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基质混合比和盐含量对餐厨垃圾与剩余污泥协同产气的影响评估

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姓　　　　名　ALI ALHRAISHAWI
申请学位级别　工 学 硕 士
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指 导 教 师　黄 涛 教 授

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EVALUATION THE IMPACT OF MIXING RATIOS AND SALT CONTENT ON BIOGAS PRODUCTION BY ANAEROBIC JOINT DIGESTION OF FOOD WASTE AND SEWAGE SLUDGE

Grade: 2015

Candidate: ALI ABDULZAHRA ALI ALHRAISHAWI

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Supervisor: Prof. Huang Tao

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摘　　要

世界各个领域都认为有机质的堆积浪费已经到达了敏感阶段，需要用一种可持续的方式去阻止这种浪费所造成的自然资源的消失，以减少对人们健康的影响，减缓生态恶化并保持环境系统的整体平衡。厌氧消化 ACOD 技术可以用来处理食品垃圾，可以达到很好的减容效果并且可以完成能量的回收利用。ACOD 是一条生物操作链，是在缺氧的条件下实现的，有机物质在缺氧的条件下并且在一系列物理化学因素的影响下，会产生气体，而当这些物理化学条件的浓度达到很高时，比如像盐浓度的含量很高时，细菌的活性可能会受到影响。所以中国人在做饭时通常会用到很多盐。盐在 FW 中可以通过影响“细胞系统的渗透压”来抑制厌氧发酵的效率。

本研究的目的是探讨利用不同比例的废弃物联合过剩的消化污泥和食物废弃物共同作用的可行性，该试验利用批罐试验来检测不同浓度的底物和盐含量的影响。该实验的研究结果用于评估与污水污泥共同消化的食物废物的生物潜能。污水污泥和过剩污泥是由污水处理厂（成都第七污水处理厂）提供的，食品垃圾是从公司(博文生物科技公司)收集的。接种物是从成都的第 7 污水处理厂采集到的。FW、SS、inoculum 和 ES 分别被收集了三次，作为新材料。这些底物是从它们的物理化学性质进行考虑的，例如，pH，TS，VS，电导率和含油量。

本实验以沼气为研究指标，探讨了厌氧消化的食物残渣和污泥的理想混合比例。工作分为三个阶段，第一阶段取重量为 300g 的“FW + SS”按照 1 : 0，1 : 1，4 : 1，1 : 4，0 : 1，3 : 7 和 7 : 3 的比例，以不同速度进行食品废物和污水的厌氧消化。 第二阶段是根据第一阶段的最佳混合比进行的，根据 300：300 毫升（食品废物：污泥）的容积比，分别以 1 : 1，1 : 0，3 : 7，7 : 3，0 : 1 的比例，使用不同的底物。在第三阶段，为了检测盐的作用，对在高盐浓度的情况下进行了试验，将氯化钠添加到联合反应器中(1、2、3、4、5)，分别对应 0 g 和 1.2 g、2.4 g、4.8 g、7.2g 的氯化钠。新材料(FW，污泥，ES)用于开始下一个循环。将混合的 FW、SS 和 ES 添加到相同速率的反应堆中(90 + 210 + 300 ml / FW + SS + ES)。根据体积，基质的混合比是 410 毫升。在所有阶段都按照这些比率反一次，在 37℃的情况下停留一段水力时间进行发酵，持续 21 天。第一阶段的结果表明，食物浪费

比为 1:0 的情况下，食物浪费会提高碳氮比(C / N)，从而增加沼气量与污泥量的比值。此外,其他的混合比例对消化有积极的影响,尽管浪费食物会增加产气量，但是在比率为 1：4，3：7 的比例情况下会导致细菌的增加和减少碳氮比例的“C / N”。总的来说，这一阶段的特征参数是稳定的，如 pH 值、VS、TS、EC 和石油含量。在第二阶段，这个阶段是根据第一阶段的最佳比例进行的。结果表明，气体体积产量最高的情况是 1：0。通过减少 VS，我们发现只有一种食物被浪费会使“TS”减少达到最大比例，VS 与 TS 在食品浪费中分别为 5.46%和 7.86%。此外，一些混合比例对于消化过程有积极的影响，如比率为 3:7 时。在消化过程中，污泥中有大量的底物，底物的脂肪含量很高。

本实验研究了氯离子浓度对厨余垃圾和废渣活性污泥的厌氧消化的影响。并研究了生物气的生产性能，对相应的生物气生产进行分析并对钠盐效应进行了研究，对其降解效率进行了分析。随着钠盐浓度的增加，发现在用盐 7.2 克的情况下沼气产量最高，为 1321.5 ml。在用盐 1.2 克的情况下，沼气产量最低，为 1023.61 毫升。在盐浓度范围为 2 - 7.2g 时生物气产量的下降是可以忽略不计的。而在抑制效率＜10%时与此相反，在发酵过程中观察到沼气的产量急剧下降。生产沼气的空白反应器从第一周开始计算，在第一周,盐浓度过高会对天然气的生产起到抑制作用，高浓度氯化钠会导致渗透压过高，这可能引起产甲烷菌的细胞内的水的损失，抑制关键酶的活动。在第二周发酵过程中，沼气产量最高为 7 克，而产量最低的则是 1.2 克，所有 5 个反应堆都产生天然气，分别为 135.65 毫升、79.31 毫升、114.65 毫升、125.64ml、160.65 毫升(1、2、3、4、5)。当其在反应器中出现时，碳水化合物和蛋白质的含量有很大的提高。当 NaCl 的含量从 1.2g 上升到 7.2 g 时，数据表明，NaCl 的增加促进了有机物质的形成。结果表明，纳盐增加了活性污泥中蛋白质和碳水化合物的含量，从而提高了活性碳的浓度，使基质的溶解性更大。第三周的天然气生产的速度比以前慢一些,特别是在一号反应堆(控制),因为剩余污泥含量高而浪费食物,如前所述。随着时间的推移，ES 越少越会增加天然气产量,由于剩余污泥来自二级处理，导致微生物在活性污泥系统中比在基本消化污泥中活性要差一些,因为它包含了复杂的“碳水化合物,蛋白质,脂类和长链碳氢化合物。如上所述，沼气的生产与水解和酸化的步骤有关，因此有必要比较氯化钠在水解和酸化过程以及在食物废弃物的共同消化过程中的作用。结果表明，5 号反应器中化合物的降解速率比其他反应器的低。例如，当氯化钠的水平为 7.2 g 时消化体系的降解率在最后几天较高，这些数据表明，加入 NaCl 促进有机

物的形成。还表明 NaCl 的作用增加了废水活性污泥消化中蛋白质和碳水化合物的含量，较高浓度的 NaCl 会导致较多的溶解底物生成。这项研究的结果对于在有 NaCl 存在的情况下，从食物垃圾中回收甲烷具有重要意义。

关键词：厌氧消化；分批发酵；沼气生产；盐含量；混合比

ABSTRACT

The accumulation of organic waste is thought to be arriving sensitive stages in all places of the world. These wastes demand to be achieved in a sustainable method to preclude elimination of natural sources, a limit hazard to people health, reduce ecology deterioration and keeping an overall equilibrium in the environmental system. Anaerobic digestion" ACOD", as a substitution of food waste disposal, is described by the benefits of reduction size and get back energy. ACOD is a chain of biological operations that take place in the absence of oxygen, where the organic material is converted into a biogas several physical - chemical factors impact the production of gas, and bacterial efficiency may be damped by certain materials when their concentrations arrive high levels like salt content. So salt is usually much in Chinese cooking. Salt in "FW" can inhibit the efficiency of anaerobic fermentation by affecting "the osmotic compression of the cell system". The objective of this study is to evaluate the feasibility of digestion of excess sludge and food waste for the treatment of bio-residues through joint digestion of waste with different ratios, batch tank tests were used to detect the impacts of the ratio of substrates and salt content. The review went for assessing biogas potential of food waste under co-digestion with sewage sludge. The sewage sludge and excess sludge were given by the wastewater treatment plant of (seventh sewage plant of Chengdu), while food waste was collected from the company in Sichuan (Bowen biotechnology com., LT. A biogas potential examine was completed to discover the ideal blending proportion of food waste and sludge for anaerobic co-digestion. Where the work divided into three stages, the first pHase included anaerobic co-digestion of food waste and sewage at different rates depending on the weight 300g "FW+SS" 1: 0, 1: 1, 4: 1, 1:4, 0: 1, 3:7. The second pHase was performed based on the best mixing ratios in the first stage different substrates were used depending on the size of 300: 300 ml (food waste: sludge) 1: 1, 1: 0, 3:7,7:3,0:1. In the third stage, the test was conducted on high salt content in order to detect the effect of salt, sodium chloride on fermentation was added to the co-reactors (1,2,3,4,5) corresponded to 0g and 1.2 g, 2.4 g, 4.8 g, 7.2 g of sodium chloride respectively. The results in the first pHase indicated that the food waste in the ratio 1:0 gave higher production in the volume of gas compared to the other ratios while "pure sludge" gave lower volume of gas, was 3309.3 ml and 391 ml for food waste and sludge respectively, food waste improved the carbon to nitrogen ratio (C/N) and thus increased biogas production compared to sludge alone .On the other hand, the other mixing ratios had a positive effect on digestion, although the waste food is the most productive gas except for the ratios 1: 4, 3:7 due to percentage of SS is greater than the proportion of food waste, it also leads to an increase in bacteria and a decrease in the ratio of carbon to nitrogen "C / N" .. In the second pHase, this stage was carried out based on the best five ratios in the first stage the result indicated that the highest production in the volume of gas was at the ratio of 1: 0.Through TS and reduction of VS, we found that food waste alone has the largest proportion of reduction of “TS, VS” in comparison with other ratios TS”, VS in the food waste 5.46%,7.86 % respectively. Also, the digestion process has a positive effect on some mixing ratios except for the ratio of 3: 7.

The effect of chloride sodium concentrations on anaerobic digestion of kitchen waste and waste activated sludge was investigated. The bio gas production performance, the corresponding bio gas production analysis and sodium salt effect were studied, and the degradation efficiency was analyzed. With the increase of sodium salt concentrations .The highest biogas yield of 1321.5ml was found with salt addition 7.2 g, while the lowest was obtained with addition of 1.2g NaCl the biogas production was 1023.61 ml. where the highest gas production of the concentration of 7.2g while the lowest production was within the concentration of 1.2 g, gas production has reached all five reactors 135.65 ml, 79.31ml, 114.65 ml, 125.64ml, 160.65ml for (1,2,3,4,5) reactors respectively. When NaCl presented in the reactors, the contents of carbohydrate and protein were highly improved. When the rate of NaCl rose from 1.2 to 7.2 g. Those data proposed that the adding of NaCl led to the forming of organic matters. It was also indicated that the effect of NaCl increased the content of “protein and carbohydrate" in waste activated sludge "WAS" digestion, and higher concentration of NaCl led to higher dissolve substrates

Keywords: Anaerobic co - digestion, batch fermentation, biogas production, salt content, mixing ratio

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ABBREVATIONS

AD - Anaerobic Digestion

AMPTS II – automatic methane potential test system

BMP - biomethane potential

BMP15 – biological methane potential

CCHP – combined cooling, heating and power

CHP – combined heat and power

COD – chemical oxygen demand

EC – electric conductivity

EMAS – eco-management and audit scheme

FW - Food waste

GP21 – biogas potential

MCC – microcrystalline cellulose

N – total nitrogen content

P – total pHospHorus content

SM – sludge mixture

TS – total solids content

VS – volatile solids content

WWTP – wastewater treatment plant

ACoD- Anaerobic co- digestion

ES- Excess sludge

SS-Sewage sludge

KW-Kitchen waste

I/S-Inoculum/substrate

Chapter 1 INTRODUCTION

This Policy Position Statement traces the principle issues concerning expanding the levels of co-digestion of waste (at high salt and oil content) together with sewage sludge. It considers the specialized, statistic, economic, and lawful and strategy boundaries to more extensive co-digestion of waste. It highlights territories where achievable open doors exist and where there is a prerequisite for more noteworthy help and considers the general supporting co--digestion can make to “AD” targets, it is set inside the more extensive context arranged expanded levels of AD and ought to be perused in conjunction with CIWEM's PPSs on Wastewater bio solids Treatment and Use. Anaerobic co-digestion of natural matter enhances digester working attributes and its execution.

A pilot-scale co-digestion of high salt, oil content, and sludge (before rotator) showed the procedure dependability of anaerobic digestion. The use of anaerobic co--substrate of "food waste and sewage sludge”, albeit entrenched in numerous European countries, is still at its outset. This procedure has many advantages to offer, with a fruitful application regularly connected with expanded renewable energy potential, exceeding constraints connected with the changeability of food waste and its taking care of necessities before co-digestion. With both controls and water foundations composed and constructed on the premise of direct perspectives and sectorial necessities and conditions and advances from the past in many parts of the world, sewage sludge and food waste digestion operations are likewise under altogether different administrative and administration administrations. With supportability requiring that we don't address single issues in confinement, however, through a frameworks approach that conveys incorporated arrangements, co-digestion of food waste with sewage sludge could become such an answer. In the event that painstakingly connected, co-digestion can convey gainful cooperative energies for the water business and powers in charge of food waste administration. The collaboration of every single applicable partner and controllers to bolster changes to current administrative structures to empower this is proposed as the path forward, especially as their complexity has been recognized as the significant obstacle to the execution of co-digestion. Anaerobic digestion (AD) is a normally happening natural master cess of microbial decomposition in oxygen exhausted situations. Amid the AD procedure, the natural matter is separated into more straightforward synthetic components, for example, methane (CH4), auto on dioxide (CO_2), hydrogen sulfide (H_2S), and fertilizer (slurry). The anaerobic digestion can be spilled into four steps, specifically hydrolysis, acetogenesis, acetogenesis, and methanogens and is by hydrolytic, acidogenic, acetogenic and methanogenic archaea, separately[1].

Methanogens are either hydrogenotropHic or acetogenins including two diverse methane-shaping pathways, to be specific a hydrogenotropHic pathway and acetoclastic pathway. The family Methanosaeta comprises species only utilizing the acetoclastic pathway. Types of the family Methanosarcina can utilize both pathways, while other members of the request Methanosarcinales are methylotropHs or hydrogenotropHic. Other methanogenic orders (Methanomicrobiales, Methanobacteriales, and Methanococcales) applicable for the biogas procedure create methane just by means of the hydrogenotropHic pathway[2-4]. Sludge is rich in nitrogen and follows components, however low in the bio-degradable natural matter. Subsequently biomethane potential (BMP) will be low. Food waste (FW) is a problematic natural waste and is accessible in abun-move. FW is exceptionally rich in unstable solids, which can be effectively converted to methane utilizing an anaerobic procedure. Nonetheless, it, as a rule, has a low measure of supplements. Anaerobic co-digestion is a procedure where at least two substrates with complementary attributes are blended for combined treatment. The most important case is when a master amount of a substrate (e.g. muck or, food waste or sewage sludge with high oil, salt concentrations) [5]. Co-digestion of FW holds guarantee attributable to a higher methane yield and in addition a quickened methane creation rate[6]. Co-digestion of FW can use the supplements and bacterial diversities in different wastes to advance the digestion procedure. Obviously, it has a synergistic impact that overcomes the lopsidedness in supplements and enhances biodegradation. This impact brings about a higher methane yield compared with AD of a solitary waste, which expands the natural content inside the reactor, improves digested adjustment, weakens the potential inhibitory as well as lethal compounds, for example, salts, Na+, and excess oil so on.

Aside from the above advantages, occupying natural waste from landfills takes into consideration the generation of natural composts and conditioners for rural and land utilize, nursery gas outflow decreases, and economic advantages.

Biomass represents a manageable wellspring of renewable energy. It is portrayed by its wealth and offers a safe energy supply. Biomass has been known as organic material created by pHotosynthetic apprehend of heliacal energy and stored as chemical energy [7]. A few natural substances have been utilized for anaerobic digestion. Anaerobic digestion of biomass is a multi-organize microbial process, which produces biogas and digestion buildups as the last items. Biogas is an energy-rich blend of principally methane and carbon dioxide and can be utilized for enthusiastic purposes. Digestion buildups are described by high supplement content and can be effectively connected to soil treatment. The accompanying proposal gives a diagram of anaerobic digestion and biogas generation.

The review went for assessing biogas generation under co-digestion of food waste with sewage sludge in lab-scale reactor frameworks. The particular points included a substrate and digested characterization, the discovery of biogas potential of the substrates and natural methane potential estimation.

1.1 The source and composition of food waste

Food wastes (FW) from various origins, like, domestic and merchant, are being generated at a rising rate due to the growing inhabitance and increasing housing criterions. FW is obtainable all year for a high ratio of domestic waste [8]. Food waste or food misfortune is food that is disposed of or lost uneaten. The reasons for food waste or misfortune are various and happen at the pHases of creation, preparing, retailing and consumption. Current assessments put worldwide food misfortune and waste between 33% and one portion of all food created. Misfortune and wastage happen at all pHases of the food inventory network or esteem chain. In low-income countries, most misfortune happens amid creation, while in created countries much food around 100 kilograms (220 lb) per individual every year is wasted at the consumption organize. A portion of the food waste created by handling can be hard to lessen without influencing the nature of the completed item. Food wellbeing directions can guarantee foods which contradict models before they achieve markets. Despite the fact that this can conflict with endeavors to reuse food waste, (for example, in creature bolster), wellbeing directions are set up to guarantee the soundness of the consumer; they are indispensably vital, particularly in the handling of foodstuffs of creature inception (e.g. meat and dairy items), as contaminated items from these sources can prompt to and are connected with microbiological and compound dangers.

1.2 Treatment technique of food waste

Population in the world still to raise with planning nearing 7.3 billion at 2015. Speedy domestication joins this direction with a predestined "thirds" of the world's human living in huge cities by 2027 [9]. Civilian community in developing states grow by further than 160,000 person every day by day though civilization itself is not related a problem, accidental and unplanned outgrowth can outcome in many environmental problems such as public area and riverside transgression, air, and water pollution, and food waste creation solid waste "MSW" is the most complicated solid waste current, as unfavorable to much uniform waste currents coming from manufacturing and agrarian effectiveness. the slight increments in the "income" can lead consuming modality of human to modification , which the rising sizes of "solid waste" being created would not be a big issue if this waste was perceived as a source and carried out properly" leads to waste kinds and amounts that cause the greater challenge for the townships to treat [10]. Many types technology can be diverted the solid waste typically prepared for a "landfill", like incineration with gas production, composting of organic rubbish, and substance reset. "Gasification and Pyrolysis" are two comparable ways, jointly of which degradation organic matter by offering waste to minimum amounts of oxygen with high temperature. There are many methods previously used in the treatment of food waste like "open Burning, dumps, and landfills…etc".One of the predominant methods of high economic and environmental benefits is aerobic treatment, it biological treatment to reduction organic matter. , meanwhile, it uses " oxygen and the bacteria-free environment" to reduction the material where manure must have areas COD to let the growth of microbes inside the reactor and in the end, we will get the energy[11].

1.3 Anaerobic digestion

Anaerobic digestion is a procedure that utilization microbes that live without oxygen to convert natural matter into bio-gas (methane). It can be connected to any natural matter including local waste, modern waste, agrarian waste, sewage sludge or even uncommon developed bio fuel crops like maize silage. Despite the fact that the anaerobic digestion process is the same whether it is treating sewage sludge or household waste, it is extraordinary for both sorts of waste to be dealt with together. This is primarily because of an absence of commonality between the associations included sewage sludge is discarded by the water utility that creates it, while the local waste transfer is the duty of nearby government.

The best test to the designers in charge of the program was not the innovation, but rather orchestrating family unit waste to be sorted before collection. The achievement of the venture is in no little part because of the cooperation of the nearby open, and the arrangement of good communications that has given their inspiration to sort their waste at source upHeld by a fines framework for family units that neglect to sort. The model plainly works and has exhibited the capacity of current anaerobic digester innovation to co-process family unit waste, mechanical waste, and sewage sludge. For rustic sewage treatment works there is an important lesson to be scholarly.

Biogas is a blend of methane (CH_4), carbon dioxide (CO_2) and a little measure of trace gasses [12]. Which is created by the microbial debasement of natural substances under anaerobic conditions? Anaerobic corruption happens actually in oxygen lacking natural surroundings, for example, organic waste materials ranging from activated sludge (AS), manure and food scraps to square waste and industrial wastewaters may be decomposed in a controlled [13]. Nonetheless, the same microbial process, alluded to as anaerobic digestion, accounts for the arrangement of landfill gas and is broadly utilized for the commercial generation of biogas in present day biogas plants. The composition of biogas changes relying upon the degradable substrate and in addition handle conditions e.g. temperature. Ordinarily, the methane content accounts for 50–75 vol% of biogas, trailed by a carbon dioxide content of 20–45 vol%. Methane is the energy bearer of biogas, subsequently, a high methane content, as opposed to CO_2 content, is attractive for energy creation. The concentration of water vapor differs from 2–7 vol% relying upon the temperature of digestion. Biogas may likewise incorporate hints of nitrogen (N_2), smelling salts (NH_3), oxygen (O_2), hydrogen (H_2) and hydrogen sulfide (H_2S), the last one acting corrosively to metals.

