HARVESTING THE NUTRIENTS FROM FISH FARM EFFLUENT VIA ULTRAFILTRATION PROCESS AS FOLIAR SPRAY

NUR ADLIN BINTI MOHD ZOL

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by

NUR ADLIN BINTI MOHD ZOL

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LIST OF ABBREVIATIONS

BOD	Biological Oxygen Demand
Ca	Calcium
CO_2	Carbon dioxide
EPS	Extracellular Polymeric Substance
FS	Foliar Spray
GR40PP	Polysulfone membrane
K	Potassium
kDa	Kilodaltons
Mg	Magnesium
N	Nitrogen
NaClO	Sodium hypochlorite
NH_3	Ammonia
NFT	Nutrient film trickles
NO_2	Nitrogen di-oxide
NO_3	Nitrate
P	Phosphorus
pH	Power of hydrogen
PVDF	Aquasource Polyethersulfone, Polyvinlidene Flouride
RAS	Recirculating Aquaculture System
RDW	Root Dry Weight
RFW	Root Fresh Weight
SDW	Shoot Dry Weight
SFW	Shoot Fresh Weight

T_1	Treatment 1
T_2	Treatment 2
T_6	Treatment 6
WMCO	Molecular Weight Cut Off

LIST OF SYMBOLS

Δm	Mass of permeate (g)
Δt	Process duration
A	Active area of membrane
G	Growth rate
H_1	Height of plant for first measurement
H_2	Height of plant for second measurement
NL	Number of leaves

MENGUMPUL NUTRISI DARI EFLUEN KOLAM IKAN MELALUI PROSES ULTRAFILTRASI SEBAGAI SEMBURAN DAUN

ABSTRAK

Satu kajian telah dijalankan untuk menuai nutrisi terlarut dan mengeluarkan pepejal terampai dan mikrolaga daripada efluen ladang ikan menggunakan membrane ultraturi dan untuk menilai kecekapan nutrisi yang dituai untuk dijadikan baja cecair hidroponik melalui semburan daun. Pada bahagian pertama, dua jenis membrane ultratusi dengan potongan berat molekul berbeza (WMCO) iaitu membrane ST (10kDa) dan membrane MK (30kDa) telah dinilai untuk kecekapan pemisahannya. Keputusan mendedahkan bahawa saiz liang membrane UF tidak mematuhi fluks resapan yang lebih tinggi kerana faktor permukaannya. Fluks membran ST ialah 79.173 L/m^2.j manakala membran MK dengan liang lebih besar hanya mencatatkan fluks 4.228 L/m^2.j. Prarawatan menggunakan mesh kuprum dengan saiz 500 mesh boleh memisahkan mikroalga dan jumla pepejal terampai tanpa mengudah kandungan nutrisi dalam efluen ikan. Keadaan kekotoran membran dikaji melalui deklinasi fluks dan permukaan diperiksa menggunakan Pengimbas Mikroskop Elektron, X-ray penyebaran tenaga dan Spektroskopi Inframerah Transformasi Fourier. Didapati bahawa membran ST mengambil masa lebih kurang 3 jam untuk fluks resapan mula munurun dari fluks resapan tertinggi pada 100.12 L/m^2.j sehingga 85.39 L/m^2.j pada 9.9 jam. Seterusnya, kajian ini menunjukkan bahawa efluen ikan yang dirawat sebagai semburan daun mempunyai manfaat yang besar kepada tumbuhan dari segi ketinggian tumbuhan, bilangan daun dan berat segar. Baja cecair selepas praturasan mesh tembaga dan proses UF mempunyai jangka hayat yang lebih lama tanpa mikroalga yang ketara mekar selepas disimpan 15 hari.

HARVESTING THE NUTRIENTS FROM FISH FARM EFFLUENT VIA ULTRAFILTRATION PROCESS AS FOLIAR SPRAY

ABSTRACT

A study was conducted to harvest the dissolved nutrient and remove suspended solid and microalgae from the fish farm effluent using ultrafiltration membrane and to evaluate the efficiency of the harvested nutrient for hydroponic liquid fertilizer via foliar spray. In the first part, two types of ultrafiltration membrane with different molecular weight cut off (WMCO) namely ST membrane (10kDa) and MK membrane (30kDa) were evaluated for its separation efficiencies. Results revealed that the pore size of UF membrane does not conform a higher permeation flux due to its difference in surface energy. The flux of ST membrane was 79.173 $L/m^2.h$ while the MK membrane with bigger pore only recorded flux of 4.228 $L/m^2.h$. Pretreament using copper mesh with 500 mesh size could separate microalgae and total suspended solid without altering the nutrient content in fish effluent. The fouling conditions of the membrane were studied via flux declination and the surface were examined using Scanning Electron Microscopes (SEM), Energy Dispersive X-Ray Analysis (EDX) and Fourier-transform infrared spectroscopy (FTIR). It was found that ST membrane took approximately 3 hours for the permeate flux to start decreasing from the highest permeate flux at 100.12 $L/m^2.h$ to 85.39 $L/m^2.h$ at 9.9 hour. Next, this study shows that the treated fish effluent as foliar spray has a great benefit to the plant in term of plant height, number of leaves and fresh weight. The liquid fertilizer after copper mesh prefiltration and UF process has longer shelf live with no significant microalgae blooming after storing for 15 days.

CHAPTER 1

INTRODUCTION

Recovering a nutrient from an organic source such as fish farm effluent and recycling the nutrient to a hydroponics plant is a sustainable agriculture practice which gain a lot of attention for the past few years. The combination of fish farm and hydroponics plant is also known as aquaponics system was introduced by lowland Maya who raised a plant on raft on the surface of a lake. Succeeding of the first system, Mark McMurtry and Professor Doug Sanders created a closed loop aquaponic system where they use a fish farm effluent to trickle-irrigate tomatoes and cucumbers in sand grow-beds (Rusty Acres Organics & Aquaponics, 2022). The sand grow beds is used as a bio-filters and the drained water from the sand grow-beds will be recirculate into the fish tank. There are three primary methods for aquaponic system. The first one is a raft method where it allows the water to flow constantly from fish tank, through the raft and back to the fish tank and the plant is grow on a raft allowing the roots to be directly in water. Another one is nutrient film trickles (NFT) where it trickles a thin film of water through the root but this method is the least common method to be used as it requires biofilter to nitrifying bacteria. The last method is a media-filled bed method. This method grows a plant in a box filled with a growth medium on top of the fish tank. This method solely depends on the density of fish in the tank (Junior Science & Humanities Symposium (JSHS), December 5, 2020).

