the holistic concept of total water cycle management, one solution to the challenge is wastewater reuse, which facilitates the use of treated kitchen effluents as a new source for non-potable water supply. Reuse or recycling of treated kitchen wastewater reduces effluent discharges into receiving waters and offers a reliable alternative supply of water for applications that do not require high quality water, freeing up limited. This study was mainly focused on the applicability of aerobic SBR to overcome the deficiencies in lack of prior treatment of kitchen wastewater before depositing into body of water and for reuse for irrigation purposes. Performances were investigated for twelve different hydraulic retention times as 135 minutes to 300 minutes. It could be found that regardless of HRT, COD removal efficiencies were not more than 63 %, besides; better nitrate removal efficiency was achieved when the system was running for HRT 300 min and it was 86%. Similarly, in terms of total suspended solid removal efficiency, HRT 300 min provided removal of 94 % from wastewater. Results obtained were within the standard. Finally, it was justified that HRT 300 minutes (5hours) was the best operating condition among them. The sequencing batch reactor is an efficient tool for biological carbon and nutrient removal, capable of achieving effluents with very low nitrogen and phosphorus concentrations from concentrated wastewaters.

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