Table 1-1 Bio gas composition includes

Methane	CH_4	Content (vol%)
Carbon dioxide	CO_2	50–75
Water vapour	H_2O	25–45
Oxygen	O_2	2–7
Nitrogen	N_2	< 2
Ammonia	NH_3	< 2
Hydrogen	H_2	< 1

The methane content of biogas is dictated by the biochemical composition of the debasement substrate. Crude protein has the most noteworthy hypothetical methane yield (70–71 Vol%), comparatively, crude fat is described by a high hypothetical methane yield (67–68 Vol%). Nonetheless, crude fat demonstrates an essentially more noteworthy hypothetical biogas yield than crude protein: 1200 Nm3/t-TS compared to 700 Nm3/t-TS, separately. Considering a standard methane content of 50 Vol%, the enthusiastic estimation of biogas is 21 MJ/Nm3.

Anaerobic digestion of natural matter is a four-stage prepares accomplished by the co-operation of a few microbial gatherings. The four pHases incorporate depolymerization of natural substances (hydrolysis), angiogenesis, acetogenesis, and methanogenesis, which deliver biogas and digest as the last results of anaerobic digestion. A nearby co-operation between various microbial gatherings is fundamental for the imperativeness of the microorganisms because of the lower energy yield of the anoxic corruption of natural matter as compared to the thermodynamically more positive vigorous debasement in oxygen-rich situations.

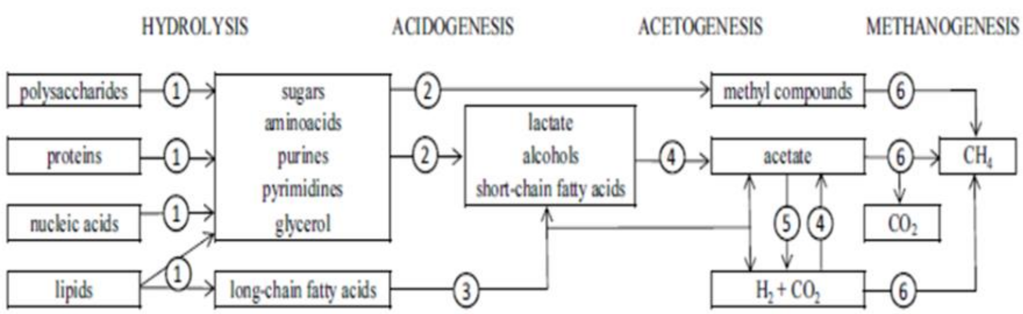

Figure 1-1 Stages of anaerobic digestion of the organic matter

1.4 Potential substrates for bio gas production:

Bio gas can be created from different sorts of biomass containing starches, proteins, fats, cellulose, and hemicellulose as the fundamental components. Lignin-rich substrates (e.g. wood) are unsatisfactory for bio gas generation because of their moderate corruption rate in anaerobic conditions [14, 15]. Because of the assorted qualities of substrates and in addition variable process parameters and maintenance time in the bioreactor, the synthetic composition and yield of biogas are liable to varieties. Verifiable, creature compost and sewage sludge from wastewater treatment have been utilized for biogas generation. In contemporary bioreactors, common feedstock incorporates compost from pigs, dairy cattle, and chicken together with a co-substrate, which conveys a higher gas yield. Common co-substrates incorporate energy yields, for example, maize, search beet, clover, collect deposits, rural wastes of the creature and in addition vegetable inception, civil natural waste from family units, and food waste.

Table 1-2 Bio gas yield and average methane content of different organic substrates VS stands

Substrate	Biogas yield (l/kg-VS)	Average CH4 content (%)
Cattle slurry	200–500	60
Pig slurry	300–700	60–70
Municipal organic waste	150–500	58–65
Maize silage	450–700	50–55

The amount and also nature of biogas is empHatically influenced by the substrates utilized for anaerobic digestion. An extensive variety of studies has dissected the biochemical methane potential of various substrates, giving numerical information. Normak et al (2009) have abridged the biogas yield and its normal methane content for various natural materials as showed. The outcomes uncovered homegrown biomass (silages, feed) and agro-mechanical buildups as promising substrates for biogas creation, the most elevated methane potential was distinguished for drain wastes 458–714 l/kg-VS (unpredictable solids). The (AD) of mono materials (single-digestion) offers some negatives connected to organic features as i. Sludge (S), described by lower organic capacities; ii. the organic of food waste (FW) could have involved inappropriate materials as well as excess ratios of heavy minerals, among others. The ACOD is the AD of several substrates, is a typical choice to take control the drawbacks of single –fermentation [16].

Anaerobic co- digestion technology can render as an exemplary organic waste to decrease path of treating the organic waste, fundamentally food waste as in China, if the performance of AD is made better substantially. As indicated in the on top of tests, the combined anaerobic fermentation together with two or more organic materials with various chemical characteristics would have been an efficacious method to obtain this, which is also proposed by different studies [17]. The high fermentation effectiveness of combined anaerobic fermentation is depending on integral utilities of the various properties of several organic wastes, which can promote the biological impact of fermentation and diversion rate. The mixing up proportions of several materials are subsequently spirited to improve rising the off-unbalanced feeding of fermentation substrate, as proposed in this study, and at the same time, the toxic impacts of toxic materials should be decreased through the digestion operation[18].It is obvious that the combined AD with two or more organic materials blended at appointed proportion could have higher fermentation activity than that of any single material, and the suited proportions should be searched for more organic materials in moreover studies[19].

1.5 Research aim and objectives

1.5.1 Research objective and significant

1. The principle target of this review was to examine the co-digestion of sewage sludge and FW at lab-scale and at pilot-scale and to concentrate the methanogenic differences amid the anaerobic co-digestion handle.

2. The purpose of the study is to investigate of using waste resources for the production of biogas, in particular, using anaerobic co-digestion with sewage treatment activated sludge and food waste at mesopHilic temperature.

3. Moreover, it is the possibility of studying the optimal ratio mixture of food waste and sludge and feed size of inoculum.

4. And the proportion of salt in the fermentation will increase, so we can observe an increase in the proportion of salt on the results of fermentation.

This experimental study discusses to start the method of indicating the scalability of "anaerobic fermentation" at excess salt. This will be accomplished by comparing different ratios of biowaste and sludge in terms of biogas production, biogas composition, VS-destruction, and pH. By focusing on scalability and the reproducibility/transferability of results within and between (different ratios from oil and salt), the results that will be obtained from this study should prove beneficial to other researchers working on anaerobic co-fermentation of (high salt). Specifically, the results will help in determining the predictive value of bench-scale studies and will uncover potential issues associated with scaling.

The work from this project will help shape the direction the environmental engineering department’s biofuels lab will take in terms of future equipment purchases and bench-scale system designs by highlighting areas in which improvements can be made in the situation (high salt content Chinese traditional food). Another important aspect of this research project is re-designing the bench-scale system set-up. As part of this process, efforts will be made in determining the ideal bench-scale system design, so that data collected from future students will be as accurate and consistent as possible.

1.5.2 Research content

The main objective of this project was to investigate the stability of the anaerobic co-digestion system, which has been developed by the Southwest Jiaotong University, under the effect of different types of mixing ratios and salts. The performance studied in this project included the effects mixing different ratios and high content of salt. The first and second parts of this project looked into the improvement of the co-digestion system treating by multi substrates from food waste and sewage sludge .The last part of this project looked into the effect of NaCl salt on the fermentation system. The system treating food waste and WAS with different NaCl concentrations, i.e., 0(Control), 1.2g, 2.4g, 4.8 g, and 7.2 g were investigated.of digestion. The diagram of proposed work is as follow：

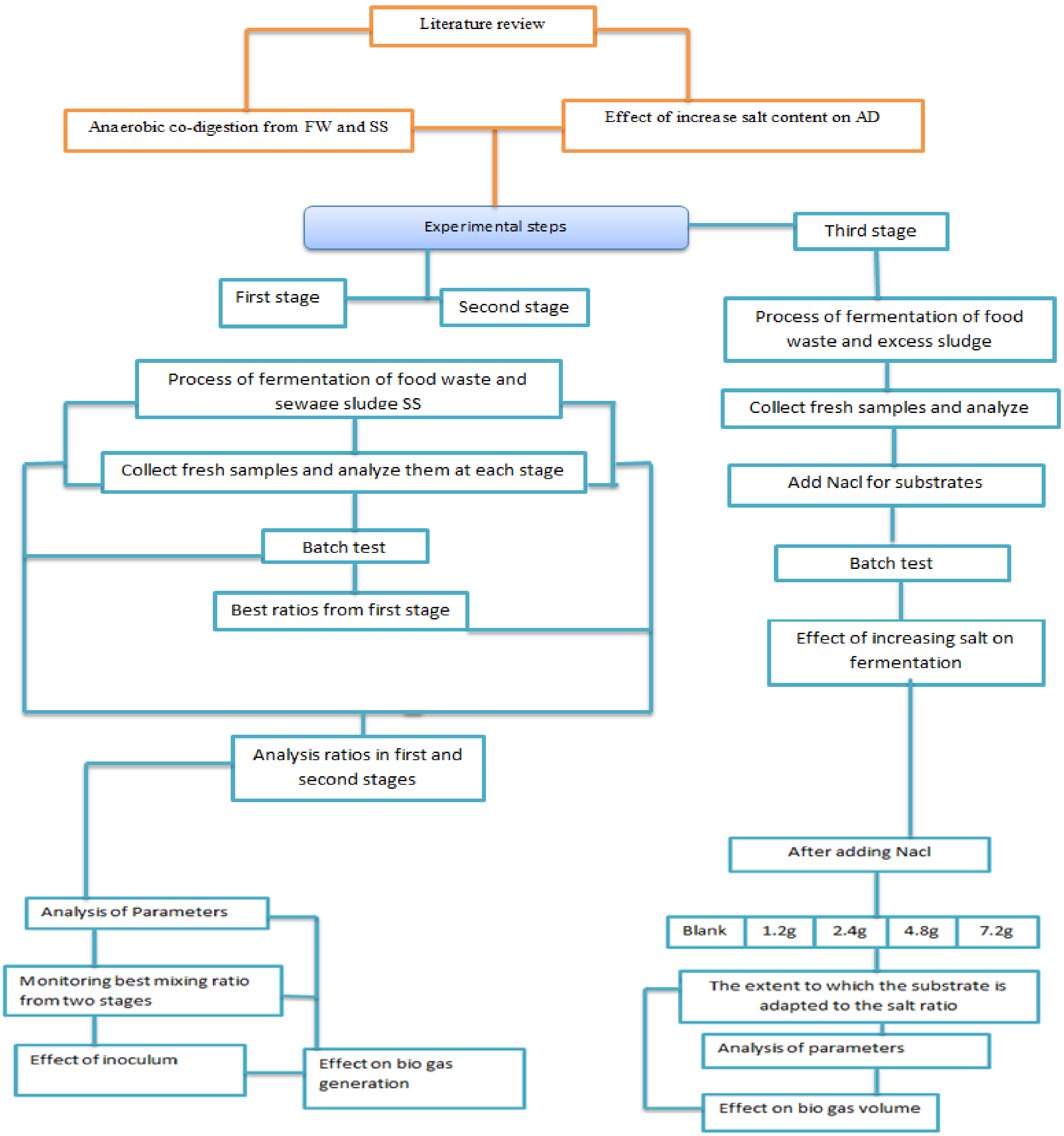

Figure 1-2 Figure 3Diagram for proposed work

Chapter 2 LITERATURE REVIEW

2.1 Anaerobic digestion

The date of AD can be traced back 2100 years ago by the anaerobic fermentation of beast manure in China and India [5].In the new age, after the invention of CH4 emissions from naturalistic anaerobe reported[8] by Volta in 1776, humans began to gather the natural gas and utilized it as a fuel, essentially for lighting. But, it took spending the last of 1899 until anaerobic fermentation was been utilized for the treatment of biowaste"solid, liquid" [6].The initial anaerobic plant was recorded to have been built in Bombay, India in 1850. Anaerobic digestion arrived the UK in 1894 when biogas was generated from a sludge treatment facility to fuel lamps in Exeter [7]. The usage of this technology with the major purpose to decrease and stabilize solid biowaste acquired and the introduction of sludge systems in the midst of after 1900 in last century. To now, the anaerobic system of sludge is as yet a criterion application for new activated sludge plants.

Suitable strategies must be received for biosolids taking care of and transfer in view of the way of the biosolids being referred to the controls for biosolids transfer are directed by the.In light of the controls, biosolids are extensively ordered into two classes:

Class a Biosolids are those in which the pathogens are lessened to levels beneath current perceptible levels. These can be specifically dewatered and utilized for land application. These sorts of biosolids are frequently thickened, dewatered and arrive connected. Class B Biosolids are those in which pathogen levels are "probably not going to represent a danger to general wellbeing and the earth under particular – utilize conditions". These solids can't be sold or specifically arrive – connected. The gathering of solid organic waste is thought to arrive ticklish levels in almost all parts of the world. These organic wastes demand to be achieved in a sustainable technique.Anaerobic Co-digestion which is considered to be one of the generality applicable options for recycling the organic portion of solid waste[9].Among implementation of environmental biotechnology for contamination minimization from biowaste, anaerobic co-fermentation has been assumed to be of utility because of its cost-performance in primary development as well as working. Moreover, the ability of energy reclamation from biowaste to released biogas has been evidenced. Anaerobic digestion of biosolids created in a wastewater treatment plant has been done for quite a long time. The easiest frameworks utilize a solitary, blended reactor with no reuse stream. A water powered maintenance time (HRT) score of 10 – 30 days (10 days being the base required HRT at 35+2 degree Celsius is generally utilized). Nonetheless, HRTs of 15 – 20 days are regularly utilized for most extensive scale operations. The solid maintenance time (SRT) is identical to the HRT for conventional, suspended development anaerobic digesters [10].

2.2 Anaerobic co-digestion “ACOD”

Co-digestion is preferably utilized for the charitable product of anaerobic digestion of solid organic wastes due to its numeral advantage. For example, reduction of the toxic component, increased load of biodegradable organic matter, improved equilibrium of nutrients, the synergistic influence of microorganisms and better biogas yield are the potential benefits that are achieved in a co-digestion process. Anaerobic co-fermentation can easily exceed the methane yield of biowaste digests by up to 190 %, be based on the operating factors and the features and the amount of co-biomass utilized [11, 12].Co-digestion of an organic waste also provides nutrients in excess all classes of biomass, including carbohydrates, proteins, lipids, cellulose, and hemicelluloses, as main compositions, are proper to be utilized as substrates for biogas production. Sewage sludge from aerobic wastewater treatment, animal manure, crop residues, organic wastes from agriculture-regarding factories, meat and fish, industrial wastes, dairy wastes, food waste, collected municipal organic solid waste from markets and households and energy crops are the substrates generally applied to feeding anaerobic digesters [13-15].

2.3 Review of ACOD from FW and SS

A-Co can be utilized for various kinds of organic waste. Presently, carrying the cost of the co-organic waste from the production point to the AD station is the first choice standard. In spite of this fact, it is as yet important to select the better co-substrate and to choose the optimum mixing ratio with the aim of enhancing synergies, reducing harmful components, improvement the bio-methane generation and not deactivate digestion system quality [1]. various studies have shown that admixtures of agricultural, domestic and processing wastes can be digested successfully and efficiently with each other[16]. ACOD is not an unprecedented idea, precocious bibliograpHies to this operation utilizing sewage sludge(SS) and the food waste (FW) found in the late 50 years ago [17-20].Anaerobic co-fermentation consists of an admixture of different biowaste with full properties and has assured to be a dependable selection for improving bio-methane product[21].A stimulatory impact on the composition of methane gas has been observed when sewage sludge was co-digested with food solid waste. The co-digestion of food solid waste with sludge in a different ratio of producing the high amount methane gas (1:1, 1:2, 2:1), compared to food solid waste single. Similarly, in a two-stage anaerobic fermentation system [22].Moreover, since waste activated sludge has minimal biodegradability; the anaerobic digestion of sludge has the weekly activity for the processing.

One of the different planning to promote the implementation of anaerobic fermentation is the co-fermentation of sewage sludge (ss) with other bio-wastes as it increments bio-fermentation organic material and supplies a feedstock with a best C/N ratio[23, 24].AD as a mono substrate may suffering different damping involving piling up of VFA [1. Thus, these bio-wastes (FW, SS) could be helpful in ACOD for rising energy recovery as well as organic waste destruction [25]. Mixing of fresh food waste(FFW) and SS outputs biogas with a high ratio at (15-30) days. According to the previous study, the researchers found the best nutrition ratios of fun / s with a fixed vaccine that could contribute to the enhancement of biogas production It was (1: 0,1: 1, 2: 1)[26]. In a previous study indicated the high methane yield when a mixture of olive mill sludge and olive crush solid waste (2:1) was co-digested. The process has also been beneficial in getting a valuable sludge which can eventually be utilized as a soil amendment after treatments[27].

Also in another study shown anaerobic co-digestion in different ratio of kitchen waste ,sludge and fixed inoculum in two cases A, B every day monitoring got the best result in two cases-A of kitchen waste and sludge (2:1), where have used 6 kg kitchen waste, 18 sludge and 6 kg inoculum and in B 8Kg food waste, 16 sludge(2:1.3) , 6 inoculum under biogas production during 22 days and under mesopHilic temperature [28]. Estimated the rendering of anaerobic digesters utilizing a mixture of apple waste and swine manure. This admixture improved the biogas product by approximately 18% and 49% at mesopHilic temperatures, compared to the utilize of swine manure only[29].The more appealing way seems to be the anaerobic co-digestion of sludge with food waste (FW) or with another kind of biodegradable waste generated. The advantage of the sludge and biowastes co-fermentation include better biogas product, higher loading of biodegradable organic matter, improvement equilibrium of nutrients, etc[30].Biogas production from sludge between 0.25-0.4 m3/K. But Co-fermentation of sewage with FW can improve the biogas yield between 0.4 and 0.6 m3/Kg[31, 32]. ACOD of FW: ESS ratios indicated by Wen and .el. In the four statuses when ESS: FW are 1:4, 2:1, 1:2 and 4:1, the VS degradation rate reduce from 33% to 10.4%. It is clear that in the status of ESS: KW=(1:4,2:1) the VS degradation the rate is the higher, the like as in COD reduction, which points a synergistic impact between the ESS and the food waste in expressing of anaerobic co-digestion [33].

In the former study have been pointed, co-digestion of SS (sewage sludge) with rice straw at various ratios (1:2, 1:0, 2:1 and 3:0, 4:1%), rice (organic waste) to (SS) based on weight, was completed utilizing batch digestions. results indicated that the (SS) with rice improved the ratio (C/N) and then rose biogas yield at mixing ratios (4:1,2:1) than the sludge digestion [34]. A similar study indicated that the digestion processes unsuccessful at the proportion of 0: 1(FW: SS), and there was no methane generation. The presence of sludge caused high acidification, but there was no VFAs gathering at the finish of the fermentation [35]. But another study indicated that the maximum biogas of the three feed mixtures were 0.2 of 1:4, 0.96 of 2:1 and 1.15 m3 of

CH4/(m3•d) of 1:1 ratio at an HRT of 20 d with batch reactor at 37 C that mean optimum operating conditions of the biomethane yield was found to be at an HRT of 20 d with a feed mixture ratio of 1 WAS :1 FW not different too much from 2:1(FW:SS) percentage as related work in my research [36] . The SS: FW blending proportion impacts the ACOD.

When the amount of FW considered for more than 80% of the admixture, the co-fermentation implementation was most favorable. In contrast, the use of lower amounts of FW than SS upset the stability of the process, most likely due to retention in the hydrolysis of the organic case and unstable processes concerning to VFA accumulation. In the previous study, the optimal status got along with to (1:4,0:1) mixing ratio(SS: FW) ; under these circumstances, and faster substrate devolution, as well as higher biogas production, were also acquired compared to the ratios 1:0, 8:2, 6:1and 4:2[37] .Other research indicated the biogas production from the co-fermentation of canteen FW and SS. Batch tests were implemented under several ratios1 : 1 : , 1 : 2 , 1, 2 : 1, 3 : 2 , 4 : 2 , 6 : 5 , 8 : 5 , 10 : 3 , and 0:1 (canteen FW : SS) at 37 temperature. The biogas generation was recorded daily for a retention period of 17 days. The results investigated that fermentation mixing ratio of 1:: 1, 2:1 was recorded to be best, which produced the biogas yield to 88.9 l/d [38].Anaerobic co-digestion of food waste and sewage sludge for hydrogen creation was performed in serum bottles under different unstable solids (VS) concentrations (0.5–5.0%) and blending proportions of two substrates (0:100–100:0, VS premise). Through reaction surface system, the exact conditions for hydrogen advancement were acquired. The particular hydrogen creation potential of food waste was higher than that of sewage sludge.

Be that as it may, hydrogen creation potential expanded as sewage sludge composition expanded up to 13–19% at all the VS concentrations. The greatest particular hydrogen generation potential of sugar COD was found at the waste composition of 87:13 (food waste: sewage sludge) and the VS concentration of 3.0%. The relationship between starch concentration, protein concentration, and hydrogen generation potential showed that improved protein by including sewage sludge may upgrade hydrogen creation potential.