1.1 Research background

A combination of fish effluent and a crop production has increase significantly due to a high demand of organic food among the consumers. A lot of research done found that the nutrient content in fish effluent has a great nutrient to be used a liquid fertilizer to grow plant either on soil or hydroponic.

In fish effluent, there is a lot of suspended solid, microalgae, micronutrient and macronutrient. The micronutrient and macronutrient have a significant benefit towards the hydroponic plant but the presence of microalgae and suspended solid may interrupt the quality of fish effluent as a liquid fertilizer. The presence of the microorganism also is not favour for long term storage of the harvested dissolved nutrient. Upon microalgae death and decomposition, it will utilize the dissolved oxygen from hydroponic system. This incident will increase a biological oxygen demand (BOD) to the system which results in insufficient dissolved oxygen for the root. Moreover, decomposition of microalgae will attract pathogenic fungi such as pythium which will increase the reduction of dissolved oxygen to the roots. Not only that, the accumulation of microalgae in fish effluent will gives a rotten smell. Thus, it is important to filter out microalgae from fish effluent during the nutrient harvesting process. In a nutshell. it is essential to make sure that only the essential nutrient and no microalgae nor suspended solid left in the liquid fertilizer. Therefore, a suitable membrane is required to ensure that both suspended solids and toxic microalgae should be completely removed before it is use as a liquid fertilizer. A membrane filtration such as microfiltration, nanofiltration and ultrafiltration is becoming more favourable as a wastewater pre-treatment method. The membrane used can be classified according to its retain particle sizes.

1.2 Problem Statement

To harvest the nutrients from the farm fish effluent, the material chosen for the ultrafiltration membrane is essential so that it could give the optimum separation performance in terms of flux and separation efficiency. Since farm fish effluent consist of microalgae, suspended solids, excess organic particles, macronutrients and micronutrient it will pose a challenge where the membrane fouling will occur. Based on literature studies, the ultrafiltration membrane can be ranged from Polysulfone hollow-fibre membrane, Polysulfone membrane GR40PP, Flouro polymer membrane, Regenerated cellulose acetate membrane to Polyvinylidene Flouride. In common, these membranes show a similar trend of membrane fouling in which initially it will give a high permeate flux and start to decrease significantly in a short time especially for a bigger pore size of ultrafiltration membrane (Castaing, et al., 2010; Sun, et al., 2014; Nia Yusmaydiyanti, March 2021). Moreover, since ultrafiltration pore size is small and tend to have membrane fouling in a short time, it is favourable to add another pre-filter before ultrafiltration membrane to reduce the unwanted particle from deposited onto the ultrafiltration membrane.

Next, note that microalgae have an extracellular polymeric substance (EPS) where at higher temperature favours the metabolism of microalgae. The EPS release will lead to formation of gel layer onto the membrane surface which will cause a flux drop (Sun, et al., 2013). Thus, it is vital to limit the temperature so that no EPS will form. Significant amounts of algae will reduce nutrients and oxygen uptake of the plant in the water. It can decrease the growth of plants and impact the pH of the system. Algae creates a barrier making it difficult for water to penetrate to the root zone. Although the presence of algae is impossible to be fully eliminated, however, its presence should be well controlled.

Furthermore, even though there is a lot of articles reported that fish effluent shows a great benefit on a plant growth, however, there is less research found for the productivity of liquid fertilizer from fish effluent on hydroponic system via foliar spray. Foliar spray (FS) or known as foliar feeding is basically watering the fertilizer directly to the leaves and commonly use in vegetative and flowering stages as it is linked to higher yields and produce a great quality of fruit. This method will reduce the chance of having a pest-attack and stress from drought (HyLine, 2019). Besides, the essential nutrient of foliar spray can minimize the nutrient deficiency in plant. The weather conditions and time of a day has a great influence on the effectiveness of foliar fertilizer. Hence, the best time to spray the leaves is during the rain-free forecast and calm winds to protect the vegetable foliage from rain and wind exposure. Since both foliar spray and fish effluent has been studied separately but serves a similar benefit on plant growth, this led to the conclusion that the combination of fish effluent and foliar spray has a great potential to further increase the vegetative growth of plant. Technically, the micronutrient and macronutrient from fish farm effluent can be directly absorb by the leaves with the aids of foliar spray, hence giving the plant an easy access to absorb the nutrient and grow healthily.

1.3 Objectives

a. To harvest the dissolved nutrient and to remove suspended solid and microalgae from the fish farm effluent using ultrafiltration membrane.

b. To evaluate the efficiency of the harvested nutrient for hydroponic liquid fertilizer via foliar spray.

CHAPTER 2

LITERATURE REVIEW

2.1 Fish farm effluent as fertilizer

Fish farm effluent has been long study as a nutrients source or irrigation for plant. For example, a study was carried out by Khater, et al. (2015) on the utilization of fish farm effluent towards the tomato cultivation. In their study, the method used is recirculating aquaculture system (RAS) where the hydroponic component works as a biofilter. The water sample is collected from a fish tank. Based on the study, the fish farm effluent consists of NH_3, NO_2, NO_3, P, K, Ca, and Mg. It is observed that the higher the flow rate, the higher the nutrient consumption by tomato which directly increase the number of leaves, shoot and roots length, fresh and dry mass of root, fruit mass and fruit yield. However, the nutrient consumption begins to decrease after it reaches 75 days and the number of leaves start to decrease after 90 days (Khater, et al., 2015).

A study done by Castro, et al. (2006), on the fish effluent efficient as irrigation water to increase cherry tomato yield. The experiment done by using drip irrigation system with an auto-compensated drippers with plastic disc filters. The water sample of collected from the tilapia pond and divided into two. One of the divided water samples was left as it initial and another one is added with chicken manure. The chemical composition of nutrient in the fish effluent mainly consists of 1.95 mg/L, 0.071 mg/L, 0.8 mg/L and 0.013mg/L of N-NH_3, N-NO_2, N-NO_3 and P-PO_4^3 respectively. This study examined on the cherry tomato productivity where it shows a great number of tomato fruit number on the first three harvest period by using fish effluent compared to well water. However, the mean fruit weight is decreasing as the liquid fertilizer has a deficiency over time. Thus, the liquid fertilizer from fish effluent is not enough to maintain the mean weight of tomato. The phosphorus nutrient is essential for the vegetative and reproductive traits in tomato including leaf area, flower production, fruit mass, seed number, pollen production and days until first flower (Castro, et al., 2006).

Another study done by Lewis, et al. (1978) on the efficiency of liquid fertilizer to tomato. The waste sample is collected from a catfish (*Ictalurus punctatus*) fish tank. The nutrient content in catfish effluent is 33.6 mg/L, 6.2 mg/L and 3.9 mg/L of N, P and K respectively. There is also high concentration of other micronutrient such as 354.6 mg/L of Cl and 40.1 mg/L of Ca. From this study, it is reported that tomato need a high level of calcium and magnesium to grow healthily. These nutrients can be supply by addition of makeup water. From this study, it shows that the fresh and dry weight for tomato plant increases with the aids of fish effluent. Hence, fish effluent coming from different sources with a different nutrient content will surely give a great impact to tomato growth.

Since fish effluent shows a great impact on tomato, another study done to evaluate the efficiency of fish effluent on french bean. The study collected the water sample from Sagana Fish Farm with tilapia and african catfish effluent. It is separated to 2 seasons where the first season is to harvest the french bean after 46 days and continued for 28 days and the second season is harvest after 52 days and continued for 28 days. It is observed that the nutrient content in french bean leaves for the first season is 42.1g kg^{-1}, 2.6 g kg^{-1} and 1.82 g kg^{-1} for N, P and K. As for second season, the nutrient is slightly increase for N which is 45.2 g kg^{-1} and slight decrease for P and K which are 2.5 g kg^{-1} and 1.4 g kg^{-1} respectively. It is also reported that application of fish effluent for crops production is feasible. However, it is still insufficient to meet crop nutrient demand. Thus, fish effluent does not really work for french bean as it need another fertilizer to increase the nutrient content for french bean (Meso, et al., 2004)

Next, a study done for efficiency of fish effluent on lettuce from two water samples. The first sample is collected from Zoroa World fish waste that consist of random type of fish while another one is from tilapia fish effluent. The nutrient content in tilapia fish effluent is much lesser than Zoroa World fish waste where for tilapia fish effluent, the nutrient concentration are 352 mg/L, 330 mg/L and 2676 mg/L for N, P and K while for Zoroa World fish waste, the nutrients contents are 27500 mg/L, 36600 mg/L and 2300 mg/L for N, P and K respectively. However, even when the nutrient concentration from different sources has a great value difference, it comes to a same conclusion in which the usage of fish effluent produces a lower number of leaves, height, fresh and dry weight. This factor also affected probably due to the EC level of water effluent. The optimum EC level for lettuce growth is between 0.3 – 0.8. However, in their report, the EC level is between 2.0 – 2.5 (R. Ahmed, et al., 2021). Moreover, the usage of tilapia fish effluent has increased the plants' chlorophyll A, chlorophyll B, total carotenoids and free radical scavenging activity (Felix & Rosario, 2019).

On the other hand, fish effluent shows a great benefit on basil and purslane. The nutrient collected from fish farm block pool consist of 0.53 mg/L, 0.66 mg/L, 7.98 mg/L, 18.3 mg/L, 34.2 mg/L and 0.615 mg/L of NO_2, NH_4, P, K, Ca and Mg respectively. It observes that fish effluent increases the shoot fresh weight for basil and purslane by 104% and 192%, respectively. Not only that, the fresh weight of root in basil and purslane also increases by 110% and 58% respectively. In fish effluent, the rich amount of nutrient especially nitrogen and phosphorus enhance the growth of fresh and dry weight of plant. Moreover, by using fish effluent, the nutrient content in basil and purslane reaches its highest concentration and fish effluent increase the nitrogen concentration up to 2.5 and 6 times in basil and purslane, respectively. Thus, it can conclude that fish effluent is a good liquid fertilizer for basil and purslane (Omei, et al., 2019).

Electrical conductivity (EC) is an indicator of the total amount of nutrient salts presence in water. The maximum EC level for all hydroponics plant is 3.0. However, different crops require different amount of nutrient to achieve its optimum growth and quality.

Mostly, vegetables have an EC range between 1.4 - 2.4. The EC value for different type of plant is tabulated as below:

Table 2. 1: EC value for different type of plant (Joe, 2021)

Type of plant	EC level
Lettuce	0.3 - 0.8
Cooking herbs- basil, mint, chives, thyme, sage	1.0 - 1.6
Beans, eggplants, onion, strawberries	1.8 - 2.4
Tomato	2.2 - 2.8
Spinach	1.8 – 3.5
Asparagus	1.4 - 1.8

EC is an important factor in nutrient solutions. It shows the total content of macro and micro element available to the plant. Not only that, EC level measures the influence of the plant's ability to absorb water. Low level of EC leads to nutrient deficiencies which will slow down the growth of the plant while high level of HC also will disrupt the growing pattern of the plant as it will impede the nutrient uptake by increasing the salt stress and osmotic pressure (Nguyen, et al., 2011). Hence, it is really important to check the EC level to always aware with our plant whether the plant is getting sufficient amount of nutrient or vice-versa.

2.2 Foliar Spray to enhance the growth of green vegetable

The efficiency of foliar spray on a green vegetable can be observed from different researcher using different type of foliar spray on different type of plant. Firstly, a study done by Roosta (2014) on the effect of foliar spray of potassium, K on different type of green vegetables such as mint, radish, parsley and coriander plant. This experiment uses an aquaponic system with a composition of food waste of 46% of protein, 13% of fat and ash, 2.5% of fibre, 1.5% of phosphorus and 11% of moisture. Based on this research, it is observed that the height of parsley and coriander plant increase significantly from 19.0 cm to 22.7 cm and 14.3 cm to 21.3 cm respectively. However, mint and radish height did not affect by the presence of foliar spray. This indicates that different type of plant is affected by different agroclimatic and biochemical factors. Furthermore, the root and shoot for fresh and dry weight increase with the presence of foliar spray for all type of plant. Hence, this experiment concludes that the application of foliar spray using potassium increased the vegetative growth of plant in aquaponic system. The result of this research done by Roosta (2014) can be observe in Table 2.2:

Table 2. 2: Effect of foliar spray on mint, radish, parsley and coriander plant

Plant	K Spray ($g\ L^{-1}$)	Height(cm)	RDW($g\ m^{-2}$)	RFW($g\ m^{-2}$)	SDW($g\ m^{-2}$)	SFW($g\ m^{-2}$)	LAI
Mint	0	47.0 ± 1.00^{a}	76 ± 1.94^{d}	463 ± 11.36^{ef}	302 ± 1.33^{c}	1477 ± 97^{d}	7.15 ± 0.10^{b}
	2	$47.7 \pm 1.86^{a\dagger}$	121 ± 4.98^{c}	731 ± 8.96^{d}	334 ± 9.62^{b}	1754 ± 54^{c}	7.82 ± 0.35^{a}
Radish	0	$16.7 \pm 0.33d^{e}$	165 ± 15.59^{b}	1498 ± 73.66^{b}	$248 \pm 4.08d^{e}$	2183 ± 113^{b}	4.73 ± 0.25^{cd}
	2	16.0 ± 0.58^{e}	205 ± 8.04^{a}	1988 ± 69.93^{a}	376 ± 8.80^{a}	3186 ± 123^{a}	4.52 ± 0.14^{d}
Parsley	0	19.0 ± 0.58^{cd}	112 ± 8.36^{c}	1265 ± 65.59^{c}	174 ± 2.92^{f}	757 ± 6^{e}	6.80 ± 0.13^{b}
	2	22.7 ± 0.67^{b}	154 ± 3.17^{b}	1219 ± 68.00^{c}	255 ± 13.86^{de}	1247 ± 75^{d}	6.75 ± 0.22^{b}
Coriander	0	14.3 ± 0.67^{e}	44 ± 2.54^{e}	408 ± 42.43^{f}	236 ± 10.65^{e}	1385 ± 77^{d}	5.27 ± 0.16^{c}
	2	21.3 ± 0.33^{bc}	60 ± 3.85^{de}	$612 \pm 38.63d^{e}$	277 ± 9.54^{cd}	1754 ± 26^{c}	5.07 ± 0.22^{cd}

* Mean ± standard error. Mean separation was done by Duncan's multiple range test and the same letter (s) in each column indicates non-significant difference at $P \leq 0.05$

Another research done by Bethe, et al. (2017) to observe the effect of foliar spray of molasses and compost tea on water spinach in aquaponic system. The weight of leaves and roots of water spinach was recorded with three different treatment which are T_1, foliar spray with molasses, T_2, foliar spray with compost tea and T_3, nothing as control.

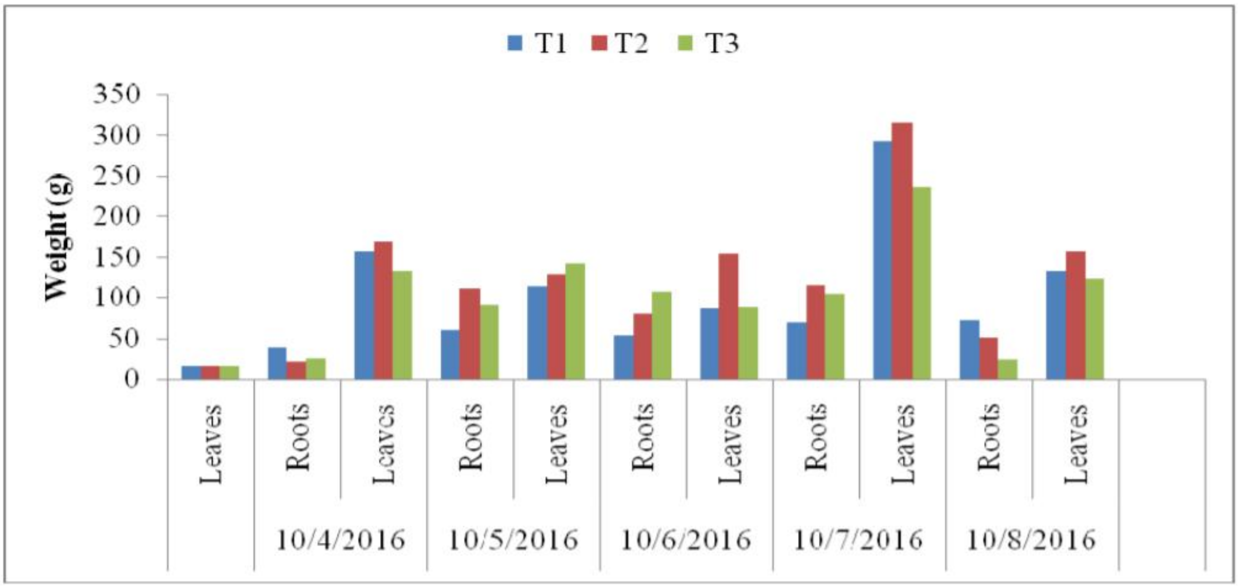


Figure 2. 1: Root and leaves weight of water spinach using different foliar spray

According to Figure 2.1, it is shown that the weight of leaves during partial harvesting have no significant different between all treatment. In the contrary, there is an increasing number of root weights for each type of treatment. From this research, according to its average calculation weight of leaves and roots, T_2 shows the greatest improvement. T_2 treatment uses compost tea and the great quality from this treatment is probably due to the soluble nutrient content extracted from compost. The presence of bacteria, fungi, protozoa and nematodes also give good benefit to the liquid fertilizer. They also stated that the presence of these microorganisms helps the plant growth by protecting the surface from harmful microbes and prevent the pathogens from attach to the leaves.

Another study done by (Yassen, et al., 2020) on the impact of vermiwash foliar spray on the growth, yield and nutritional status of lettuce. Vermiwash is a liquid extracted from vermicompost which made from a plant that contain several enzyme and plant growth hormones, micro- and macronutrient. In this research, they use 5 types of foliar spray with vermicompost, 2 vermicompost and 1 control treatment. The 6 types of foliar spray have a different percentage of vermicompost and vermiwash. The plant is harvested after 60 days from transplanting.

Table 2. 3: Effect of different rate of vermicompost and vermiwash on plant growth.

Treatments	Plant height (cm)	Number of leaves /plant	leaf area mm^2	Fresh matter of leaves g $plant^{-1}$	Dry matter of leaves g $plant^{-1}$	Head diameter	Head Fresh matter (g)	Head dry matter (g)	Total yield ton/Fed
T_1	23.68	26.33	188	288.55	55.24	15.12	218.74	31.29	10.40
T_2	26.51	28.67	220	356.03	67.66	17.46	244.41	35.73	13.18
T_3	30.11	35.67	249	370.57	71.51	19.27	263.42	40.60	15.65
T_4	33.73	38.00	263	384.93	75.14	21.17	288.70	42.61	16.33
T_5	31.89	40.33	274	390.14	78.55	22.59	300.36	42.85	15.92
T_6	29.87	36.00	245	406.80	74.49	20.13	279.49	37.03	14.10
T_7	34.52	43.67	275	405.84	81.76	23.76	300.09	40.10	17.88
T_8	37.44	44.00	288	432.49	85.28	25.17	321.44	45.93	18.84
T_9	38.11	44.67	290	425.58	87.10	26.02	314.35	42.68	19.06
LSD 5%	2.17	1.69	21.82	23.99	3.14	2.51	12.65	3.55	1.39

Based on Table 2.3, the plant height is increased with the presence of vermiwash. It is observed that T_9 shows the highest plant height, number of leaves, leaf area, fresh and dry matter of leaves and head, head diameter and total yield. T_9 consists with vermicompost and vermiwash foliar application. This concludes that the foliar application helps to induce the nutrient of leaves and head of lettuce. This study is also support by another researcher where it stated that the foliar spray with vermiwash increase the vegetative growth parameter to the maximum due to its rich content of micro and macronutrient.