In AD, suitable (C/N) percentage is essential for efficient fermentation. However, unbalanced C/N ratio in the SS dampens the anaerobic digestion effectiveness due to the formation of ammonia(NH4) and VFAs, Newly, various organic materials with higher content of organic C have been joined with sludge in an anaerobic co-digester to improve carbon(C) to nitrogen (N) percentage[39].Anaerobic co-fermentation of SS with various organic material has been investigated such as origin -isolated organic solid waste, candy waste [14].

Domestic waste, food waste ...etc.According to on the outcomes from batch tests, food waste can be added at percentages up to 49%-50% (v/v, FW: SS) without inhibition to the ACOD system . generally these outcomes expose the high possibility of co-fermentation FW with SS to promote biogas production compared than ss alone [40].The most extreme particular hydrogen creation rate was. Food waste and sewage sludge were, in this way, considered as an appropriate fundamental substrate and a valuable assistant substrate, individually, for hydrogen creation. The metabolic outcomes demonstrated that the aging of natural matters was effectively accomplished and the attributes of the warmth treated seed sludge were like those of anaerobic spore-framing microorganisms [41]. In light of the measure of books and writing accessible, obviously, anaerobic digestion of civil sewage sludge is a very much considered and comprehended the process. The measuring and outline of anaerobic digesters have been considered in detail. Anaerobic digestion is the most broadly utilized technique for sludge adjustment, as it puts bio-solids to great utilize and diminishes the energy use of the office fundamentally by creating methane gas [42].Such digesters should be blended completely and great blending is pivotal to their execution and viability [10].Such completely blended, suspended – development anaerobic digesters might be fomented by either recycling the digester gas produced by methanogens or by giving mechanical unsettling/blending [42].

Digester execution is a component of a few factors, each of which can fundamentally affect the working of the digester. These parameters have been portrayed in extraordinary detail in a few standard course readings and writing. They have likewise been intricately portrayed in the government and state directions.

Execution of an anaerobic digestion process is much subject to the sort and the composition of the material to be processed. The impacts on the corruption procedure of co-processing distinctive sorts of waste were inspected in two research center scale examines. In the principal examination, sewage sludge was co-processed with modern waste from potato handling. The co-digestion brought about a low supported framework and when the portion of starch-rich waste was expanded, the outcome was a more touchy process, with process over-burden happening at a lower natural stacking rate (OLR). In the second examination, pig fertilizer, slaughterhouse waste, vegetable waste and different sorts of modern waste were processed. This brought about a much-cradled framework as the fertilizer contributed to high measures of alkali.

In any case, take note of that alkali may be poisonous to the small scale life forms. Despite the fact that the conversion of unpredictable unsaturated fats was incomplete the procedures functioned admirably with high gas yields, 0.8–1.0 m3 kg−1 VS [3].

Food waste (FW), essential sludge (PS) and waste enacted sludge (WAS) were portrayed and observed to be complementary in the concentrations of starches, aggregate Kjeldahl nitrogen (TKN), PO4–P and some metal for organic hydrogen generation. Additionally, FW was found to have low pH buffering limit while the qualities for PS and WAS were generally higher. An anaerobic poisonous quality investigation (ATA) got from a methanogenic ATA protocol demonstrated that these waste materials had no harmfulness to hydrogen creation. Adding pHospHate support to the FW fundamentally enhanced hydrogen creation while beginning pH was 7.0 [43].

Co-digestion of FW and sewage sludge was considered utilizing a bunch respirometric development framework. All combinations of the feedstocks (FW+PS, FW+WAS, and FW+PS+WAS) indicated upgraded methane creation potential as compared with the individual wastes. A blending proportion of 1:1 was observed to be the best among the proportions tried for each of the three co-digestion bunches. A methane yield of 112 mL/g unstable strong (VS) included was gotten from a combination of FW, PS and WAS. This yield was proportional to 250 mL/g VS added if just FW contributed to hydrogen generation. The explanation behind the improvement of methane generation was proposed to be multifold in which the expansion in cushion limit in the co-digestion blend was confirmed.

Anaerobic co-digestion of food waste with sewage sludge, albeit entrenched in numerous European countries, is still in its earliest stages in the UK. This procedure has many advantages to offer, with an effective application frequently connected with expanded renewable energy potential, exceeding constraints connected with the fluctuation of food waste and its taking care of necessities before co-digestion. With both controls and water frameworks outlined and constructed on the premise of straight perspectives and sectorial necessities and conditions and innovations from the past in many parts of the world, in the UK, sewage sludge and food waste digestion operations are likewise under altogether different administrative and administration administrations.

With maintainability requiring that we don't address single issues in disengagement, however, through a frameworks approach that conveys incorporated arrangements, co-digestion of food waste with sewage sludge could become such an answer. In the event that precisely connected, co-digestion can convey gainful cooperative energies for the water business and powers in charge of food waste administration.

The collaboration of every pertinent partner and controllers to bolster changes to current administrative systems to empower this is proposed as the route forward, especially as their complexity has been recognized as the real obstacle to the execution of co-digestion in the UK [44]. Biochemical methane potential (BMP) test was utilized to assess the anaerobic biodegradability of food waste (FW), waste enacted sludge (WAS), and the blends having the proportions of 10:90, 30:70, 50:50, 70:30, and 90:10 (FW: WAS) on an unstable strong (VS) premise. The carbon/nitrogen (C/N) proportion and the biodegradability of the blends enhanced from 6.16 to 14.14 and expanded from 36.6 to 82.6% as the FW extent of the blend expanded from 10 to 90%, individually. The dependability and execution of the single-stage anaerobic digester (SSAD) for the co-digestion of FW and WAS were examined, worked at the water driven maintenance times (HRTs) of 10, 13, 16, and 20 days with five blends at 35°C, separately. Amid every one of the examinations, there were no sign of disappointment, for example, low pH, inadequate alkalinity, smelling salts restraint, and the collection of unstable unsaturated fats (VFAs) in any of the digesters, and the cradle limit was the most astounding in the digester bolstered with an encourage blend of 50:50. The ideal working conditions of the SSAD were observed to be an HRT of 13 days and a blend of 50:50 as far as the cradle limit of the digester and the gushing VS concentration, the methane content of the biogas created and the particular methane generation (SMP). The VS expulsion proficiency, biogas creation rate (GPR), and SMP in this condition accomplished 56.8%, 1.24 m3 m−3d−1, and 0.321 m3 CH4 kg−1 with a natural stacking rate (OLR) of 2.43 kg VSm−3d−1[45]. Past study was noted that organic food wastes co-digested with manure improved the biogas yield potential as compared to just muck alone[46]. Lower organic content (volatile solid /total solid) and lower C: N ratio in a combined sewer mode in China are the two primary reasons for this inactive performance.

Combining food waste(FW) to sewage sludge(ss) for co-fermentation not just raise the organic content and C: N ratio of the anaerobic digestion but also improves biogas yield; at the same time, salinity and oil concentration in the food waste could also be watered [47].

In past review, the study was completed to control the declining efficiency of anaerobic co-fermentation of sludge and food waste (FW) by joining temperature- digestion, batch system, and. It was shown that the co-fermentation of sewage and FW conducted in promoted VS removal and methane generation rate. At the OLR of 2.5 g , the batch co-digestion system reported the highest volatile solid removal (63.2%), methane production (1.29 l/g solid added and methane generation rate (1.5 g/l/d) than (1.29 l g/l/d) of the mesopHilic batch co-digestion[48] .Operation stabilization and efficiency of high concentrations solids of anaerobic co-fermentation of diluted sludge and kitchen waste (KW) in differentiation with single digestions were inspected. System balancing was amended in co-fermentation with co-bio waste. For digestion of diluted sludge, the addition of food waste not just improved reaction stability but also promoted biogas yields [49].Some studies have indicated that the pretreatment, addition of the inoculation, co-fermentation of different types of organic waste during the digestion process can improve the biogas production. The impact of inoculation addendum, pre-treatment of the substrate, and temperature on the biogas results discovered that the impact of inoculation addition was more significant than alkaline pretreatment of bio-waste materials[46]. Another study proceeded to assessment the biogas product potential from domestic organic solid wastes when treated separately with two different inoculum sewage sludge and digested maize silage. The results pointed that higher quantity of 97 L/kg of biogas was got from municipal organic waste and sewage sludge blend [50, 51].

Basing on many reports, hydrolysis betterment can be accomplished through suitable pre - treatments which have apparent links to the rising of biogas productions. Pre- treatment procedures for food waste (FW) can be biological, mechanical or chemical. In this research project was to use mechanical way. This pre-treatment is generally pursued to minimize particle volume. Combination to decrease the size of wastes supplies many benefits including the increment of disbanded components due to cell tear, an exhibition of surface parts which were already inaccessible for microbial declination and modification of the structure such as the celluloses arrangements[52, 53].

Our work also focused on changing the ratios in the second round (7: 3.3: 7.1: 1.0: 1.1: 0,1:9) (food waste: activated sludge). Our work also focused on changing the ratios in the second round (7: 3.3: 7.1: 1.0: 1.1: 0) (food waste: activated sludge). Where there have been studies related to the subject indicated that the ratios could be enhanced biogas generation or causing inhibition for the system. In a previous study, different percentages of FW and sewage were used (3: 7, 7: 3.1: 1).

The test outcomes indicated that the most VFA production was 97.4 g / kg-TS at the optimal cases. moreover, biogas production in a 22 HRT batch operated digester (at the proportion of 7:3 and pH of 6.5.) was higher than 125.0 L / kg-VS [54].Other authors found that mix FW: SS by the proportions of 1:8, 7:3, 1:0, 0:1 and 5:5. It indicated that best ratios were (7:3, 1:0) generated (350, 289) mL/g of biogas. The results proposes that as the blending ratio of FW increases, the biogas productions rises as well instead than fermentation only sludge individual [55] .according to past study indicated better blending proportions were (1:0,1:1) (300 fixed inoculum) were useful in upgrading the biogas ratio more than the (domestic sludge

DS) operated individually [56] .The impact of the substrate to inoculum ratio ((S/I ratio)) on an anaerobic system in a batch mode of the organic food waste (OFW) is very influential in order to get optimal treatment. The maximum magnitude of biogas generated was 1,551 ml of mixing fraction (1: 0)(FW: SS with fixed inoculum) where the ratio of food to inoculum was 1.6 (36.25 g / 22 . 6 g) compared to other ratios where the rate of food was low [57]. Reduction in the production of biogas in the case of the mixing ratio, which includes a larger proportion of inputs from the "SS than FW", which adversely affect the efficiency of the work of digestion [58].

2.4 Factors effect on biogas yield

The biogas product is influenced by many factors including kind and type of substrate, microbial composition, temperature, retention time, PH, mixing, and inhibition factors etc [59, 60].

2.4.1 Solids Retention Time (SRT)

SRT is the compelling measure of time that the influent spends in the anaerobic procedure. It is characterized by the proportion of reactor volume to the stream rate of material all through the reactor. SRT is an urgent parameter that influences every one of the pHases of anaerobic digestion; i.e., hydrolysis, aging, and methanogenesis. SRTs of as low as 10 days have been accounted for to function admirably with digesters. In any case, the directions command an SRT of no less than 15 days for Class B pathogen decrease (EPA, 2003). Ordinarily, SRTs of 15 – 25 days are utilized [61].The better performance for biogas yield for this operation is 21 days of HRT of anaerobic fermentation with maximum biomethane production rate of 1.9 l/d. The average maximum methane yield is 65.6% [62].

Minimum SRT for anaerobic fermentation process are in the domain of 2-6 days basing on the temperature. .Hydraulic retention time usually varies from 10 to 25 days basing on the temperature [63]. The longer a biomass is kept under suitable reactor conditions the more integral its biodegradation will become. But the reactor average will reduction with increasing HRT. The disadvantage of a longer HRT is the rising reactor size needed for a given size of the substrate to be treated. A shorter RT will lead to the highest production rate per digester volume unit, but a lower overall degradation [64]. Retention time in big part depending on the temperature of the biodigester.

Usually, 40-100 days RT is needful for biodigesters operating in the psychropHilic temperature range, 15-40 days for mesopHilic temperature, and 15-20 days for thermopHilic temperature [65]. It is nonetheless, all around acknowledged that a specific least SRT is essential for digester operation. 5 days under mesopHilic conditions is an absolute necessity for methanogens to flourish. It likewise included that a wellbeing variable of 3 – 20 times this esteem is required for effective operation of anaerobic digestion frameworks. The US EPA Process Design Manual for Sludge Treatment and Disposal (1979) states that while most frameworks function admirably inside the common SRT score of 15 – 25 days, longer SRTs might be required for wastes that contain extremely complex compounds and subsequently require more noteworthy time for adjustment. In view of the sort of temperature utilized, anaerobic procedures are named mesopHilic and thermopHilic digestion. MesopHilic digestion utilizes temperatures of 30 – 40 °C, while thermopHilic digestion utilizes temperatures in the scope of 50 – 60 °C [66].

2.4.2 Temperature

Conventionally, frameworks are intended to work in either the mesopHilic or the thermopHilic temperature extend. In any case, more current advancements utilize multistage forms that utilize mesopHilic and thermopHilic digestion at various stages [42]. Many investigators have noted important effects of temperature on the microbial group, operation kinetics and stabilization and methane production[67].Lower temperatures through the reaction are known to reduce microbial growth, biowaste employment[68] .furthermore, lower temperatures may also lead to a drain of cell energy, a seepage of intracellular materials or full lysis [69, 70].In highest temperatures lower biogas product because of the production of volatile gases such as ammonia which put down methane activities[22, 71].Mostly, anaerobic fermentation is carried out at mesopHilic temperatures The process in the mesopHilic t found that the better operational temperature was 35 C with a 20-day digestion temperature domain is almost suitable and needs a smaller energy expense.

Overall, a temperature domain between 35– 37 C is deemed stable for the production of biogas and a change from mesopHilic to thermopHilic temperatures can cause a severe reduce in biomethane production until the necessary populations have increased in number [16, 31, 72, 73].Noted a previous study about the impacts of temperature on anaerobic co-fermentation of food wastes with livestock manure is investigated The operating temperatures utilized in this study were (35, 45 and 55)°C respectively. The better biogas yield rate was happened at about 20 days for all the three statuses. highest biogas production average was in the order of biogas production at 55°C>35°C>45°C., On the other hand, progressive biogas production was also found to be higher at 55°C followed by 35°C and 45°C. It is clearly spotted that maximum biogas production rate was promoted by the thermopHilic bacteria at and mesopHilic bacteria, while at 45°C, the active of the methanogenic bacteria is not that efficient [74].

2.4.3 Substrates

All types of biowaste including carbohydrates, proteins, lipids, cellulose, and hemicelluloses, as master compounds, are stable to be utilized as materials for biogas production. Biogas can be created from very biowaste. Substrates utilized today in anaerobic fermentations involve sludge, wastewater, domestic food waste, various industrial biowaste, slaughter place waste, muck of cattle and energy yields[75].

Among implementation of environmental biotechnology for contamination minimization from biowaste, anaerobic co-fermentation has been assumed to be of utility because of its cost-performance in primary development as well as working. Moreover, an ability of energy reclamation from biowaste to released biogas has been evidenced. , anaerobic co- fermentation of oil- biowaste is not ever more cushy and modest since anaerobe is completely susceptible to oil -rich cases as well as to medium compositions of fatty biowaste digestion system [76].

Lipids are Described as fats, (oils) and (greases). They are usually present in food wastes and in some wastewaters, like those produced by slaughterhouses, dairies or fat strainer. Lipids are appealing for biogas yield due to the high number of C and H, which implies a high theoretical methane production, and also fat, oil grease is stable for anaerobic co-digestion treatment due to its highest biomethane yield possibility, 0.9-1.8 Lg-1 at 60-70% methane [77, 78]. However, they can too present many problems like failure of methanogenic bacteria and adsorption onto biowaste that can cause sludge flotation and be unsuccessful[79-82].Lipids (FOG) usually mention to the lipid-rich substrates produced from wastewater and food processing like restaurants. This type of biomass is damaging for gathering systems (drains, pipes) as it sticks to walls and causes closing. moreover, direct drain in the environment is considered hurtful to the environment[83-85]. Several studies have indicated that co-fermentation of FOG in domestic anaerobic co-digesters can rising biogas yield from 30-82%, with smaller experimenter studies performance almost 180% excess in bio-digester gas yield [86-88]. The fat, oil, and grease from wastewater treatment arose the methane production potential when co-fermentation with organic foods waste.

Beneath mesopHilic conditions and a fodder ratio of 1:5 (lipids to food waste f), methane yield increased from 0.4 L/g VSfeed to 0.6 L/g VSfeed in a 6-liter lab-scale digester [1, 89]. For the time being, lipids waste, also named fat, oil, and grease (FOG), has become an interesting material for anaerobic co-fermentation because it is produced in high quantities by many industries. Its high theoretical methane production in differentiation with other biomass makes lipids wastes an eligible substrate to treat in the anaerobic co-digestion system[90].There is almost difference relating the irreversibility of the inhibition due to the appearance of precarious lateness pHases in the biomethane yield[82, 91].To solve these problems, fats, oil, grease is often co-fermentation with different biowastes like sludge or manure. motivating for this co-biowaste is the exuberance of buffering compounds like bicarbonate(HCO3) and nutrients. Many researchers indicated that the co-fermentation of sewage sludge and oil are obtainable for lab scale the results reported biogas production increases up to 150 % [78, 88, 92].

Some studies conducted on anaerobic fermentation of fat in different proportions.The effectiveness of the lipid(oil) on the anaerobic co-fermentation of domestic biomass waste and activated sludge in the batch reactor at mesopHilic temperature. The impact of rising the (VS) of oil from 0.3% to 77% was inspected. Results indicated that oils in domestic biomass waste could promote the biogas yield. The results reported that a oils concentration of 60% of total volatile solid was the inhibition concentricity. Methane production increased with rising oil(fat) concentration. but when oil concentration rose 70%, biogas yields reduced clearly[93].Similarly, a study indicated that the most concentration of grease to digest with sludge-activated (AS) was examined in the batch test. results showed when the ratio of grease rose from 0% to 65%, methane yields rose by more than 61%. When the grease ratio rose from 65% to 85%, the bioreactor production reduced by more than 70% [94].

Nominated bio-waste can have a high content of cellulose, especially food scraps or food treatment wastes, which include the unsound for eating part of manufacture, i.e. fruit and vegetable. Cellulose is a long series carbohydrate compound of crystalline glucose polymers. In cellulosic plant substance, crystalline cellulose is related with ragged parts of hemicelluloses and pectin [95].

Main features of microbial cellulose using are checked at successively great levels of collection involving the composition of cellulosic biowaste. Cellulosic biowaste has a very highest carbon: nitrogen ratio in the domain of 170 to 1000, whilst the optimum C: N ratio bespoke for anaerobic fermentation reaction is 20/30 [96-98].Lignocellulosic materials obtainable for anaerobic fermentation can be split into forest waste remaining, lignocellulosic waste remaining from the agriculture, the lignocellulosic waste current flowing from manufacture make from the pulp and paper industry [99-102].

Carbohydrates are the master compounds of biowaste from the agricultural part, food manufacturing industries and origin -class organic of domestic trash [103]. These biowastes are highly lying down to build of organic acids at fermentation causing to reactor souring (acidification). The volatile acid (VA) excess and causes to later decline in pH, if the acid stage efficiency in the digester takes control over the methanogenic production. Hence, anaerobic co-digestion of this biowaste are highly basing on the ratio of acid and methane reaction. However, little studies centralized on bio-degradation features of protein and carbohydrate. These studies scanned detailed bio-degradation features of protein and carbohydrate in order to acquisition insight into organics elimination during anaerobic co-fermentation. Results pointed that carbohydrate was most efficiently degraded than protein [104]. Several researchers indicated the biodegradation efficiency of these components (carbohydrate and protein) after sludge anaerobic co-fermentation. Spotted that 40% of protein and 55% of carbohydrate was degraded after anaerobic co-digestion for the sludge [105].In another study indicated that the latest destruction efficiency of protein and carbohydrate was 30% and 54%, respectively [106].

2.4.4 PH

Supposedly the foremost factor of the validity of an anaerobic co-digestion is its pH, many portions of the microbial metabolism are greatly impacted by pH differentials in the bioreactor. Though the passable enzymatic performance of acid step bacteria can happen at pH 5.5, methane production only at the highest average when the pH has remained in the balanced range. generality anaerobic reaction including methane releasing bacteria working in a pH range of 6.5 to 8.5, but optimally at a pH of 6.8 to 8, and the average of methane yield may reduce if the pH is below than 6 or more than 8.5 reported that an anaerobic fermentation of food wastes with pH at 8.0 led in a high rate of reaction with about 88% of total organic content and 85% of COD were removed. [107, 108] . The best domain of pH for the anaerobic system has been pointed to be between 6.5 and 8.0, with pH values between 6.5 and 7.5 being quixotic for suitable digester process. The domain of pH values stable for anaerobic formation has been indicated by several researchers, but the better pH for methane production has been found to be nearly 7 [109]. Another study indicated that methane formation in an anaerobic co-digester takes place efficiently at pH 6.5– 8.2 [110]. However, the digester pH can be decreased by the realization of organic acids as well as carbonic related with the highest concentrations of CO2 gas [111]. Some authors indicated that to save a balanced and suitable pH in the digester, it is important to have a high and steady alkaline [112]. Alkalinity is the limit of the reactor to kill corrosive and in this manner oppose a bringing down in pH. According to values distributed by the EPA in 1979, alkalinity values for digester influent are generally in the scope of 500 – 1500 mg/L while those of the emanating are considered to be "great" when they are in the scope of 2500 – 3500 mg/L. VFAs can develop in the reactor and cause issues. Low VFA levels are an indication that natural material in the digester is in effect proficiently changed into methane [42]. They are normally expressed as mg/L of acidic corrosive and incorporate natural acids containing 2 – 7 carbons. A VFA estimation of <1000 mg/L is good for stable digester operation [61] .