The application of foliar spray not only increase the rate growth of plant, it also shows a great impact on the micronutrient content in the leaf. According to (Yassen, et al., 2020) on the macro and micronutrient of all type of plant such as K, Mg, Ca, Na, Fe, Mn and Zn is increased. These micro and macronutrient are the factor that influence the quality of the plant. For example, as Fe increases, the chlorophyll content in leaves also increases which will produce a greener vegetable. Besides, K is known as an activator of important enzyme such as protein synthesis, photosynthesis and sugar transport. The reason why K is very important is because the high presence of K will stimulate and controls ATPase in plasma membrane which will then generate acid stimulation and loosening the cell wall and hydrolase activation which results to higher cell growth. The important and efficiency of K has been agreed by various researcher. These researchers found that K has improved the quality of Red Fuji apple, pear and orange (JIN, et al., 2007; JW, et al., 2001).

Table 2. 4: Micro and macronutrient of different type of plant (Yassen, et al., 2020).

		(% DW)			($mg\ Kg^{-1}$ DW)			
Plant	K Spray($g\ L^{-1}$)	K	Mg	Ca	Na	Fe	Mn	Zn
					Shoot			
Mint	0	2.66 ± 0.20^{c}	0.45 ± 0.02^{c}	0.70 ± 0.03^{d}	13.06 ± 0.41^{e}	103.17 ± 0.84^{bc}	24.20 ± 0.40^{f}	35.80 ± 1.72^{cde}
	2	$3.67 \pm 0.12^{b\dagger}$	0.44 ± 0.01^{c}	0.67 ± 0.04^{d}	18.16 ± 0.72^{e}	113.37 ± 4.67^{b}	26.80 ± 0.95^{ef}	42.70 ± 1.21^{b}
Radish	0	3.10 ± 0.09^{c}	0.69 ± 0.04^{a}	1.51 ± 0.06^{a}	55.48 ± 0.84^{c}	75.50 ± 7.92^{d}	29.77 ± 2.70^{de}	39.77 ± 1.35^{bc}
	2	3.88 ± 0.20^{b}	0.47 ± 0.03^{c}	1.10 ± 0.03^{bc}	32.83 ± 2.51^{d}	94.83 ± 3.27^{c}	30.60 ± 2.11^{cd}	48.87 ± 3.88^{a}
Parsley	0	3.06 ± 0.33^{c}	0.34 ± 0.02^{d}	0.57 ± 0.01^{d}	51.02 ± 0.90^{c}	95.37 ± 1.28^{c}	33.77 ± 1.76^{bc}	30.83 ± 0.97^{e}
	2	4.12 ± 0.15^{b}	0.44 ± 0.04^{c}	0.65 ± 0.05^{d}	38.58 ± 0.15^{d}	109.53 ± 0.35^{b}	34.37 ± 2.29^{b}	32.93 ± 2.22^{de}
Coriander	0	3.75 ± 0.06^{b}	0.60 ± 0.04^{ab}	1.20 ± 0.04^{b}	80.05 ± 0.80^{a}	128.43 ± 4.05^{a}	40.13 ± 1.09^{a}	$36.50 \pm 2.26^{b\text{-}e}$
	2	4.67 ± 0.09^{a}	0.57 ± 0.04^{b}	0.99 ± 0.05^{c}	69.20 ± 5.25^{b}	129.43 ± 3.18^{a}	30.13 ± 0.81^{de}	37.37 ± 1.21^{bcd}
					Root			
Mint	0	1.10 ± 0.22^{b}	0.54 ± 0.02^{b}	1.16 ± 0.02^{c}	40.17 ± 0.86^{b}	171.93 ± 3.51^{cd}	24.57 ± 0.33^{d}	37.20 ± 3.18^{bcd}
	2	1.55 ± 0.01^{a}	0.38 ± 0.01^{c}	0.93 ± 0.03^{d}	31.24 ± 2.13^{c}	186.67 ± 11.5^{bc}	34.77 ± 1.58^{c}	43.47 ± 0.71^{bc}
Radish	0	1.24 ± 0.16^{b}	0.27 ± 0.01^{d}	0.51 ± 0.06^{f}	49.42 ± 2.44^{a}	130.27 ± 7.24^{e}	16.87 ± 0.65^{e}	33.40 ± 1.29^{d}
	2	1.73 ± 0.06^{a}	0.35 ± 0.03^{cd}	0.51 ± 0.01^{f}	52.93 ± 3.08^{a}	153.27 ± 5.64^{de}	17.50 ± 0.81^{e}	34.37 ± 2.82^{d}
Parsley	0	1.02 ± 0.02^{b}	0.61 ± 0.06^{b}	0.64 ± 0.05^{e}	45.59 ± 2.39^{ab}	158.57 ± 4.46^{d}	33.90 ± 2.67^{c}	35.57 ± 3.17^{cd}
	2	1.05 ± 0.05^{b}	0.70 ± 0.02^{a}	1.31 ± 0.00^{b}	46.55 ± 2.57^{ab}	211.00 ± 9.18^{b}	44.77 ± 1.37^{b}	46.00 ± 1.94^{b}
Coriander	0	0.67 ± 0.06^{c}	0.56 ± 0.03^{b}	1.49 ± 0.02^{a}	52.61 ± 0.65^{a}	272.80 ± 14.1^{a}	59.27 ± 2.94^{a}	58.83 ± 1.16^{a}
	2	0.65 ± 0.08^{c}	0.53 ± 0.02^{b}	1.50 ± 0.05^{a}	47.19 ± 3.75^{ab}	294.17 ± 7.33^{a}	63.07 ± 1.23^{a}	61.73 ± 4.36^{a}

Based on their research findings in Table 2.4, it can be concluded that the presence of foliar spray will give a great addition on to the vegetative growth of plant. It is interesting to note that the effectiveness of foliar spray is highly influence by the nutrient composition and type of liquid fertilizer used for the foliar spray. In this study, since the focus is more to usage of fish farm effluent as foliar spray, it is crucial to extract the best nutrient from the fish farm effluent and separate the unwanted substances before applying to the plant.

2.3 Effects of algae to the plant growth

Hydroponic system is one of the ideal environments for algal growth especially with the recirculating nutrient solution. A lot of research found that the presence of algal will become a competitor for nutrients, and some of the species may produce toxins to the plant (Huizebos, et al., 1993). Moreover, the algae will accumulate at the root of the plant which will reduce the penetration of oxygen on the roots that will inhibits the plant growth. However, algae may also be beneficial on the plant. This is due to the oxygen produce by the algal photosynthesis which prevent the anaerobiosis in the root. A study done by Schwarz & Gross (2004) stated that *Chlamydomonas* sp. and *Scenedesmus* sp. will exhibit the promoting effects growth on plant. These microalgae will produce extracellular mucilage and weak auxin-like and cytokinin-like activity which known to gives a good impact on the plant growth. However, the result indicates that there is no significant effect from the presence of mucilage, auxin, and cytokinin-like on the plant growth and reduced the fresh weight of plant with a decreasing amount of water and nitrogen uptake. From this research also stated that the presence of algae in hydroponic system gives a negative impact but it cannot be generalized since there are still a lot of research found a great benefits on the presence of algae. However, it concludes that the factor influences the different result obtain is highly influence by the algal community and density present along with the type of plant studied.

Moreover, algae can easily reproduce on any surface and it can make its way to any tube or pump which results in clogging and causing the system to break down. As the number of algae increases, the tendency of having a sluggish system increases. As mentioned earlier, the presence of algae will be a competitor to the plant as it will absorb the nutrient and uses them to grow. When algae die and decompose, it takes out the oxygen from the system which will reduce the dissolved oxygen leaving the roots with insufficient oxygen. Furthermore, significant number of algae will disrupt the optimum pH level of water because microalgae will absorb carbon dioxide from water during the day for cell growth. This will increase the pH level of the water. During the night, as there is no more sunlight, the process of photosynthesis will stop and algae will continue to release CO_2 and lowers down the pH level. This indicates that the presence of algae will creates a fluctuation pH level. From this reading, it shows that algae has its benefits on the plant growth but it is best to eliminate or at least reduce the presence of algae as it also give a bad side effect to the plant.

2.4 Membrane for treatment of fish farm effluent

Undesirable suspended solid and microalgae from fish effluent will reduce the efficiency of liquid fertilizer for hydroponic plant. To preserve a good quality of liquid fertilizer, the unwanted material such as suspended solid and microalgae need to be removed. Considering that there is lack of studies on removing microalgae and suspended solid using ultrafiltration membrane, hence this literature review is mainly focus on the filtration of suspended solid and microalgae from other medium such as microalgae cultivation medium and wastewater. The reason why microalgae cultivation and wastewater are chosen is because these mediums are assumed to have a quite similar composition with fish farm effluent in term of presence of algae and suspended solid.

There are different types of ultrafiltration membrane that been used to separate those material such as polysulfone hollow-fibre membrane, polysulfone membrane, fluoropolymer membrane, regenerated cellulose acetate membrane, aquasource polyethersulfone, polyvinlidene flouride (PVDF), 23-channel ceramic membrane and modified polyethersulfone. polysulfone hollow-fibre membrane if a modified version of polysulfone membrane which has a fine filter that works as a selective membrane in removing some particles according to its size. This type of membrane has its own range of pore size which is vital to determine its separation efficiency. The range of the pore size membrane is tabulated in Table 2.5:

Table 2. 5: Range of pore size for different type of membrane

Type of membrane	Pore size
Polysulfone hollow-fibre membrane	10 - 300 kDa
Fluoropolymer membrane	100000 WMCO
Regenerated Cellulose Acetate membrane	10000 WMCO
Aquasource Polyethersulfone membrane	200 kDa
Polyvinlidene Flouride (PVDF) membrane	10000 - 100000 kDa
23-channel Ceramic membrane	150 - 300 kDa
Modified Polyethersulfone membrane	6 kDa
Polysulfone membrane	100000 WMCO

According to research done by Castaing, et al. (2010) polysulfone membrane with two different pore size were examined for total removal of toxic micro-algae. It was found that membrane with 10 kDa molecular weight cut off (MWCO) has a higher retention rate of suspended solid compared to 300 kDa MWCO which is 94% and 86% respectively. However, both MWCO has 99% of retention rate for microalgae. Moreover, a higher MWCO shows a high initial permeate flux but decrease significantly in a short period of time where a smaller MWCO has a lower permeate flux but has a steady performance throughout the process.