2.4.5 Total solids %

The total solids are the equal of dry, solid wastes present in a given biowastes sample. This measurement is calculated by weighing the material before and after drying the biowaste, evaporating off any wet [113].The total solids concentration of biowaste impacts on anaerobic fermentation (AD) activity, especially biogas and methane yield activity [114]. Past studies have investigated that impact of TS content on anaerobic fermentation performance in order to estimate conditions for best gas yield. The total methane yield decreased with total solids concentrations rising from 10% to 25% in batch anaerobic co-digestion of paper under mesopHilic temperature [115].Another study noted more solids concentration system could produce much higher methane yield rate compared with the low amount -solids process at the same solid retention time (SRT) in mesopHilic fermentation treating sludge[116]. But the biogas and methane yield declined with the total solids(TS) concentrations increasing from 17% to 30% in batch co-fermentation of organic food waste [117].

However, the utilize of conventional anaerobic digester for low amount –solid sludge is not constantly functional in a small-scale wastewater treatment plant or WWTPs in some rudimentary nations.For example, until to 2010, through the 2000 wastewater treatment plants in China, just 50 ones were fermented with anaerobic fermentation processes and just 20% of them were well worked[118]. Indicated that methane yield began at day 14 in a digester with 20% total solids and at day 28 in a digester with 30% total solids in mesopHilic temperature dry anaerobic batch digesters treating the domestic food waste. The general methane yield was 17% low amount at 30% than at 20% total solids. This outcome is proportionate with the one got by Forester 2008. Appeared best rendering of anaerobic bioreactors worked at 20% TS compared to (25% and 30%) TS [117, 119].

2.4.6 Mixing

The significance of blending for good execution in anaerobic frameworks has been underscored in writing and additionally standard course books. Blending is fundamental to keep up homogeneity in the digestion procedure and is accomplished by inside mechanical blenders, outside mechanical blenders (including distribution of tank contents), gas distribution or distribution of the material contained in the digester by means of pumps[120].

2.5 Inhibition factors

2.5.1 Ammonia

Ammonia can be pestilent to AD and the effective compound in charge of for ammonia, suppression is the unionized free NH3. ammonia (inhibition) is increased under thermopHilic temperatures and high pH. Among the bacteria included in the anaerobic system, methane formation is particularly affected by NH4 inhibition so, when an anaerobic system is dampened by ammonia, the VFAs will raise and this will lead to a reduce of pH[120].

2.5.2 Nitrogen oxides

It is indicated that hydrogen using bacteria of methane can be dampened by nitrogen, such as (nitrate, nitrite and nitric oxide); both are found in the natural environment and in man-worked environments with the whole cell of Methanol bacterium. test results proposed that the inhibitory impact was not because of redox modification or substrate(organic waste) competition, but because of the damper of the action of some compound of the methane yeast series itself. Hydrogen using methane bacteria is the master ways in anaerobic fermentation system, particularly when AD is operated at high temperatures, and acetate using methane bacteria is prevented by increased temperature [121, 122].

2.5.3 Shock loading of organics rates

Aside "ammonia and nitrate/nitrite, toxic minerals", such as Zn, Cu ...etc can be lead to toxic acidic bacteria. However, several of these components can be loaded in comparative elevation concentration because absorption in the solid material included in the reactor digester [123].

2.5.4 Sulfide

Sulfide is a component of several industrial sewage sludges. The formalization of sulfide onto decreasing of sulfate and other sulfur including compounds is big problems related with anaerobic WWTPs. emission of sulfide is unfavorable because of its odor, its toxicity, and its corrosive features. also, lowering of sulfate to sulfide by (sulpHate-decreasing bacteria) can be a disadvantage to bacteria of methane at high fully ratios then lead to toxicity [124].

2.5.5 Salinity

The treatment of saline and hypersaline biowaste could appear as much as 5% of the world. the digestion process is known to be inhibited by more salt mainly.Previously studies been noted that a sodium concentration skipping 10 g /l hardly dampen methanogenesis production[125, 126].spite of the stumbling block produced by high salt, an appointed number of experiments have been used successfully for the fermentation treatment of salt wastewater.

Some of the studies utilized a halopHilic inoculum, while some another required the acclimation of a no halopHilic inoculum to increasing salt amount [127, 128] .another overview of microbial ecology, the modification of a non-salty sludge to high saline suggest the acclimation of halotolerant micro bacteria to signification amount salt content. Several studies propose that this acclimation is potential, according to on the nature and the introductory adaptation of the sludge to elevation salinity[129, 130].Several reported studied the effect of salt on anaerobic fermentation. The effectiveness of salt like NACL on the production of biogas by methanogenesis, it can be seen, methanogenesis began to be dampened by NaCl at a concentration of 6 g l−1, the biogas yield rate decline from 0.38 to 0.33 ml g−1. This dampens then arrived 90% (from 0.38 to 0.02 ml g−1) at an NACL the concentration of 55 g l−1, but the biogas average in this study generated by angiogenesis first enhanced at low saline concentrations (0–8 NaCl) [131].The sway for Different salt focus on anaerobic Maturation of FW might have been accounted. The critical methane creation from claiming 500 mLwas pointed with no sodium hydroxide expansion same time those most reduced might have been got for those augment of 10 g for every l NaCl. The methane item might have been measly when the sodium salt focus might have been The following 10 g/L, which matched should <8% dampen activity, and the unsaturated fat acids, ethanol progressively amassed for the overabundance of the NaCl [132].Another study was investigated any potential influence of add up to Fe salts on the AD of sludge. The acquired results appeared that Fe salt negatively influenced the anaerobic fermentation system by decreasing the rate of biogas [133].Also in another situation was proceeded to investigate the impacts of the rate salt in seafood on the anaerobic fermentation procedure. The results of the AD process adequacy according to the salt concentration indicated that the reduction efficiency of TCODcr was 80.1~90.2% beneath a salt concentration, and mid-70% at a salt concentration. beneath a salt condensation, the methane production was 65.7~78.3 but reduced with a rising in the salt concentration, to 50-54.2% [134].

Chapter 3 METHODOLOGY

3.1 Materials and methods

The review went for assessing bio gas potential of food waste under co-digestion with sewage sludge. The sewage sludge tests together with the microbial inoculum were given by the waste-water treatment plant of (Seventh sewage plant of Chengdu), while food waste was collected from the company in Sichuan (Bowen biotechnology com., LT. The substrates were collected four times, at which stage fresh materials were collected. Samples of fresh materials were stored in cold (4°C) until their use. The samples were collected three times over the number of stages in the first stage, second pHase, the samples fresh materials were collected from (Bowen biotechnology com., LT), (Seventh sewage plant of Chengdu), for food waste and sludge respectively while in the third stage, the high salt content test pHase, the food waste was collected from the company (Bowen biotechnology com., LT) and the excess sludge was collected from(Seventh sewage plant of Chengdu).

Inoculum source, emanating from the current anaerobic pilot plant treating sewage sludge in our establishment was utilized as the inoculum. The gushing was gotten the research center in a shut container and was checked for gas creation. It was pre-brooded at 32 °C until it achieved the endogenous breath arrange and was then utilized for the BMP measure. The inoculum utilized had a pH of 7.4 and a VS content of 23.2 g L−1.

In the mechanical stage, wastewater goes through a screen, coarseness chamber, and oil trap. This is trailed by essential sedimentation and natural treatment with nitrification and pre-denitrification in two parallel enacted sludge lines. As the last stage, secondary settlement tanks are utilized to expel all sedimentary material from the water. Prepare items are incompletely reused (return actuated sludge), mostly processed anaerobically for biogas generation (oil, essential sludge, overabundance enacted sludge). The outpouring is frequently controlled by the expository assurance of significant wastewater components and released to the Waterway Inn.In the present review, essential enacted sludge and abundance initiated sludge from WWTP were utilized as digestion substrates.

3.2 Pre-treatment

The underlying material was homogenized in a blender for 20 seconds to expel greater portions, for example, bread scraps, rice grains, maize globules and so on. A size lessening and the subsequent augmentation of the accessible particular surface account for an enhanced organic digestion of the substrate. This was done by taking samples of food to be tested and stored in the refrigerator in advance and placed in the food mixer after making sure that they are free of unwanted objects that affect the process of fermentation, it was mixed up to 5-10 minutes to ensure that the material was completely and homogeneous and gave the form of thick liquid .

3.3 Reactor set up

16,15 and 15, batch tanks were installed for three stages respectively (1,2,3). The size of each reactor was 1liter (1000 mL). These anaerobic tanks were created of high-density glass. Batch tanks (reactors) consisted of tanks linked to the gas collector with (P.V.C) tube and the gas collector was joined to an open flask by a tube to measure the volume of water collected due to the water uprooting technique. These reactors were sealed with a rubber seal containing two holes. A glass tube was installed in the first hole for the purpose of taking the samples to be examined and the other opening is for the purpose of passing the gas to the water flask. The batch tanks were placed in a water bath fitted with a heater and temperature optimal for mesoplilic 37 Celsius. These batch reactors are shown in Figure 3-1,3-2.

Figure 3-1 Batch reactors fitted in water path

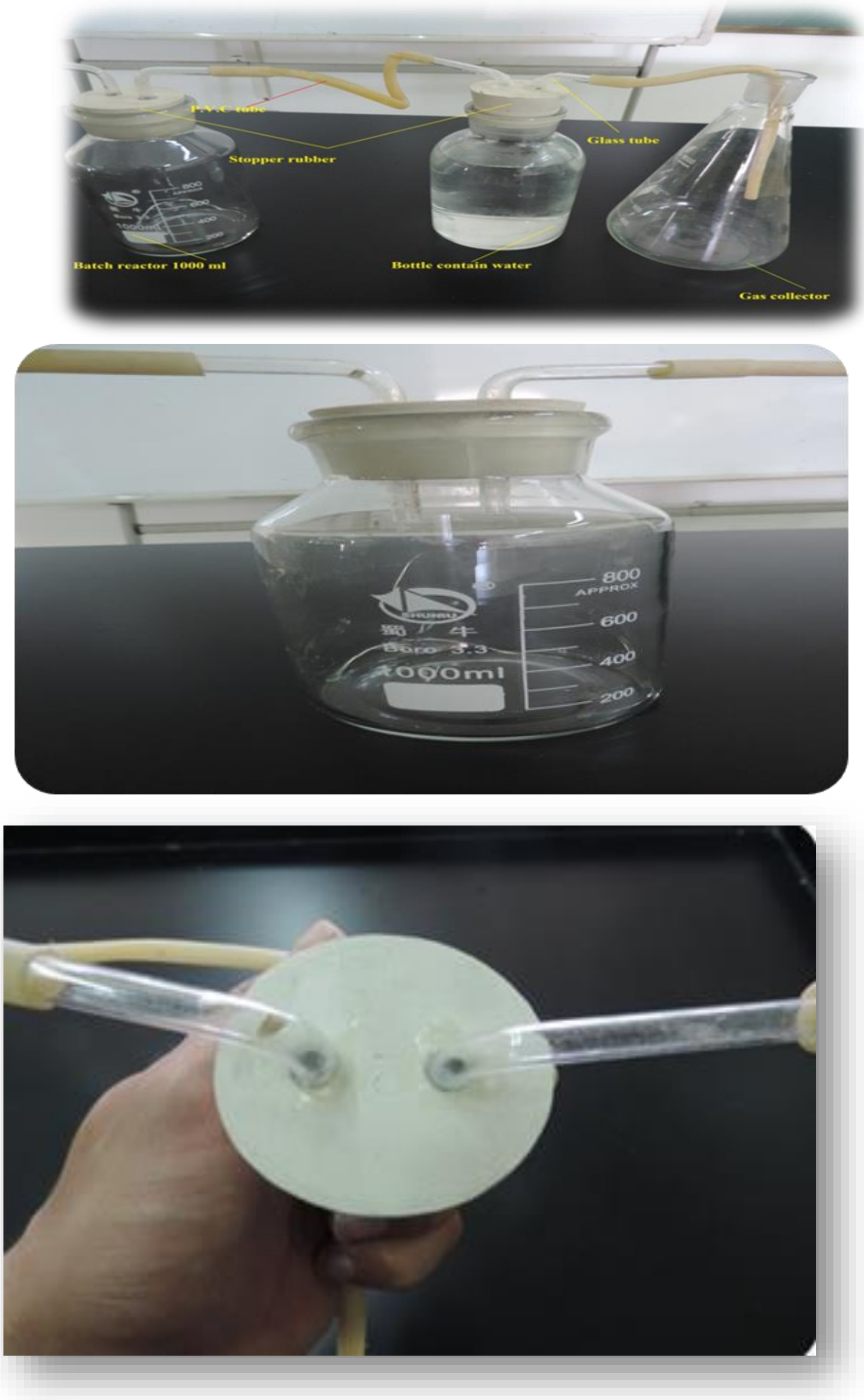

Figure 3-2 Batch reactor materials

3.4 Batch experiment

Bio gas test was completed for every individual substrate and also for the blended substrates to discover the ideal proportion of blending of FW and sludge for anaerobic co-digestion. The BMP measure was performed utilizing serum bottles. Jugs were prepared by including the substrate, inoculum, and sewage sludge in first and second stages while in the third stage prepared by including the FW, ES, and SS.

Three stages have carried this research:

The main objective of this project was to investigate the stability of the anaerobic co-digestion system, which has been developed by the Southwest Jiaotong University, under the effect of different types of mixing ratios and salts. The performance studied in this project included the effects mixing different ratios and high content of salt. The first and second parts of this project looked into the improvement of the co-digestion system treating by multi substrates from food waste and sewage sludge .The last part of this project looked into the effect of NaCl salt on the fermentation system. The system treating food waste and WAS with different NaCl concentrations, i.e., 0(Control), 1.2g, 2.4g, 4.8 g, and 7.2 g were investigated.

To evaluate the biogas potential of the substrates, sewage sludge and additionally food waste specimens were portrayed as far as synthetic solids content (TS), unstable solids content (VS), add up to electric conductivity (EC), also oil content and the pH-esteem. All estimations were conducted in triplicate, factual anomalies straying more than 20% from the normal were barred from the outcomes.

3.4.1 Batch testing for the first stage

In the first pHase, biogas tests were completed for each single substrate and also for the blended substrates to detect the ideal ratio of FW mixing with sludge for anaerobic digestion (FW: SS). The biogas scale was performed using water displacement. Tanks were prepared by embedding the substrate, SS, and inoculation. The mixed FW, SS with fixed inoculum was added to the reactors at different rates as in Table 3-1 (1: 1, 3:7, 7: 3, 1: 4,1:0, 0:1 and 4: 1). Where the mixing ratio between the substrate and the inoculum (1: 2) was 300: 600 depending on the weight. Rates were repeated twice, except for a ratio of 4: 1 it was repeated once and tested the food once (1:0) and sludge once too(0:1). These reactors were placed in the water bath at 37 ° C and left fermented for 21 days of hydraulic retention. Biogas collected in the head container were measured using a daily water harvesting technique at 7 pm also hand shaking of the reactors were performed twice a day during the three stages in order of mass transfer of nutrients, metabolites, and microorganisms within the anaerobic reactors [135].

Table 3-1 Different ratios from FW, SS with fixed inoculum for the first stage depending on the weight.

FW: SS- 300 g							Inoculum
1:0	**0:1**	**3:7**	**7:3**	**4:1**	**1:4**	**1:1**	
300:0 g	0:300 g	90:210 g	210:90 g	240:60g	60:240g	150:150g	600 g

3.4.2 Batch testing for the second stage

New materials (FW, SS, Inoculum) were used to begin the following cycle, biogas tests were completed for each single substrate and also for the blended substrates to detect the ideal ratio of FW mixing with sludge for anaerobic digestion (FW: SS). The biogas scale was performed using water displacement. Tanks were prepared by embedding the substrate, SS, and inoculation. The mixed FW, SS with fixed inoculum was added to the reactors at different rates as in Table 3-2 (1: 1, 3: 7, 7: 3,1:0, 0:1). Where the mixing ratio between the substrate and the inoculum (1: 1) was 300: 300 depending on the volume. Each ratio was repeated twice.These reactors were placed in the water bath at 37 ° C and left fermented for 21 days of hydraulic retention. Biogas collected in the head container were measured using a daily water harvesting technique at 7 pm also hand shaking of the reactors was performed twice a day.

The biogas scale was performed using water displacement. Tanks were prepared by embedding the substrate, SS, and inoculation. The mixed FW, SS with fixed inoculum was added to the reactors at different rates as in Table 3-2 (1: 1, 3: 7, 7: 3,1:0, 0:1). Where the mixing ratio between the substrate and the inoculum (1: 1) was 300: 300 depending on the volume. Each ratio was repeated twice.These reactors were placed in the water bath at 37 ° C and left fermented for 21 days of hydraulic retention. Biogas collected in the head container were measured using a daily water harvesting technique at 7 pm also hand shaking of the reactors was performed twice a day.

Table 3-2 Different ratios from FW, SS with fixed inoculum for the second stage depending on the volume.

FW:SS- 300 ml					Inoculum 300 ml
1:0	**0:1**	**3:7**	**7:3**	**1:1**	
300:0 ml	0:300 ml	90:210 ml	210:90 ml	150:150 ml	300 g

3.4.3 Batch testing for the third stage

In order to detect the effect of salt, sodium chloride was added to the reactors (1,2,3,4,5) Corresponded to 0 and 1.2 g, 2 g 4 g, 3.2 g, 7.2 g of sodium chloride respectively. New materials (FW, sludge, ES) were used to begin the following cycle, bio gas tests were completed for each blended substrates to detect. The bio gas scale was performed using water displacement. Tanks were prepared by embedding the FW, SS, and ES. The mixed FW, SS, and ES were added to the reactors at same rates as in Table 3 (90+210+300 ml/FW+SS+ES). Where the mixing ratio between the substrates were 410 ml depending on the volume. Each ratio was repeated twice.These reactors were placed in the water bath at 37 ° C and left fermented for 21 days of hydraulic retention. Biogas collected in the head container were measured using a daily water harvesting technique at 7 pm also hand shaking of the reactors was performed twice a day.

Table 3-3 Add salt to the substrate with five different concentrates.

FW /ml	SS /ml	ES/ml	Salt concentration /g
90	210	300	0 g
90	210	300	1.2 g
90	210	300	2.4 g
90	210	300	4.8 g
90	210	300	7.2 g

3.5 Evaluation of digestion performance

The implementation of digestion has been estimated using a series of different parameters that are closely supervised and on a regular basis. These parameters were pH, total solids (TS) volatile solids (VS), electronic conductivity (EC) and oil content where these factors were measured before and after the fermentation period.

3.5.1 PH monitoring

Digester's pH was observed using PH paper. Before and after digestion pH magnitudes were, recorded on a regular basis.PH is used as drops of the sample are taken and placed on the paper. After a moment we will notice a change in the color of the paper and then compare the color with the colors listed. Each color indicates the pH number from 1-14.

3.5.2 TS, VS monitoring

The measurement of TS and VS together with the following calculations was conducted according to the protocols described by Kroiss (2007). Total solids content (TS) was determined by drying the sample overnight at 105°C until weight constancy [136].

TS was expressed in weight percentage according to the formula (1),

$$TS = \frac{W_t - W_d}{W_{sample} - W_d} \times 100$$

Where:

W_t: Weight of dried residue and dish (g)

W_d: Weight of dish (g)

W_{sample}= Weight of wet sample and dish (g)

Volatile solids content (VS) was determined by an additional ignition of the dried samples in a muffle furnace at 550°C for two hours.VS was firstly expressed in percentage of the TS according to the formula (2) .

$$VS = \frac{TS - W_{volatile} - W_d}{W_t - W_d} \times 100$$

Where:

TS: total solids

W_{volatile} : Weight of residue and dish after ignition (g)

W_d : Weight of dish (g)

W_t : Weight of dried residue and dish (g)

The content of TS and VS was examined before and after fermentation and for all proportions. The figures 3-(3-8) below illustrate the solid - volatile test:

Figure 3-3 put fresh materials before and after digestion in Curitiba

Figure 3-4 The weight of each container before filling and after filling

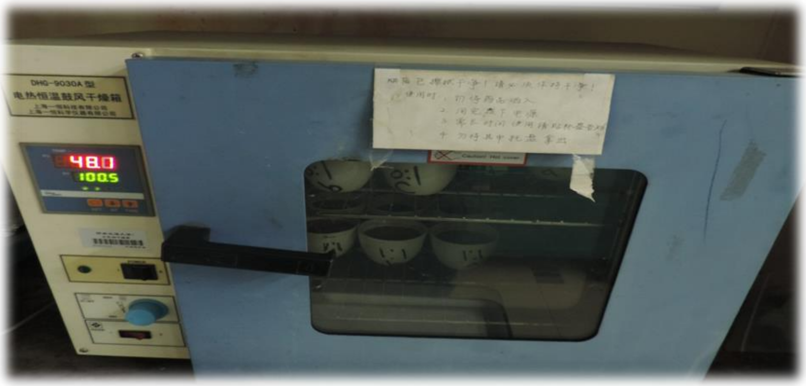

Figure 3-5 Measure total solids by placing samples in the dry oven and at 105 ° C for 12 hours

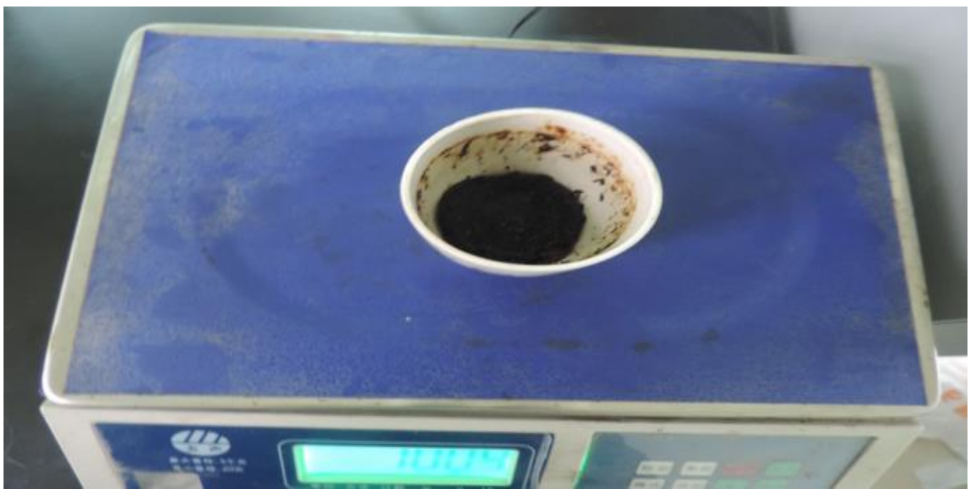

Figure 3-6 weight of dry sample

Figure 3-7 Measure the volatile solids by placing the dried samples in the combustion furnace at a temperature of 550 ° C for 2 hour

3.5.3 Electronic Conductivity

The salinity ratio was monitored before and after fermentation using an electrical conductivity device. DDS-307A Conductivity Meter.It is most used in oil industry, biological drug, sewage water treatment... etc. Determination of the percentage of salts in food waste before fermentation was conducted Where the amount of waste was taken (fresh) and ground in the blender and then weighed 20 g and add 200 ml liters distilled water over 20 g of waste for food and then mixed well and left the mixture for 30 minutes after the filter was filtered by filter paper and then measured.

The ratio of conductivity of the solution previously filtered by the conductivity device through the position of the poles of the device, one of them to measure the conductivity ratio and the other to adjust the temperature where the optimum temperature (15-25). Sewage sludge was also measured by placing 50 ml of sludge in a glass cup. The device was used directly to detect salinity in pre-fermentation. After fermentation, approximately 100 ml of the previously blended and fermented materials were taken after 21 days (food waste and sewage sludge) for each reactor and were then filtered. The salinity ratio was measured as mentioned above and as in Figs 3-8.

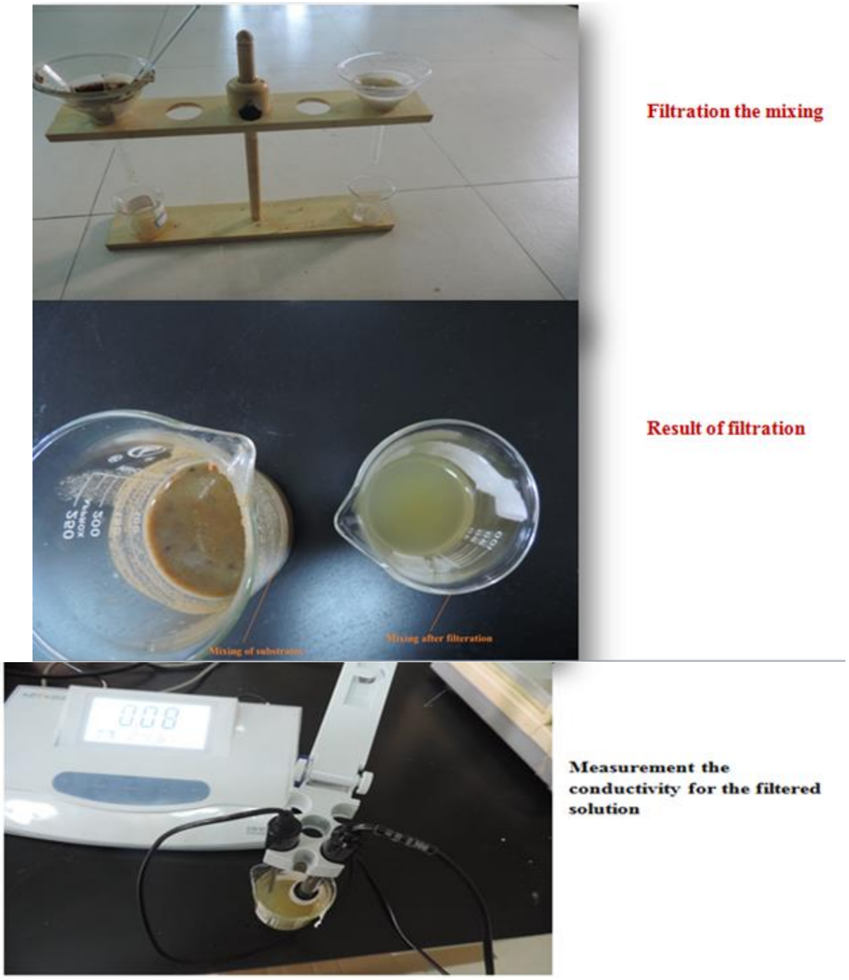

Figure 3-8 Salt content measurement by EC device

3.5.4 Oil content

Weigh about 2 g food waste, place in a large tube of 50 ml, add 8 mL distilled water, and then every 5 min or 10 min until sample digests completely, about 40 min - 50 min. Remove the tube, add 10 mL ethanol, mix. After cooling the mixture, transfer into 100 mL plug cylinder, use 25 mL diethyl ether wash the tube inside several times and pour into the cylinder. after all the diethyl ether pour into the cylinder, cover the lid, and shake for 1 min, open and release gas, and then cover the lid, standing for 12 min, use equal petroleum ether- ethyl ether mixture wash the oil attached to the cylinder mouth and plug. Standing for 10 min-20 min, when the upper liquid becomes clear, suck the upper liquid into the flask, plus 5 mL diethyl ether into the cylinder, shaking and stand, suck the upper liquid into flask again. The flask evaporates on a water bath for half hour, and dry in the oven for 100℃ about 2 hours, weigh it after cooling, repeat the above operation until constant and as in Figure 3-(10-16).

Figure 3-9 Weight of grams of food waste

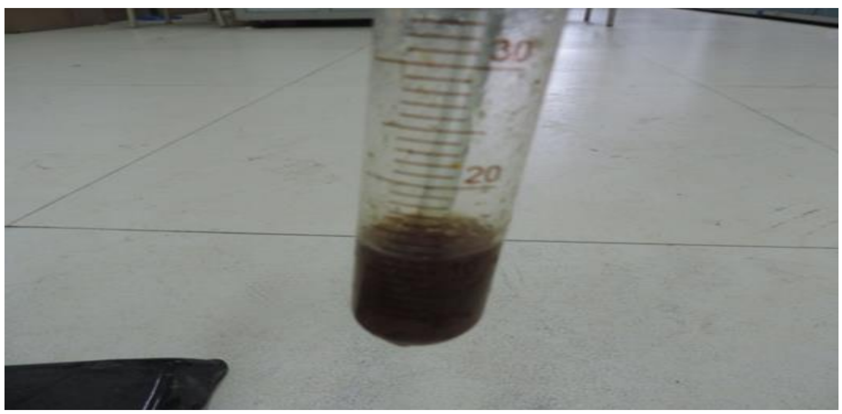

Figure 3-10 Dissolve the food after adding hydrochloric acid

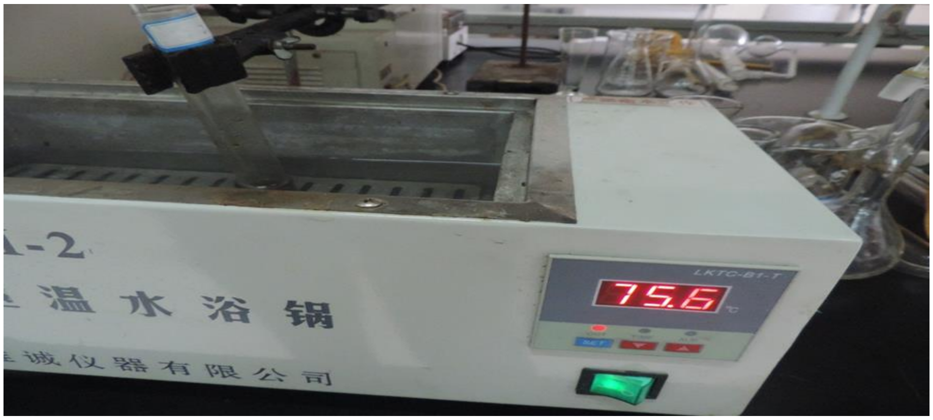

Figure 3-11 After the addition of hydroxide acid, the tube was placed water path at 75.6 c for 40 minutes

Figure 3-12 After 40 minutes, the mixture was transferred to a 100 ml tube and washed from the inside by petroleum and either for the purpose of oil release

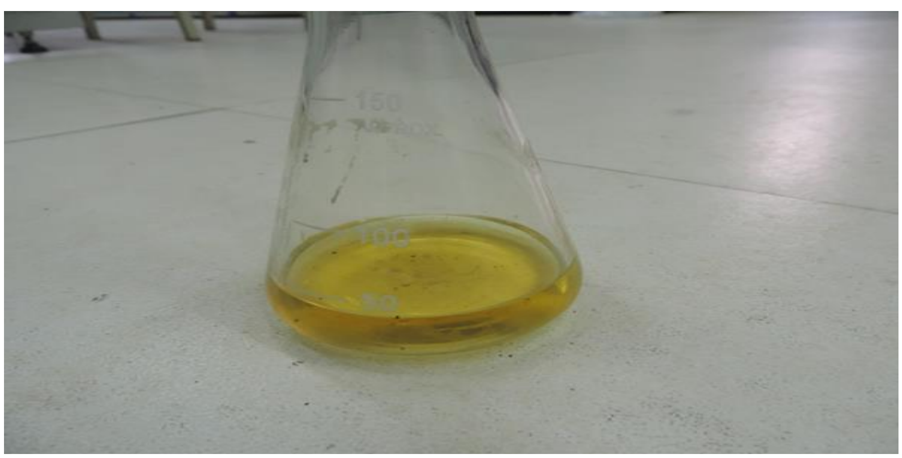

Figure 3-13 Transfer the oil from the tube to the flask by pipette

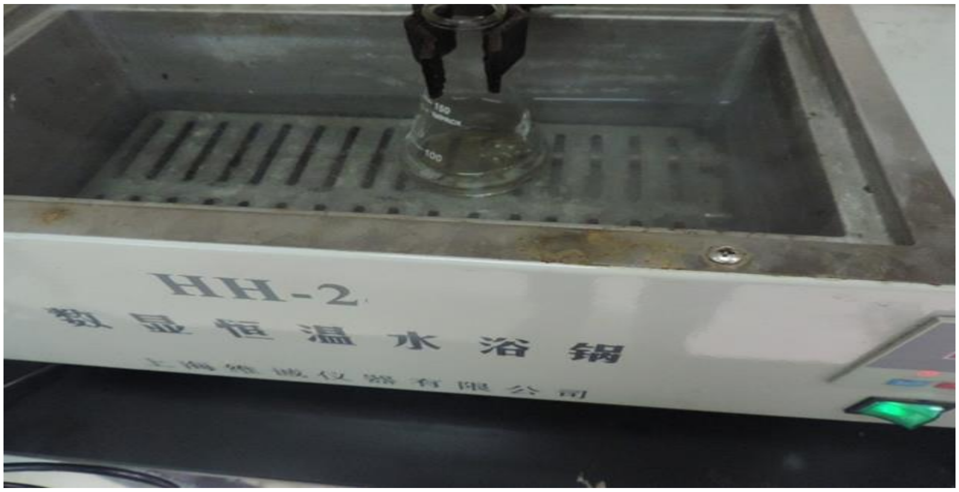

Figure 3-14 Place the flask inside a water bath for 1 hour and 80 ° C

Figure 3-15 Place the flask inside a drying oven for 1 hour and 100 °C

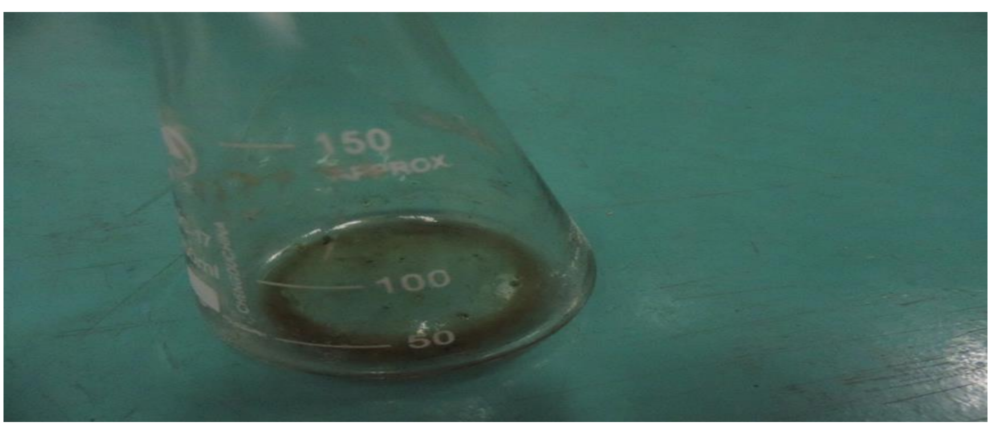

Figure 3-16 The remaining oil in the flask after it has dried

Chapter 4 RESULT AND DISCUSSION

In this section, outcomes of experiments mentioned in chapter 3 are explained. Most of these results were obtained utilizing types of equipment available in the laboratory of "Geo-sciences and Environmental Engineering School". All the following aspects are discussed briefly to take out the correct results as much as possible to go along with other similar researches except for some results that never taken up before (up to our knowledge), for instance, Determining optimal conditions with the innovation of using food waste and excess sludge in sewage plant of Chengdu are carried out, the sampling materials are extracted by statistic method which ensures the Representative of samples. Also investigate the impact of high oil and high salt on the anaerobic co-fermentation by using food waste with oil and salt content by adding cooking oil and calcium chloride respectively, and to find the convenient content of oil and salt that enhances the production of biogas.

4.1 Analysis of bio-gas production

Bio gas production can be monitored by a several of ways. the most way used and simplest methods are through liquid uprooting "displacement. In another side, there are another, ways more precise technical ways of determining gas production volume, such as with the utilize of "wet gas” and "flow meters". However, in the absence of such equipment, the method of liquid displacement is applicable, (but in this way it must be a confirmation that the gas will not leak from the plug or pipe for accurate and acceptable results). Bio gas was analyzed as described below:

After 21 days of anaerobic fermentation, the bio gas yield through this period for each ratio is shown in Figure 4-5 for the first stage. Where we mentioned earlier that food and fresh-water waste were collected, seven mixing ratios were conducted at this stage “ 1:1, 3:7, 7:3, 1:4,4:1,1:0,0:1”. The percentage of mixing was between food and water based on weight, with the constancy of the percentage of inoculate as mentioned in Table 3-1.Each ratio started to generate bio gas from the totally first day as stated in Table 4-3, the results pointed that the food waste produced the maximum bio gas, while the sludge produced the lower. Where the value of the production of gas from waste food "FW" and sludge “SS” was 3306.5 ml, 391 ml respectively during 21-day co-digestion.

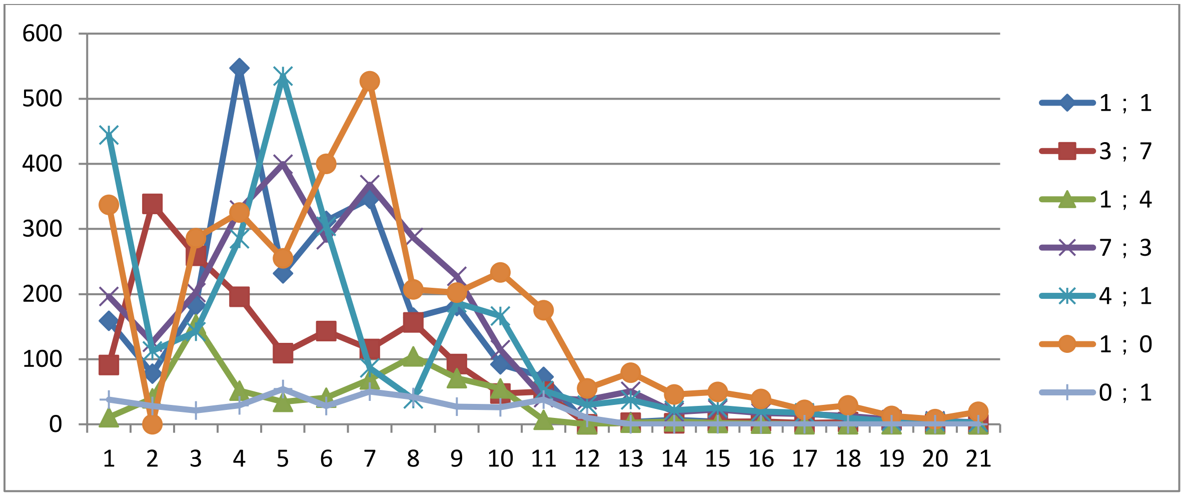

Figure 4-1 Through the above diagram showing the stages of production of biogas during 21 days of fermentation of the common and individual materials

Table 4-1 It shows the values of biogas production from different ratios during 21 days from hydraulic retention time.

Mixing ratio FW: SS	Inoculum	Biogas generation /ml
1:0	300 g	3306.5
0:1	300 g	391
1:1	300 g	2394.833333
3:7	300 g	1623.833333
7:3	300 g	2765
4:1	300 g	2525
1:4	300 g	647.0333333

The bio-gas yield through the second stage for each ratio is shown in Figure 4-2. In the second pHase, five different ratios were used respectively: 1: 0, 0: 1.3: 7, 7: 3, 1: 1 “Food waste: sludge” depending on the size with a fixed inoculum percentage as mentioned in Table 3.1. Where the results indicated that the highest percentage of the generated vital gas is 1: 0 while the lowest percentage of gas produced is 0: 1 "2628.66 ml, 461.33 ml” Respectively, while the remaining percentages produced gas in reasonable quantities and acceptable as indicated in Table 4-2.

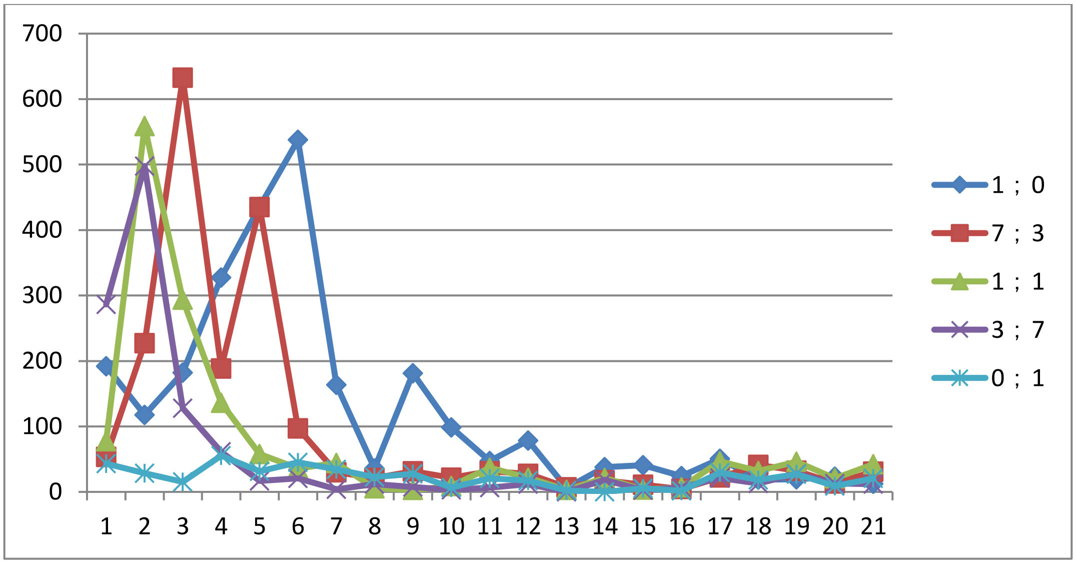

Figure 4-2 Through the above diagram showing the stage of production of biogas during 21 days of fermentation of the common and individual materials.