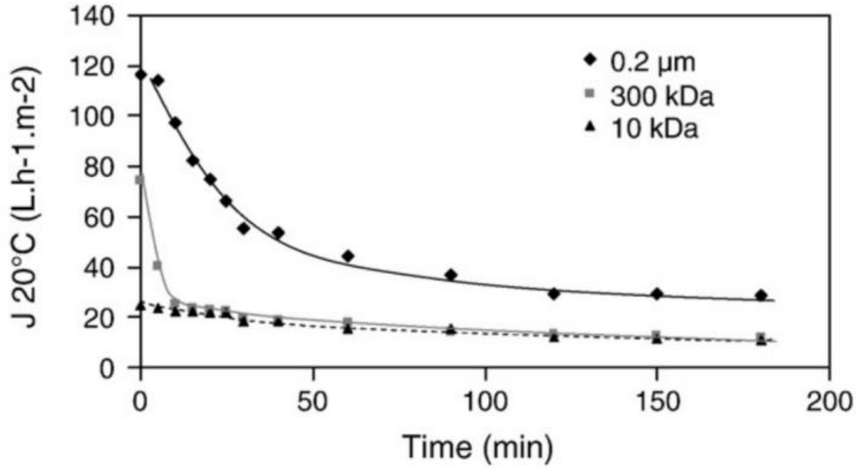


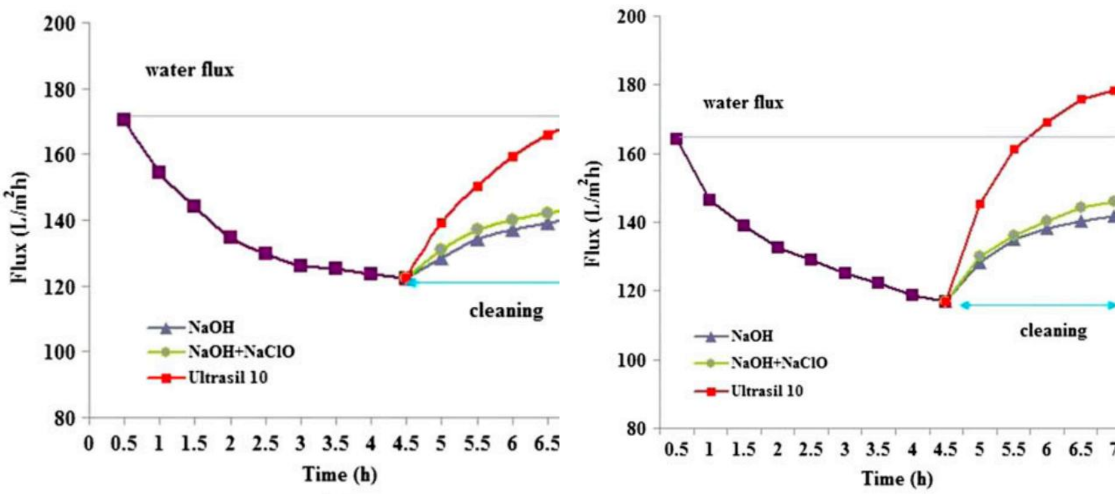
Figure 2. 2: Permeate flux at different pore size (Castaing, et al., 2010).

From a result shown by Nedzarek, et al. (2015), the permeate flux of 300 kDa on 23-channel ceramic ultrafiltration membrane, shows a higher permeate flux at the beginning which is 7.50 x 10^{-2} $m^3m^{-2}s$ but decrease drastically to 3.0 x 10^{-2} $m^3m^{-2}s$ in one minute. Another research found the same trend where membrane flux decrease drastically as the feed concentration increases where the initial flux is 1.0 J_w/J_o to 0.72 Jw/J_o after 10 minutes (Nia Yusmaydiyanti, March 2021). This indicates that a higher MWCO membrane is more susceptible to pore blocking which increase the hydraulics resistance of the system.

From this literature review, it indicates that the filtration of microalgae and suspended solid will surely rise a blockage on the membrane which then reduce the efficiency of membrane. Since ultrafiltration membrane has a very small pore size, this incident is expected to happen. Hence, the pretreatment of fish effluent using pre-filter membrane is essential to reduce the accumulation of suspended solid and algae on the ultrafiltration membrane.

2.5 Membrane with algae fouling and cleaning method

Membrane cleaning is also important to ensure that the membrane can be operated for a long time. There are few types of membrane cleaning agent which are NaOH, HNO_3, backwashing and forward washing using permeate that aims a same result to reduce membrane fouling. One of the most common membrane cleaning agents is Ulrasil10. This cleaning agent is a formulated cleaning agent and works better compared to other method mentioned above. It is important to know whether the fouling is irreversible or reversible. This is because, not suitable cleaning method may worsen the membrane fouling. For example, reversible fouling formed by the gel layer can be removed by strong shear force of backwashing while irreversible blockage can only be removed by chemical cleaning agent.



(a) FS40PP (b) GR40PP

Figure 2. 3: Permeate flux on different type of membrane with different cleaning agent for FS40PP (a) and GR40PP (b) UF membrane.

A study done by Sun, et al. (2014) where there is an application of membrane cleaning to examine the flux. As shown in Figure 2.3, both membranes have an increasing flux after cleaning. The three chemical agents use in this study is NaOH,

NaOH + NaCIO and Ultrasil10. These cleaning agents were applied to remove the fouling residue and cake layer on the membrane surface. It was reported that by applying the chemical cleaning agent, the flux recovery for FS40PP and GR40PP achieved 68.15% and 67.74%. However, this flux recovery is not effective enough to remove any microalgae attached on the membrane. Another result shows that UF membrane with hydrophilic property has a flux recovery achieved at 96.15%. Hence, it concludes that the membrane property has a significant impact on the cleaning agent usage. This study also found that flux recovery using NaOH is lesser compared to NaClO + NaOH. This is because, presence of NaOH have restructure the membrane pore size which results in a bigger and looser structure that enhance the penetration of NaClO to extract the foulant from membrane and it is easier to reach on the inner fouling material.

However, both of the cleaning agents are not favourable to remove algae deposited onto the UF membrane. By further emphasizing on the Ultrasil10, application of Ultrasil10 have higher permeate flux compared to clean membrane because it is formulated cleaning agent which has a caustic-based reagent with surfactants. The addition of surfactant in cleaning agent product has increased the adsorption rate on membrane surface as well as reducing the hydrophobic on membrane which enhance the recovery of water flux. However, even though Ultrasil10 is a formulated cleaning agent, it still need an optimum time since short-time cleaning is not sufficient to remove foulants on the membrane surface.

CHAPTER 3

METHODOLOGY

This section is mainly focus on the methods and materials that going to be used throughout this project. The overall flowchart of the process is shown in figure 3.1.

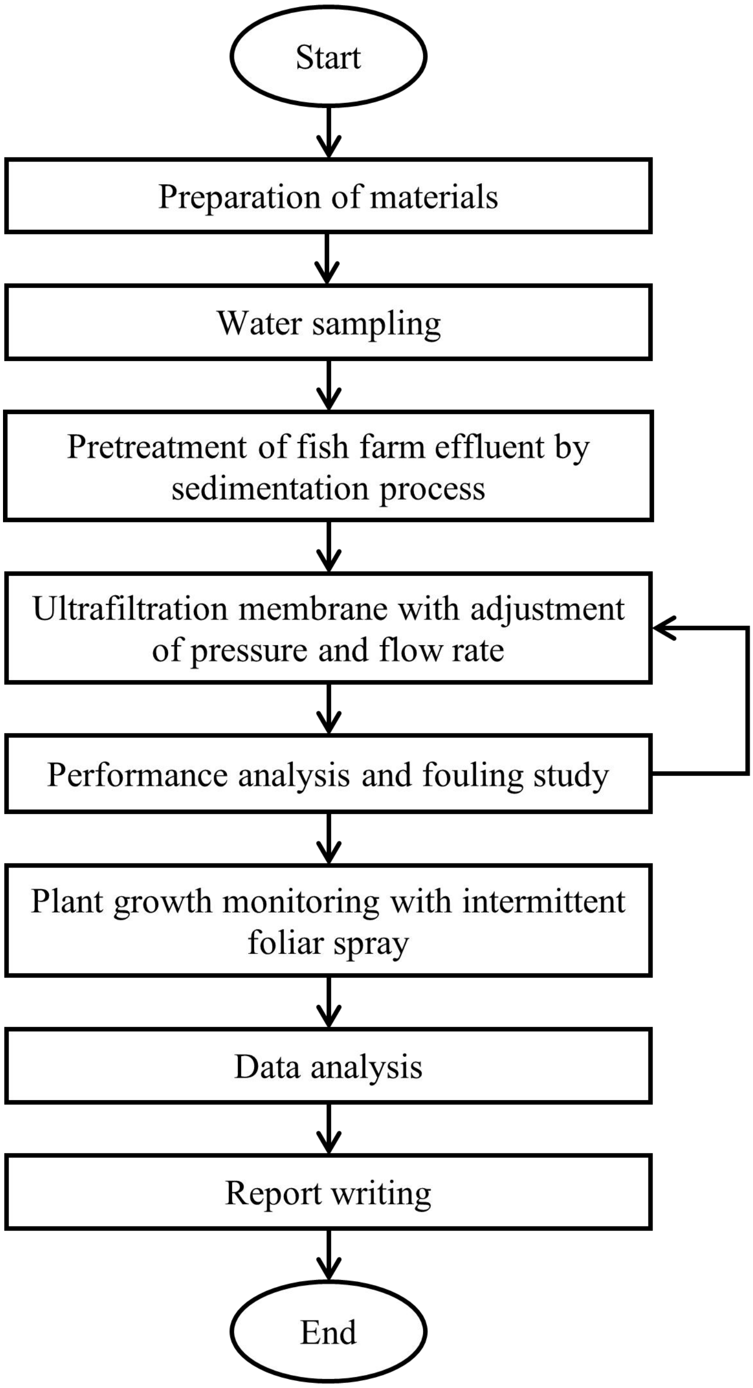


Figure 3. 1: Flowchart of experiment throughout this experiment

3.1 Materials and chemical used

The materials used for this project are shown in the Table 3.1:

Table 3. 1: The list of materials use throughout this experiment.

Material	Usage
Pre-filter membrane	To filter suspended solid and unwanted substances
Ultrafiltration membrane (Type: DK)	To filter out microalgae
Electrical conductivity meter	To determine the EC level of liquid
Tap water	To clean the membrane
Fish farm effluent	To obtain the nutrient from this medium
Spinach seed	To plant the vegetable and test the foliar spray

3.2 Equipment

a) Storage tank
b) Stopwatch
c) Freezer
d) Beakers
e) Electrical conductivity meter (ECM)
f) Oven
g) Measuring tape
h) Spray bottle
i) Cutter
j) Weighing scale
k) Tintometer to check the nutrient content

3.3 Experimental set up

The feed water (fish farm effluent) used in this study was collected from Sungai Udang. The fish farm effluent contains suspended solids and microalgae that needs to be filter out before extracting the nutrient from fish farm effluent. The flat sheet of DK membrane was used for ultrafiltration experiment while copper mesh filter was used as pre-filter membrane. For this experiment, a flat sheet membrane with different molecular weight cut off (Synder UF Membrane UF, 10kDa and 30kDa) will be used.

A crossflow ultrafiltration unit (Figure 3.2) was employed to evaluate the performance of various membranes in the fish farm effluent separation. The membrane chamber (Sterlitech, CF042) has an effective geometrical area of 0.0042 m^2. The pure water and pre-filtered fish farm water were re-circulated from feed tank to whole ultrafiltration unit at a constant flow rate of 0.4 L/min by peristaltic pump (Flex-Pro A4 Series). Prior to each filtration process, membranes were subjected to 30 min compression at transmembrane pressure (TMP) of 1.5 ± 0.1 bar. After the membrane compression process, the TMP was lower down to 1.0±0.1 bar and the pure water flux was recorded. The permeation data was collected at a time interval of 1 min and the readings was recorded using electronic balance that connected to computer (Model: Fx-3000i, A&D Company). The filtration of the fish farm effluent was performed under the same temperature and TMP conditions for 1 h. 500 ml of the prefiltered effluent was first prepared and pump through the UF unit. The solution was recirculated through the membrane chamber. TMP was monitored throughout the experiment.

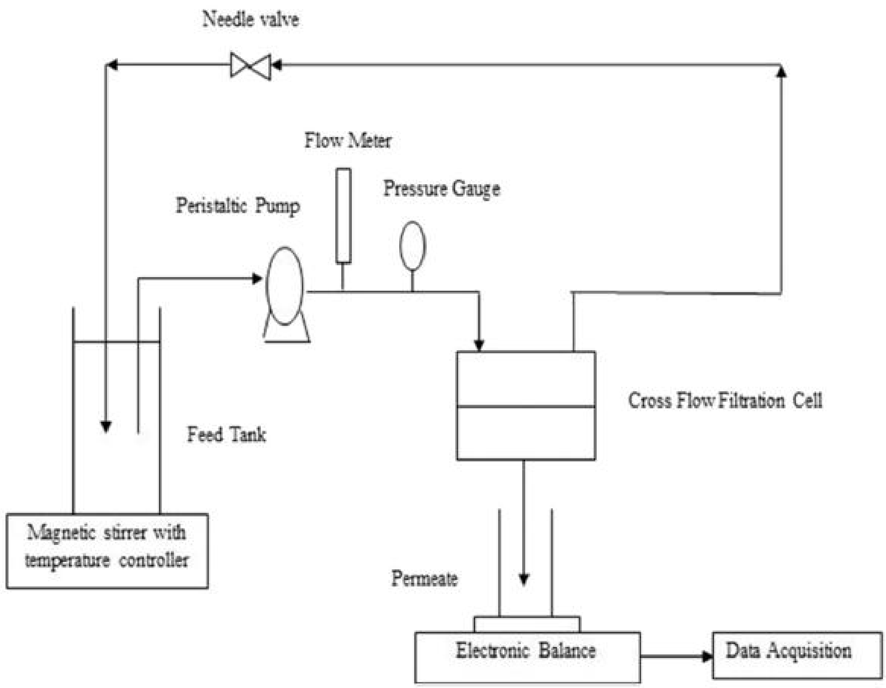


Figure 3. 2: Schematic diagram of the UF system

Copper mesh (Mesh size 500) was used as a pre-filtration before the ultrafiltration process by pouring the sedimented fish farm effluent slowly on the filter set up operated under vacuum condition.

3.4 Analysis method for membrane

3.4.1 Surface Morphology and foulants characteristic

The morphology and composition of the deposit layer on both the membrane surface and cross-section, before and after ultrafiltration process, were examined using scanning electron microscopy, SEM (FEI Quanta 450, United Stated). For membrane surface observation, the membrane samples were cut into small pieces of approximately 1-cm length fibre while for membrane cross-section observation, the membranes were immersed into liquid nitrogen and cryogenically fractured to have a clean brittle facture for SEM images. The samples were mounted onto the sample