Table 4-2 It shows the values of biogas production from different ratios during 21 days from hydraulic retention time.

Mixing ratio FW: SS	Inoculum	Biogas generation /ml
1:0	300 g	2628.666667
0:1	300 g	461.3333333
1:1	300 g	1502.666667
3:7	300 g	1170.333333
7:3	300 g	1977

To give a complete estimate of the representations of salt content in a batch test on lab scale the results seen below include data gained in this stage before fermentation and after 21 HRT. Before and after the fermentation period, generally utilized indicators were measured for determining the anaerobic fermentation, such TS, VS, PH, oil content, salt content and bio gas volume. The volume of bio gas was expressed as "ml /day".The bio gas yield through the third stage for each ratio is shown in Figure 4-3. In the third pHase, five different concentrations of chloride calcium were used respectively: 0 , 1.2 g ,2.4 g, 4.8g,7.2g . These concentrations were added to the joint digestion of FW and ES before fermentation and were represented in five reactors containing fixed proportions of substrates "Food waste + excess sludge +sewage sludge" depending on the volume as mentioned in Table 3.1. Where the highest rate of gas production during the process of fermentation 1321.5 ml of the addition of 7.2 grams of chloride calcium ,while the lowest gas production was 1039.49 ml of the addition of 1.2 gram of NaCl, the remaining concentrations produced gas in reasonable quantities and acceptable as indicated in Table 4-3.

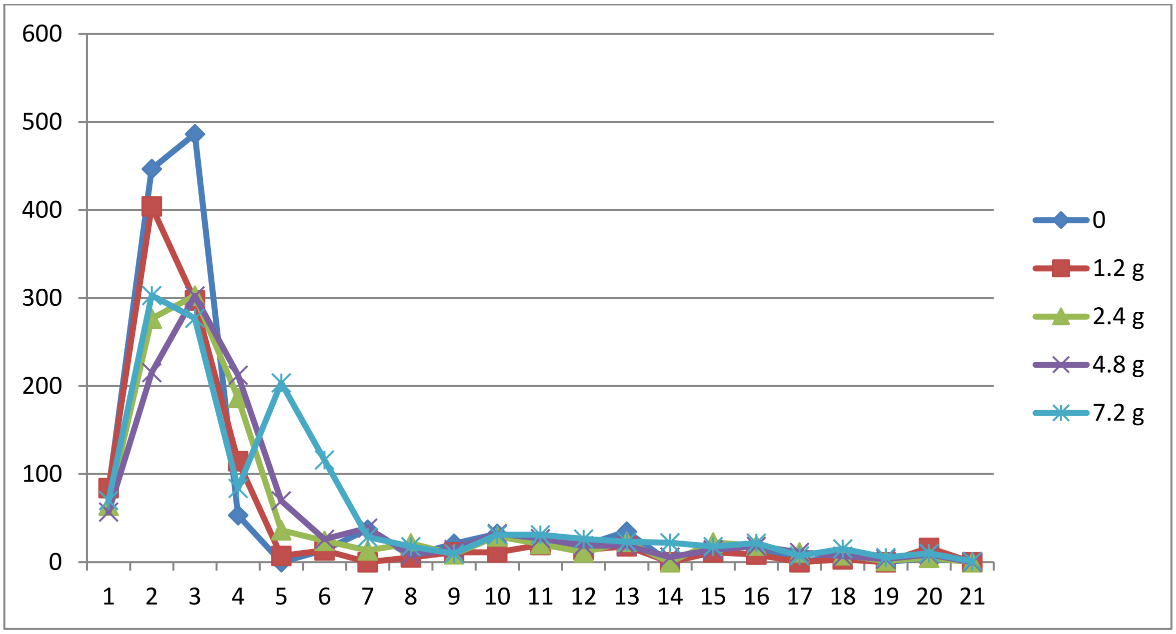

Figure 4-3 Through the above diagram showing the stage of production of biogas during 21 days of fermentation of the different concentrations of NaCl.

Table 4-3 It shows the values of bio gas production from different salt concentrations during 21 days from hydraulic retention time.

Food waste/ ml	Excess sludge /ml	Sludge/ ml	Salt concentration/g	Biogas production /ml
90	300	210	0	1297.61
90	300	210	1.2	1039.94
90	300	210	2.4	1085.6
90	300	210	4.8	1109.22
90	300	210	7.2	1321.5

4.2 Characteristics of the substrates before and after fermentation

4.2.1 Characteristics of the substrates before fermentation

In purpose to detect the quantity of "substrate" to be utilized in single, mixtures substrates tests, the main characteristics of the substrates before and after digestion studied were evaluated The proportion of oil in the three stages was measured for food waste only As for the salts, they were measured in the first and second stages separately and not in the mixture. In the third stage, the ratio of conductivity “EC” was measured in a mixture of five reactors after adding different percentages of sodium chloride. As shown in the tables below 4 (4,5,6)

Table 4-4 Characteristics of the substrates before digestion for the first stage

Parameters	**FW**	**SS**
pH	6.2	7.8
TS	11%	0.57
VS	9%	22
EC	5.22 Ms/cm	-
OIL content	10%	-

Table 4-5 Characteristics of the substrates before digestion for the second stage

Parameters	**Value**				
FW: SS	1:0	0:1	1:1	3:7	7:3
pH	6.2	7.8	6.1	6	6.1
TS%	12.44	1.37	5.80	4.27	6.19
VS%	11.52	0.893	5.36	3.69	6.51

•Conductivity and oil content for food waste and septic were measured separately and not mixed, 5.21 mS/cm, 5 % respectively.

Table 4-6 Characteristics of the substrates before digestion for third stage

<table>
<tr><th rowspan="2">Parameters</th><th rowspan="2">FW</th><th rowspan="2">SS</th><th rowspan="2">ES</th><th colspan="5">EC mS/cm</th></tr>
<tr><th>1(0g)NaCl</th><th>2(1.2g) NaCl</th><th>3(2.4g) NaCl</th><th>4(4.8g) NaCl</th><th>5(7.2)g NaCl</th></tr>
<tr><td>pH</td><td>6.2</td><td>7.8</td><td>7.5</td><td rowspan="3">3.47</td><td rowspan="3">4.31</td><td rowspan="3">4.75</td><td rowspan="3">9.13</td><td rowspan="3">11.33</td></tr>
<tr><td>TS%</td><td>27.43</td><td>0.66</td><td>0.81</td></tr>
<tr><td>VS%</td><td>21.63</td><td>0.48</td><td>0.387</td></tr>
</table>

- **Oil content for food waste was measured separately, 10 %**

In the first stage

All the ratios in the first stage were stable which suggests a good possibility for biological digestion , also the pH ratio is stable where it ranged between 6 - 6.3 for food waste , 7.9 for SS for all materials and is a reasonable rate of digestion stability , as well as the rate of connectivity stable, where it amounted to approximately 5.2 mS/cm for food waste and 890μS/cm for sludge, which is a characteristic of Chinese food and sewage, respectively, in addition to the proportion of oil amounted to 11%, a natural proportion compared to waste food for many countries. The volatile solids of the food waste were high and were considered to be an appropriate proportion compared to the percentage of the other ratios.

In the second stage

The results are given that this food waste appears well equiponderance feed stock for "AD " with predictable stable biological devolution in anaerobic case. The food waste in the case (1:0) includes a very high fraction of organic "volatile solids" comparable with another ratio. The procedure has been done to examine solid and solid volatile in mixed substrates. Where the reduction of volatilization in the food was 11 .524% while the reduction of VS in the sludge was very low 0.89 %. There is also stability in the conductivity ratios, where the proportion of salt entering the food 5.1 mS/cm, which is a normal proportion of Chinese food, and the number of pHs was also stable as in the first pHase, but the proportion of oil in which a kind of decline, reaching 5%, attributed to the nature of waste food, Previously collected, the oil content in the substrate was small but this ratio is not considered to have a negative impact on fermentation.

In the third stage

At this stage, the incoming substances were food waste with excess sludge “ES” and sludge “SS” for the purpose of testing the high salt content. The results indicated in Table 4-6 showed that the tested food waste before fermentation was balanced in terms of reduced VS. The precipitation was 21.63% and the stability of pH 6.2 and the oil ratio 10%. Compared to the “SS” and the “ES”, the “volatile solids were very low and this is normal because they contain a high percentage of moisture. The salt content in the concentration of 7.2 g of sodium chloride added before fermentation 11.33Ms cm^{-1} is considered the largest proportion of the other four ratios, but it is not considered to be the inhibitory type as indicated in Table 4-6

4.2.2 Characteristics of the substrates after fermentation in all stages

Tables4-(6,7,8) appear the results of the test properties of the substrates (SS, FW, inoculate) for first and second stages for the mixed substrates and individual substrates after fermentation within 21 days . (FW, ES) for third stage under different concentrations of NaCl after fermentation within 21 days.

Table 4-7 shows the properties of mixture substrates after digestion for the first stage.

Parameters	1:0	0:1	1:1	3:7	7:3	1:4	4:1
pH	6.2	7.9	6.1-6.2	6.2	6.2	6.1	6.1
TS%	5.466	0.0608	3.138	2.453	4.162	1.907	4.525
VS%	99.15	99.71	99.46	99.42	98.22	94.80	99.21
EC Ms/cm	3.51	1.31	2.57	2.30	2.37	2.27	4.09

Table 4-8 shows the properties of mixture substrates after digestion for second stage

Parameters	1:0	0:1	1:1	3:7	7:3
pH	6.3	7.9	6.1	6.1	6.2
TS%	5.466	0.0608	3.138	2.453	4.162
VS%	7.86	0.40	2.91	2.44	4.83
EC Ms/cm	3.43	1.31	2.57	2.30	2.37

Table 4 Shows the properties of mixture substrates after digestion for third stage

Parameters	R1with 0 NaCl	R2with 1.2 NaCl	R3with 2.4 NaCl	R1with 4.8 NaCl	R5with 7.2 NaCl
pH	6.41	6.3	6.3	6.31	6.33
TS%	4.673	4.714	4.613	4.968	5.871
VS%	2.971	2.680	2.702	2.478	3.057
EC Ms/cm	2.41	3.81	4.66	5.01	7.20

- **R 1,2,3,4,5 : number of reactor**

Table 4-7 shows mixing ratios of FW “food waste” to SS “sewage sludge” and their characteristics. The results show that the ratio of the volatile solids is stable except in the ratio of

1: 4 as the ratio is low compared to the other ratios 94.8%, because the percentage of the Sludge is greater than the food ratio, so there is instability in the reduction of volatile solids, because of the biodiversity present in the fermented mixture.

Also, the TS for food waste alone is high because the concentration of solids in the FW alone is greater than that of the common mixture [133]. The volatile solid and Total solids of food waste were 5.46% 99.15% respectively and higher than that of the sludge.Figures 4-4, 4-5 show where the volatile solid is after digestion, but the high Sludge from civil “WWTP", which utilizes chemically supported treatment with values of pH, TS, and VS that are evidence of a suitable buffer ability that supports A-Co fermentation.

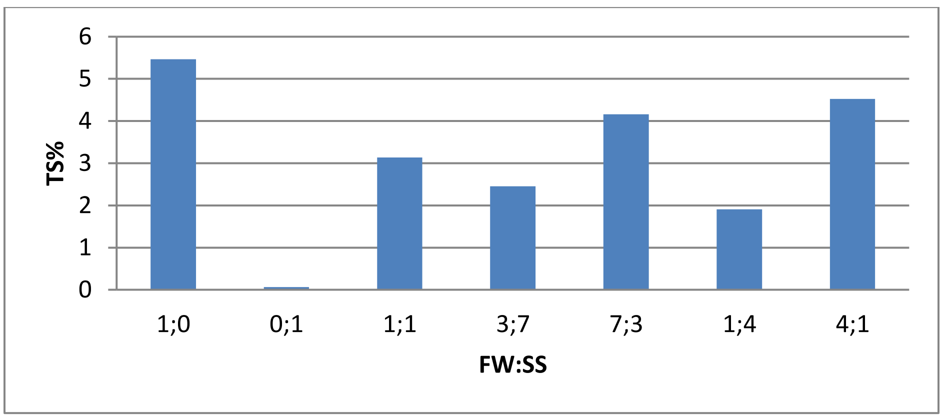

Figure 4-4 TS concentration for mixing and individual substrates after fermentation for the first stage

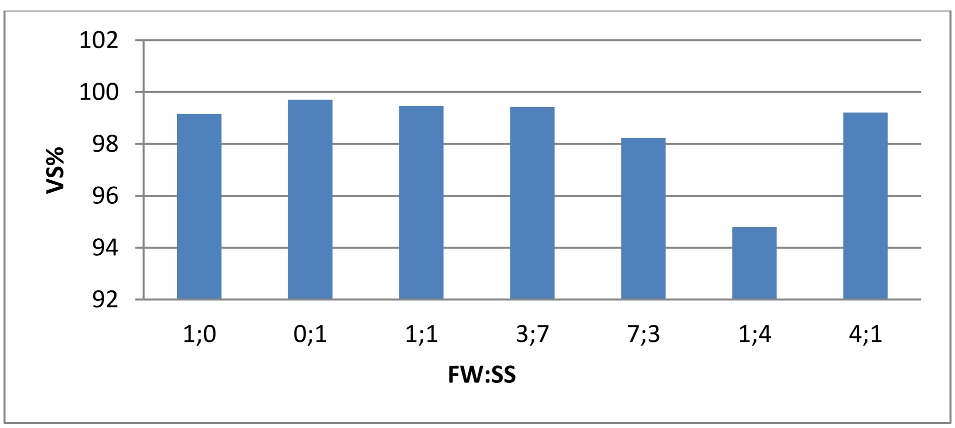

Figure 4-5 VS concentration for mixing and individual substrates after fermentation for the first stage

In Table 4-8 the properties of the material can be observed after fermentation for the second stage where the mixing ratio is concentrated on the size and not the weight as stated in the first stage. The results indicated that the reduction rate of solids is different among the ratios where the mixing ratios were 1:0 , 0:1, 1:1, 3:7,7:3 which had a reduction rate for each ratio (7.86 %, 0.40%, 2,91%, 2.44%, 4,83%) , respectively .

The VS corruption effectiveness was practically comparable in the proportions 1:0 (7.86%) and 7:3 (4.83%). This demonstrates co-digestion with an appropriate blending proportion gives more biog-as and in the meantime can deal with and deal with two distinctive waste streams. Which are matched by high ratios of the “total solid” of mixing 1:0, 3: 7, 4 “5.46 %, 4.16 %”, respectively. The ratios of TS and volatile solids can be followed by Figures 4-6 , 4-7.

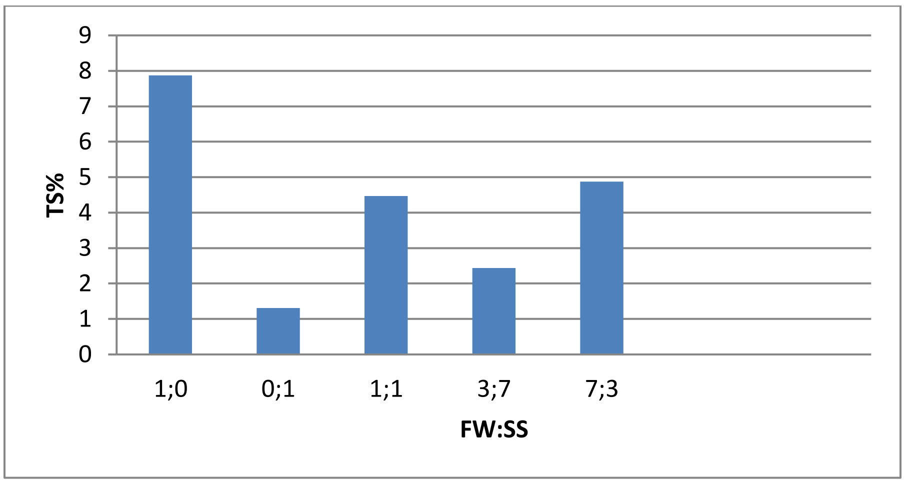

Figure 4-6 TS concentration for mixing and individual substrates after fermentation for the second stage

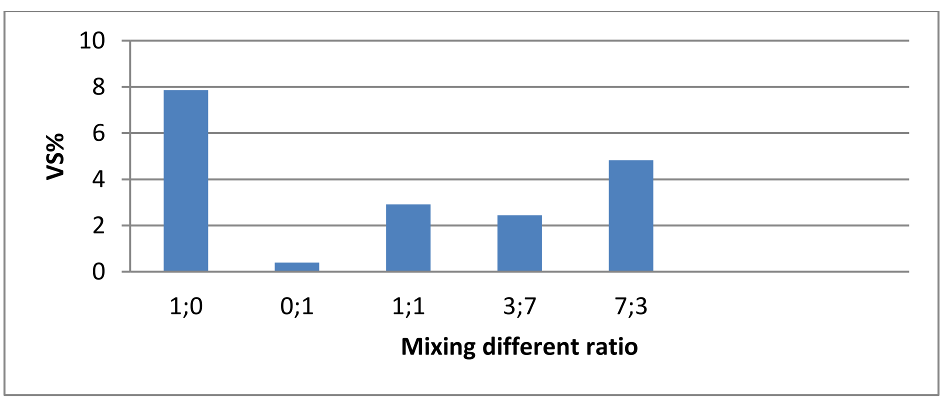

Figure 4-7 VS concentration for mixing and individual substrates after fermentation for the second stage

The reduction rates of the materials at different salt ratios are shown in the table 4-9. When the combine anaerobic digestion of FW and ES, the "TS" degradation rates of all reactors are 4.673 %,4.714%, 4.613%, 4.968%, and 5.87% respectively, and "VS" reduction ratios of the five reactors 2.971%,2.680%,2.702% ,2.478%, and 3.057 %respectively. It is evidence that in the case of 7.2 g of NaCl, all the "TS: and the "VS" reduction ratios are the highest, which mentions a synergistic impact between the ES and the FW with salt content at 7.2 g in expressions of anaerobic co-digestion. The TS degradation of bio-reactor number 5 fed with salinity NaCl was high, this indicated salt concentration at 7.2 g motivates cell lysis, and subsequently, the effluent organic solids increase. The anaerobic decomposition of FW and ES was relatively good with 7.2 g of salt added previously indicating that this ratio contributed well to the decomposition of organic matter after fermentation and as shown in Figures 4-8 and 4-9.

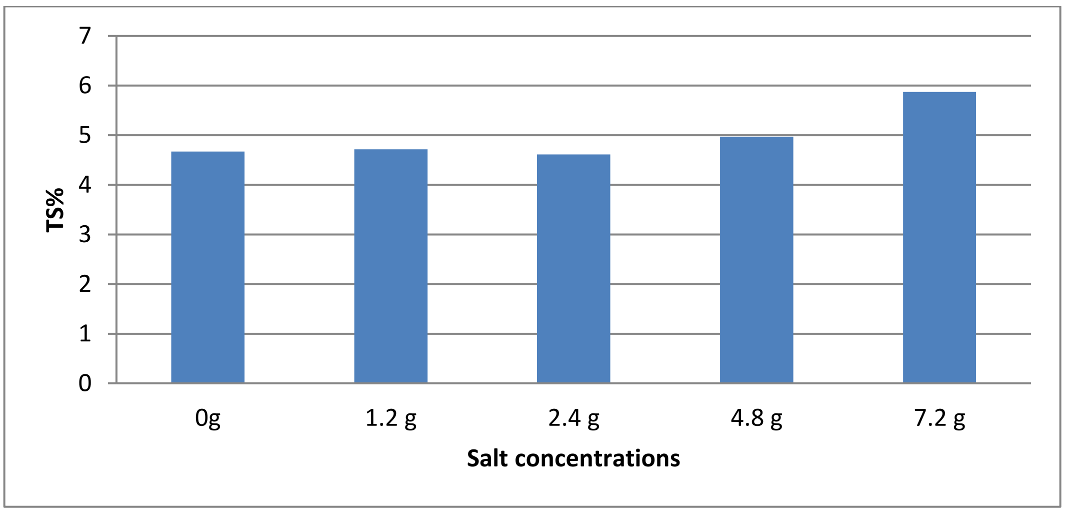

Figure 4-8 This figure shows the proportion of solids after fermentation in the third stage

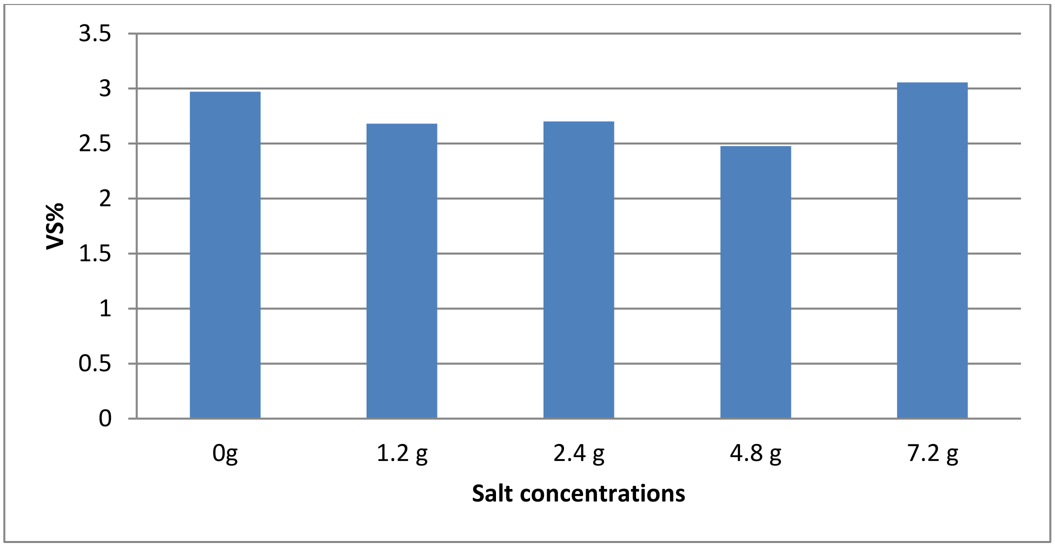

Figure 4-9 This figure shows the proportion of volatile solids after fermentation in the third stage

The results for PH also indicated that the digestion goes well when the pH rates from 6.1 to 6.5 in all stages, though the better pH rate is between 6.8 and 7.2 [136]. As appeared in Figures 4-(10,11,12) the pH rates of all ratios stabbed between 6.1 and 6.3 with the exception of sludge, ranging from 7.5 to 7.8 through the process "after fermentation" in two stages 1, 2, pointing that FW adding did not lead to high side effects on the digestion process. The pH ratio was optimal to the most appropriate range in this research. This means that food waste, whether alone or in combination, has a significant effect on the stability of the pH compared with the sludge alone process.

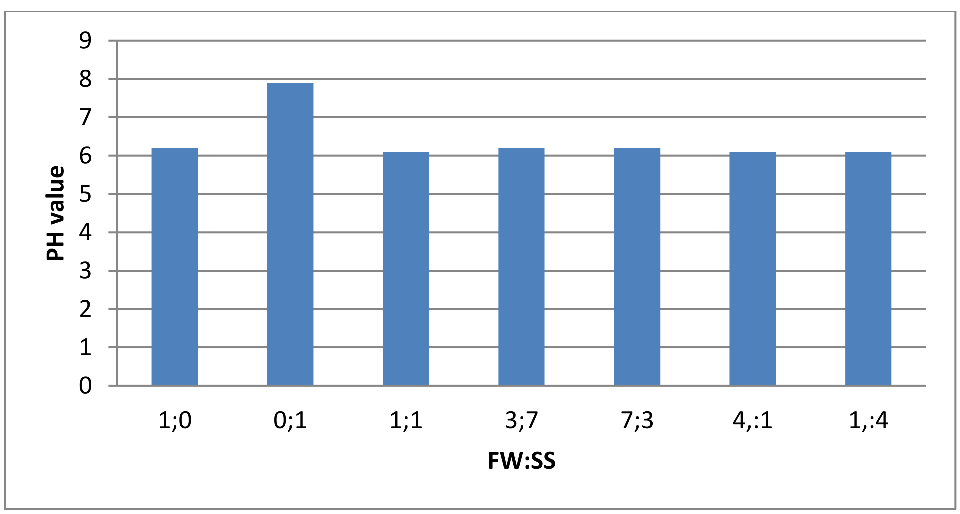

Figure 4-10 PH value for mixing and individual substrates after fermentation for the first stage

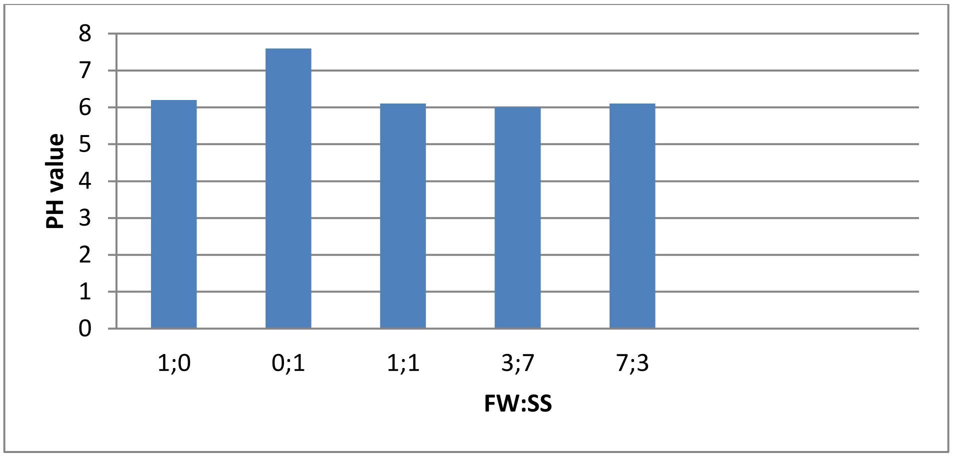

Figure 4-11 PH value for mixing and individual substrates after fermentation for the second stage

Also in the anaerobic system, the features of sludge are strictly suitable for the fermentation system and this means that if the “sludge" has a good quantity of fractional alkaline it is potential to transmit back to digestion process the optimal amount of "H-CO3"- able to raise the pH of mixing substrates above 5.

After chloride calcium addition in the third stage, the pHs in the control, R2 , R3 , R4 and R5 reactors were 6.41, 6.3, 6.3, 6.31, and 6.33, respectively, which appeared that the pH decreased as salt concentration increased , the pH decreases might be due to of precipitation of "VFAs or LCFAs"as NaCl salt , but the pH was stable till last day in the in all reactors . The different pH was in reasonable range could be due to the rate of protein reduction in each reactor because the group of protein results in the formalization of "ammonium bicarbonate, ammonium carbonate or ammonium hydroxide”. The presence of salt concentration in fermentation has not had a high negative effect on pH inhibition. The protein reduction effectiveness in the, R1 (control) was at least 3% higher compared to those in R2, R3, R4, and R5 due to of the inhibitory effect of rise concentrations of NaCl 1.2–7 g. through all the experiments, the digester pH was kept within the stable domain of 6.3–6.4 the bio gas production with presence salt content was good at a pH range of 6.3– 6.4 [137].

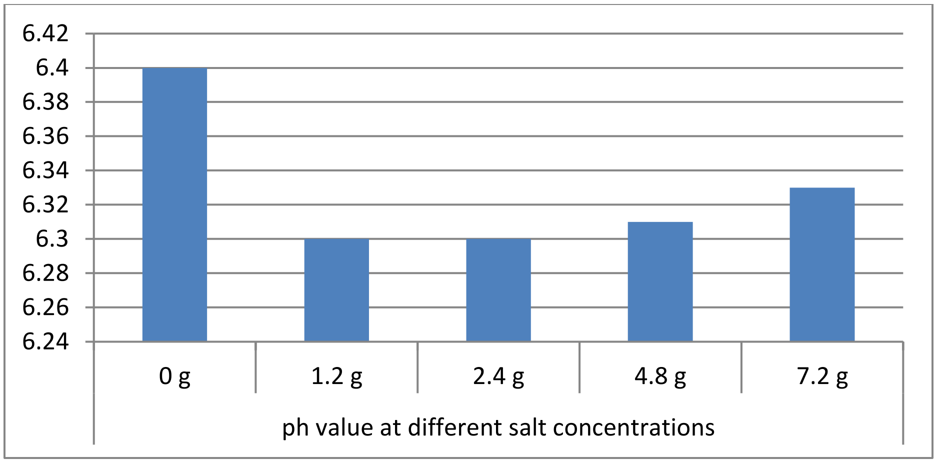

Figure 4-12 PH value for different salt concentrations after fermentation for the third stage

The analysis of the conductivity was guided at setting the "salt content" in the substrates. The fixed value for the conductivity ratio is 1, the outcomes of the conductivity (P < 1) ranged from 3.43 mS/c ,1.36 mS/ for the food waste and to the sludge respectively in first stage stage , while 3.51, 1.31 for “FW , SS” in second stage respectively , reason is attributed high EC index in ratio (1: 0) waste due to the hypothesis that the profiles of substrates in the production of biogas listed of the food rich in "metals" added to the waste of food, but it did not adversely affect the interaction, because the advantages of "Chinese food" in which the proportion of salt is 5 mS/cm. After fermentation, a reduction was observed in EC ratio for the mixed and single substrates. This was due to the fact that the addition of "SS" significantly contributed to the reduction of salts and the stability of fermentation. Not only the SS as well as the mixing of food with the inoculate “I+FW” also contributed to the stability of the percentage of salts in the fermented reaction. Figures 4-13 and 4-14 show the value of different conductivity ratios after fermentation of pHases 1 and 2.

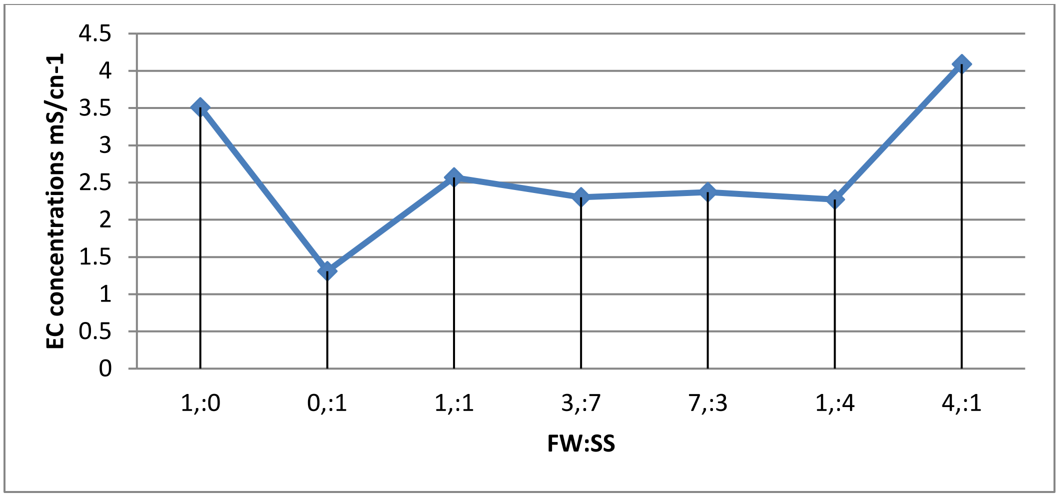

Figure 4-13 Shows the value of different conductivity ratios after the fermentation process for the first stage

Figure 3-14 Shows the value of different conductivity ratios after the fermentation process for the second stage.

EC of different batch tanks through the digestion period as in Figures 9-10, taking into account that the dates collected on day 21. However, a slight rise was observed in mixing ratios 4: 1 and 1: 0, 4.09 mS/cm, 3.43mS/cm in first and second stages, respectively and in the EC can be an indication of increased concentrations of degradable nutrients in the anaerobic process. This leads to the release of mineral salts such as pH solphate, potassium, ammonium, etc [138].

The impacts of different concentrations of chloride calcium on biogas generation were evaluated by the conductivity as like in two stages before. Five batch tanks were conducted with

NaCl in various concentrations "blank , 1.2 g, 2.4 g, 4.8 g, 7.2 g" respectively .The EC in results for 1-5 tanks were 2.41 ,3.81 ,4.66, 5.01, 7.20 mS cm-1, respectively as indicated table number 4-9. All reactors were performed in duplicate, the blank substrate of was with 0 NaCl. Fig. 4-3 shows the cumulative bio-gas generation in the anaerobic co-digestion of "FW and ES” test under different NaCl concentrations. Reactor 5 presented significantly higher biog-as generation than the control reactor. The salt concentration in reactor 5 (EC 7.2 mS cm^{-1}) did not impact the generation of biogas. By observing the salinity reading ratio before fermentation was high, especially in reactor number 1 (11mS/cm^{-1}) as mentioned in Table 4-6. This increase may cause inhibition of reaction. But the presence of excess sludge contributed to the reduction of salt to the extent acceptable.An increase in EC in the reactor 5 can be a possible indicator of increased concentrations of substrate-soluble nutrients such as some of the minerals after fermentation in the third stage[138] .Also that a rise in EC can be associated with the fermentation and breakdown of organic materials which causes to the releasing of soluble mineral.But in general, the EC concentration is considered stable in particular in the reactor number depending on gas production. Figure 4-15 shows the conductivity ratios after 21 days fermentation in stage 3

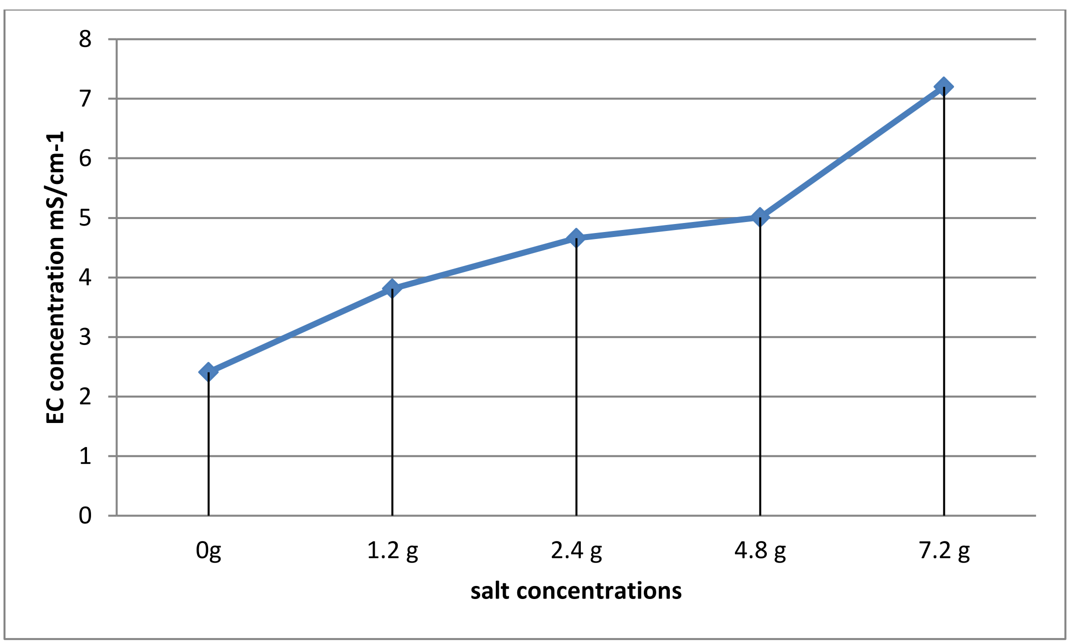

Figure 4-15 Shows the conductivity ratios after 21 days fermentation in stage 3

4.3 Effect of salt concentrations on the fermentation

Figure 4-16, display the productions of bio-gas from anaerobic co-digestion reactors with various concentrations of NaCl. The production of biogas in the blank reactor of NaCl presented mostly rise from first week. The optimal fermentation time was in first week and the highest biogas production was 1117.33 ml. when NaCl was added into the reactors, the highest bio gas production decreased and the best digestion time was in second day . For example, the highest production of bio gas with 1.2 g "NaCl" in second reactor was 404 ml , which was highest of that in other reactors , and the yield of biog-as further lowest in other reactors than in second one where the gas production was in three reactors (3, 4, 5) " 276.33 ml , 215 ml , 303 ml , respectively . when the concentrations of salt were "2.4 ,4.8 , 7.2 " g As indicated above, the common level of salt in the reactors are in the range of 1.2–7.2 (in terms of gram from chloride calcium) , however, the concentration of Na^{+} ions in the reactor is rarely documented, and the negative effect of NaCl on the microorganism is at most due to the turn of Na+ rather than Cl[138]. so that the appearing of Na+ at the at most level would show a negative effect on the production of bio gas from FW and WAS anaerobic co-digestion. In addition, the optimal digestion time was also influenced by the levels of NaCl, and the optimal fermentation time was lagged from first week when the content of NaCl increased from 1.2 g to 7.2 g. Those data strongly proposed that the appearing of NaCl was capable of little inhibiting the production of bio gas compared with blank reactor, but they are reasonable values compared to previous studies[139].

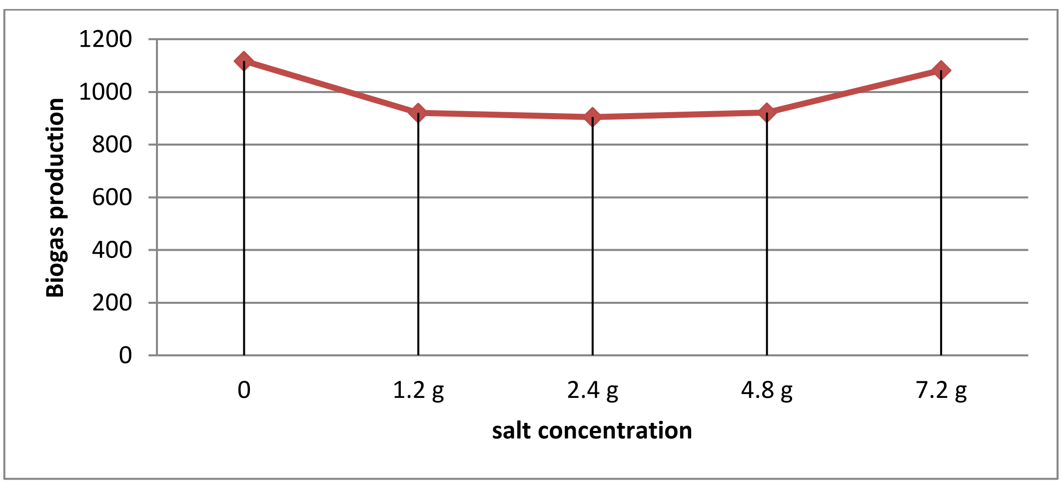

Figure 4-16 It shows bio gas production through first week of fermentation

Figure 4-17 shows the yield of bio gas during the second week of fermentation, where the highest gas production of the concentration of 7.2g while the lowest production was within the concentration of 1.2 g , gas production has reached all five reactors 135.65 ml ,79.31ml, 114.65 ml , 125.64ml ,160.65ml for (1,2,3,4,5) reactors respectively .

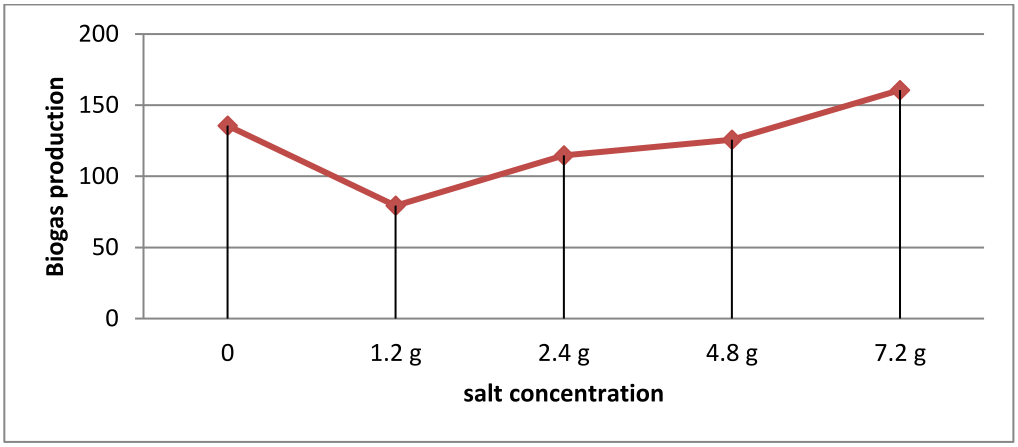

Figure 4-17 It shows bio-gas production through second week of fermentation

Although several researchers have pointed the inhibition influence of NaCl on bio gas production from food waste digestion and excess sludge [140], the specifics of how the appearance of NaCl impacts the stages i.e., "hydrolysis, acidification" and "methanogenesis" contributed in anaerobic digestion are not well discussed by now. consequently it necessary to investigate the impact of NaCl on those steps in second week digestion. Hydrolysis is theorized as the average limiting stage of co-substrate digestion [141]. "Carbohydrate and protein" are the master substrates in organic waste , and they are commonly offered in grainy situation before fermented [142]. The impacts of NaCl on solution "FW+ES” were expressed by the changes of dis-solvable "protein and carbohydrate" in fermentation liquid in this research. From Fig. 9-17, it can be indicated that the carbohydrate and protein in all reactors first increased and then decreased with digestion time in second week , and the maximal yields of "carbohydrate and protein" in the blank reactor through on biogas generation . However, when NaCl presented in the reactors, the contents of carbohydrate and protein were highly improved. when the rate of NaCl rose from 1.2 to 7.2 g. Those data proposed that the adding of NaCl led to the forming of organic matters. It was also indicated that the effect of NaCl increased the content of "protein and carbohydrate" in waste activated sludge "WAS" digestion , and higher concentration of NaCl led to higher dissolve substrates . This is evidenced by the large production of gas in concentrations with high saline content, where the production of the third, fourth and fifth reactors “114.65 ml, 125.64ml ,160.65ml respectively, while the second reactor was the production of gas 79 ml and the first reactor was 135.66 ml because the bacteria were effective in the first reactor but not significantly compared to the fifth reactor due to different concentration of salts.

In the third week, according to Fig. 4-18, gas production can be observed significantly less than in the past few days. However, despite the value of gas is low but the reactors (3, 4 and 5) have the highest percentage of gas production compared with the empty reactor (1) where the production rate gas for the Five reactors 34.99 ml, 19.99 ml, 52.32 ml 43.33ml, 46.65ml respectively. As aforesaid above, the production of bio gas is relevant to the stages of " hydrolysis and acidification", thus it is necessary to compare the impact of NaCl on the stages of "hydrolysis and acidification". According to the bio gas production in the co-digestion of food waste and WAS. From figure 9-12, it can be found that the bio gas generation in final week . For example, when the level of NaCl was 7.2 g in the biogas rate in reactor 5 in the co-fermentation system was 61 ml on third week , suggesting that the process of degradation was improved by co-digestion of "FW and WAS" in the appearing of NaCl

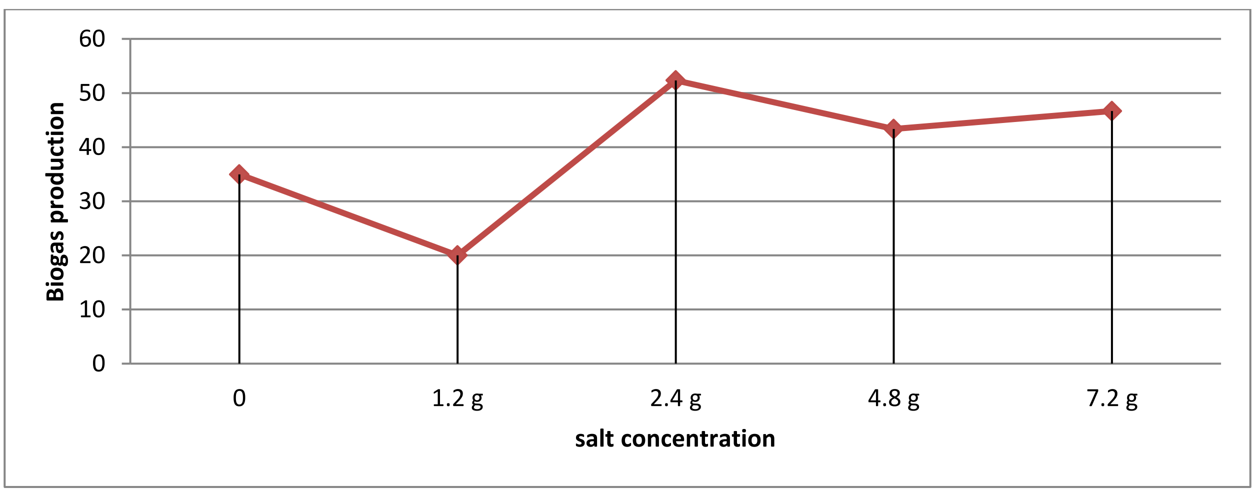

Figure 4-18 It shows biogas production through third week of fermentation

The rate of gas production in the third week is a bit less than the previous, especially in reactor number one (control) because the excess sludge content was high compared with the waste of food and as mentioned earlier, the higher the increase in ES the less gas production over time due to excess sludge which comes from the secondary treatment it‘s a outcome of overproduction of microorganisms in the activated sludge system ES is more troublesome to digest than fundamental sludge because it which contains of complex "carbohydrates, proteins and long chain hydrocarbon" [143]. Waste activated sludge, another type of civil solid waste, created from WWTP, and it also included large quantities of organic materials. Co-fermentation of "FW and WAS" might show a synergistic impact on microorganism and got better their possibility to salinity. Thus, it is substantial to compare the bio-gas production between control co-digestion of FW +WAS and co-digestion of FW and WAS with salt content. That datum from Figure. 4-18 proposed that anaerobic co-fermentation of "food waste and WAS" could rise the production of bio gas in the presence of NaCl compared with that from control co-digestion . Thus, it is necessary to discuss the mechanism of performance higher bio-gas production in the presence of NaCl form concentration in range (2-7.2) g .

4.4 Discussion

In the first stage, sixteen reactors containing different ratios (mixture and single material), were used.Gas production could be monitored within 21 days, with results indicating that the sludge gave the lowest gas content 0:1 because, since sludge has minimal biodegradability; the anaerobic digestion of sludge has the weekly activity for the processing through the above diagram we found that the highest gas production of the sludge was 54 milliliters during the fifth day of fermentation , while the value of production had reached 225 milliliters of food waste on the fifth day also because the food contains a higher rate of nitrogen to carbon “C/N”, which is considered a major nutrient during the fermentation process compared with the saturated. As for the ratios of 4: 1, 7:3, 1:1 gas production was almost not bad during the whole fermentation.

At the end of fermentation, these ratios produced 2525 ml, 2765 ml, 2394.83 ml, respectively. Except 1: 4 and 3: 7 where the quantities were given below the quantities above where the results were 647.03 ml, 1623.83 ml respectively, and the reason is attributed to that the acid pHase of fermentation mixture in statuses of 1:4 and 3:7, the yield of bio-gas produced reduces in the whole stage. When the percentage of SS is greater than the proportion of food waste, it also leads to an increase in bacteria and a decrease in the ratio of carbon to nitrogen “C/N”[144]. The lower of bio gas volume of the tow ratios due to they having higher ratio of SS, the result explains the reality that the hydrolysis of SS is the rate-shorten stage on the anaerobic bio fermentation[145].Cooking waste was generated maximum "Bio-gas". While the individual, "pour" sludge "SS" created a minimum of bio-gas. Therefore, the proportion of domestic food waste "FW" within the co-fermentation, can affect the generation of bio-gas significantly, that is, the high proportion of "FW", can lead to more generation of Biologic gas during fermentation. This is perhaps due to kitchen waste "KW" includes additional organic material which could be possessed usefulness of by microbe readily. In the same time, the higher rate of sludge to food waste SS< FW can be caused in the late or inhibition of the gas production. has been observed that co-digestion of mixtures FW+SS the feed to the bio-digestion , thereby enhancing the "C/N" ratio and reducing the concentration of "nitrogen" so that the utilize of a co-substances with a low "nitrogen, oil " lead to increase the high production of bio-gas volume also decreasing problems joined with the gathering of "VFAs". Based on the fermentation results in the first week, it can be observed that the mixing ratios "7: 3, 4: 1, 1: 1, 1: 0", the high content of the waste food has a high production capacity compared to other ratios: 0: 1, 1: 4, 3: 7 as following in figure 4-19.

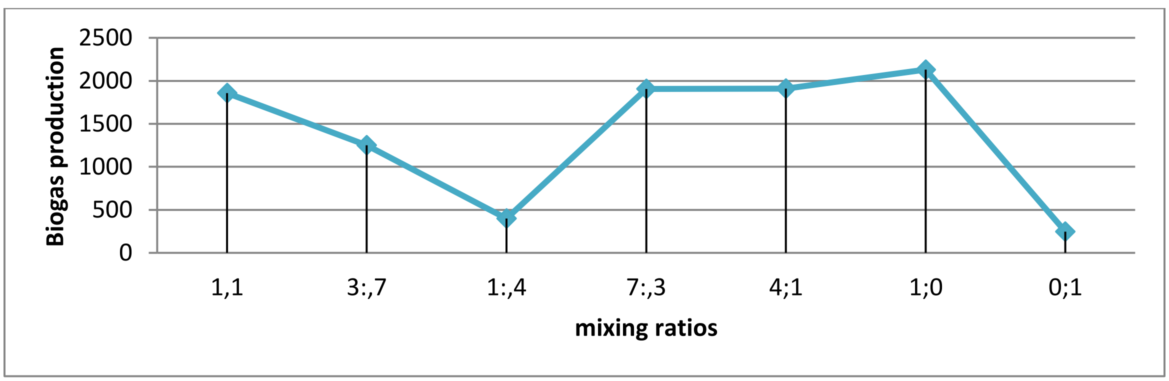

Figure 4-19 Effect of mixing ratios on bio gas generation through 7 days in first stage

From this diagram, we found in some of the cases when "FW" were added to "SS" appearing high stable biodegradability. due to the modification in "C/N" ratios during co-fermentation, compared to the ratios ",1:4,3:7" single SS. High FW to SS is a good factor of the activity of digestion that can be bounded by the amount a single substance. so that the high "carbon content" of an SS-led to high acid-pHase and methane- pHase will be damped by the low pH. The optimum ratio were 1:0 showed the highest increase in gas yield like other ratios "7:3, 1:1,4:1". Table 4 shows that the ratio of volatile solids at 1: 4 is lower because the content of the SS is greater than the FW compared to the other ratios, where the value of volatile solids is 94% compared to 1: 0, 3:7: 7:4, 1:1, 4: 1: and 0:1 99.15%, 99.4%, 99.4%,99.2%, and 99.7%

respectively . Also in the second stage “biogas” measure was completed as a cluster response in 125 ml serum vials. Comes about demonstrate that FW alone “1:0” gave the most extreme biogas generation, trailed by a co-digestion proportion FW + SS 7:3 in the second stage. Minimum biogas was delivered from the sludge. In this stage, the "biogas test" was completed. The tests of the single batch in the second pHase of 5 ratios were composed of different mixing ratios depending on the results of the first pHase.Where the best ratios were selected in terms of production of gas from the first pHase "1: 0, 0: 1, 7: 3, 3: 7, 1: 1" and was tested on biogas. The mixing rate was at this stage the FW and the SS with the stability of the Inoculum and depending on the size and not by weight as in the first stage where the ratio of mixing between the substrates and the inoculum “1: 1” as mentioned previously in Table 3-2. In the wake of considering the rate of biogas, it was watched that FW + SS at a proportion of 7:3 gives the most elevated gas creation (1977ml) for the mixture. Biogas generation from FW alone in the proportion 1:0 was (2628.6 ml). In any case, with regards to pilot scale digestion, with a blending and FW alone of different proportions, one-quarter times more sludge can be taken care of for bio-gas creation. Through the reduction of solids VS, we find that food waste alone has the largest proportion of reduction in comparison with other ratios, Where it gave the percentage of gas in 21 days 2628.6 ml. While the sludge alone produced 461.3 ml. The “ TS” in the food waste and other ratios"1:0, 0:1, 1:1, 3:7, 7:3" were 5.46, 0.06 , 3.13, 2.45 , 4.16 respectively ,where the highest ratios were 1: 0, 7: 3 while the lowest ratio is 0: 1 .

The ability to get rid of "VS" was 7.86 % during the ratio of 1: 0 and 4.83% with 7: 3. By monitoring the gas production on a daily basis, it was noticed that the gas production started a little on the first day, except for 3: 7, where the gas production was large, reaching 286 ml due to last time, the "pH" value was somewhat higher, which was not suitable for the outgrowth and efficiency of "anaerobic microorganism" but after 4 days it turns into positive through some activity in anaerobic microbial . Gas production in the ratios of 1: 0 , 7: 3 and 1: 1 is considered more than 70% of the total on the third day; while the mixing ratios 3: 7, 0: 1, 12% due to sludge alone or larger than the food waste in the case of joint digestion this procedure leads to a higher fat content in the substrates that contain large proportions of sludge[139] . As for the percentage of food waste alone "1: 0" gave the highest gas production during fermentation during 21 days, compared with the results in other ratios due to the fact that the content of food waste from carbon to nitrogen is very high and the other reason is the effectiveness of the vaccine where the vaccine positively affected the stability of food waste. Through figure 4-2 has been observed that 3:7, 1:1 and 7:3 ratios were no bedstead than the single ratio (1:0). This mentions that co-fermentation more than one substrates indigestion are not an ensure to achieve higher biogas output than the single food waste. Evidence for this proof is that the ratio of solids and volatile solids were large and stable compared to other g-mixing ratios. However, this stage was characterized by the stability of its characteristics such as the PH, totally solid, volatile solid, the proportion of salts and oil content as well as the quantities of gas in recent days has been stable. By fermentation during the first week we found that the common mixing of "sewage and food waste "in proportions 1: 0, 7:3, 1: 1 had the highest gas volume of 1955.6 ml, 1663.6ml, and 1159.6ml respectively while 0: 1, 3:7 was the least as following in figure 4-20 .

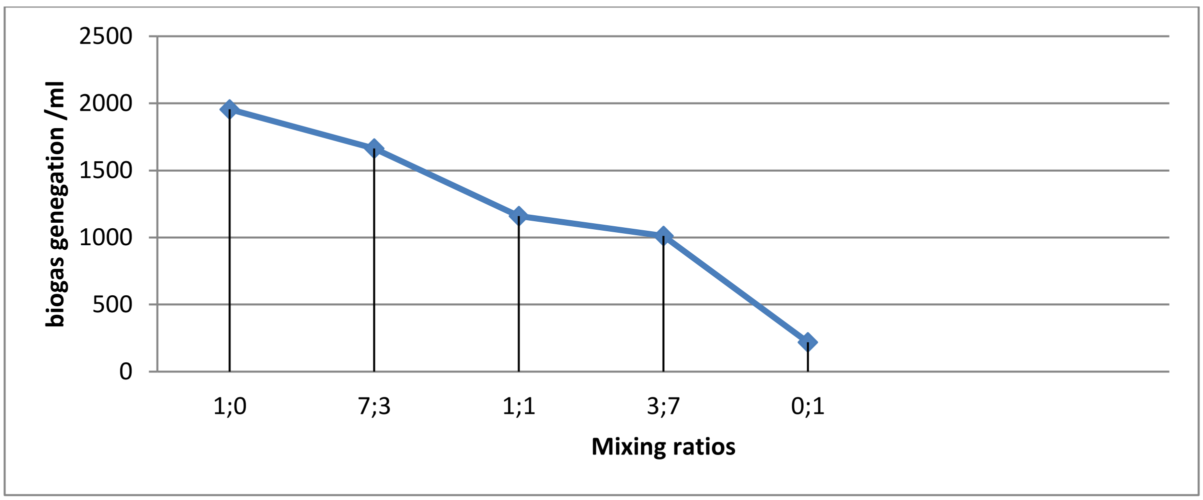

Figure 4-20 Effect of mixing ratios on biogas generation through 7 days in second stage

But, In these ratios, the gas volume was less than several times from the first stage because the ratio of inoculate/substrate was 1: 1 where the previous studies indicated that the higher the proportion of inoculum the greater the digestion is stable with the increase in the gas yield.Therefore, the results in both pHases show that 1: 0 is the largest contribution to the production of gas in both cycles, but the volume of gas in the first cycle is greater than the second here shows that the effect of the amount of inoculum can raise or reduce the production of biogas. In conclusion, the biogas test, which is envisaged, is the most convenient method for relatively easy Estimation of anaerobic fermentation activity,[146,147].We also used as an estimation tool production of biogas and digestive substrates in seven and 5 ratios for pHases 1 and 2, respectively. The results showed the cumulative biogas production recorded from the biogas test, the highest percentage was the share of food waste while the lowest percentage is the share of the SS. Which were similar to those obtained by other researchers,[142] . It was clear that most of the materials and compositions made up of food waste were biodegradable and for ease of digestion. That's why anaerobic digestion it was considered to be an alternative to the effective treatment of Chinese food waste, because it also excelled in a significant reduction in volatile solids and production biogas.

The increase in cumulative gas production in the ratios (1: 0, 4: 1.1: 1, 7: 3), (1: 0, 1: 1,7: 3) in the first and second stages respectively. Because the increase in food waste in the reactor leads to the production of higher gas compared to the high proportion of the feed because in fact the decomposition of high-SS is a step restricting the rate of anaerobic bio-degradation. [148] In high rate anaerobic co-fermentation of food waste, the optimum "C/N" ratio for biogas production with no reverse impact on the implementation was found to be in the good range, so the high rate of macro and micro-nutrients in sewage sludge can cause a deficiency of the ratio C / N which are low of sewage sludge. [149,150]. But the volume of gas in the first cycle is higher than the second cycle, due to the percentage of the substrate : Inoculate . In the first cycle, the ratio of the substrate to the inoculate was 2: 1 while in the second cycle it was 1: 1. The enhancing of the bio gas production in the first stage due to the inoculate was higher than substrate [151] . The bio-gas yield increased with the increase I/S and it decreased when I/S below than substrate. It was proposed that I/S" Inoculate: substrate “was an important operator in the anaerobic performance of food waste. The low I/S led in low heaped up bio gas production and fraction of CO_2 did not convert into CH_4.

Residues harmful to salinity concentrations on the anaerobic system of salinity entering with food waste .They were investigated by means of a combination of food waste and excess sludge by adding different concentrations of sodium chloride. The inoculum used with the reactors is sludge, which does not contain high concentration of salts, and was mixed with industrial drainage in different fields. The number of reactors used at this stage were five and each reactor is mixed with a mixture of food waste and ES. For purpose examine the impact of "NaCl "levels on anaerobic co-fermentation of food waste "FW", excess sludge "ES", salt was added before the anaerobic test at different concentrations "0 , 1.2 , 2.4 , 4,8 and 7.2" g of NaCl . Where the results indicated that the highest gas production was from reactor number one where the concentration of sodium chloride added 0. The gas production rate during the 21 days of the other concentration "1.2, 2.4,4.8, 7.2 were 1039.94 ml, 1085.6 ml, 1109.226 ml, 1321.5 ml respectively.By observing gas production during the first three days 1013.32ml, 785.66ml, 643.65 ml, 574.66 and 650 ml for concentrations (0,1.2,2.4. ,4.8 ,7.2) in gram respectively. The rate of gas production in the first three days was greater in the number one reactor. This indicates that the concentration of salt in the first three days has a negative effect on gas production through the output of other concentrations. The results of fermentation in the other three days were 2.4 g, 4.8 g, 7.2 g. The gas production was fairly close to the concentration of 0 g and 1.2 g, as these ratios produced a higher gas than other ratios through concentration Salts in these reactors were lower than other reactors. The above results show that if the concentration of salt increases to 7.2 g, this will lead to increased gas production, albeit slightly, that the process of inhibition of this pHase is not very strong and unlike previous studies. Because the substrate of the substrate (V + S) with the added salt was stable. FW + ES significantly reduced the concentration of salt in high ratios as the beginning of fermentation indicated that the empty reactor produced a higher gas than other reactors with high concentrations gradually. However, after the fermentation process continued, we found that the concentration of salt had a positive effect on gas production compared to the reactor which is controlled by empty due to VFA accumulation in the digester number (1) [152] . The increase in hydraulic retention is offset by an increase in gas production for substrates with saline content. The bacteria in the anaerobic reaction depend on the nutrients. These nutrients contain a percentage of the minerals and salts. Therefore, the addition of salt with the substrate has contributed to the validation of the results. when the level of NaCl between 1.2 g- 7.2 g. Those data proposed that the appearing of NaCl led to the release of organic matters. It was also indicated that the presence of NaCl increased the content of both "protein and carbohydrate" in excess sludge digestion liquid, and higher rate of NaCl led to higher dissolve substrates. "Carbohydrate is the important nutrients for cell growth, and metabolism, thus it can be easy to realize higher effectiveness, of "hydrolysis, acidification and methanogenesis" achieved in the co-fermentation process . So that, carbohydrate was the master substrate in FW, and its consumption is closely associated to the production of biogas .The average carbohydrate intake was high over time in the presence of a different concentration of sodium chloride. It was found that the high consumption of "carbohydrates" in saline content led to higher yields of biogas over time. For instance, when the concentration of NaCl was 7.2 gt, the rate of bio gas generation was higher than the corresponding value co-digestion in blank reactor with over time [153].

CONCLUSION

In the first and second stages the content of kitchen waste is high from carbon and nitrogen compare with the only sludge Carbon and nitrogen are essential components of anaerobic bacteria and also when the mixing ratio has high content from SS compare with FW This will lead to an increase in microbes and therefore consumption of edible food waste compounds thus high in fat, volatile fat and inhibition of the system . Typical SS has the following composition: 33% carbohydrates, 28% protein, and 28% lipid and is characterized by a low C/N ratio of 5.9 . On the other hand, food waste is reported to have the following composition: 78% carbohydrates, 6.5% protein, and 0.6% lipid . The anaerobic Co-digestion of FW result in a better balance of nutrients and higher C/N ratio in organic wastes, which are the prerequisites for a stable process performance. In other words, the high concentration of macro- and micronutrients in the sewage sludge could compensate the lack of nutrients in OFMSW, and the low C/N ratio of sewage sludge could be increased by the addition of high amount of food waste. But the volume of gas in the first cycle is greater than the second here shows that the effect of the amount of inoculum can raise or reduce the production of biogas.

In the third stage this study discussed the details of how NaCl affected biogas production from food waste anaerobic digestion. Experimental results showed that low levels of NaCl increased the hydrolysis and acidification processes but inhibited methanogenesis while both acidification and methanogenesis processes were seriously inhibited by high NaCl levels in the short hydraulic retention time. Co-digestion of food waste and WAS was proved to be an efficient alternative to mitigate the inhibition caused by NaCl on biogas production. Mechanism investigation revealed that when digested substrates were exposed to the different level of NaCl (1-7.2 g) , co-digestion system provided a preferred C/N condition and enhanced the consumption of carbohydrate thereby elevating the rate of hydrolysis, acidification and methanogenesis as compared with the mono food waste anaerobic digestion.

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My mother	***My father***
Engineer	***Assist Prof.***
RAJAA MAHDI	***ABDULZAHRA ALI***

Dear girl	***Teacher***	***Leader in our group***
Dai Jinhua	***Dr.Peng***	***Dr. Lui***

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