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Secondary Treated Sewage Waste Water Aqua / Hydro Ponics

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Abstract - *The main purpose of this research paper is to mark the difference between conventional RO water and secondary treated sewage waste water for the cultivation of aquaponics and hydroponics. For the ages now the use of RO water is made for the cultivation of aqua and hydroponics, but instead of blindly following the traditional way, we made use of secondary treated sewage waste water for the cultivation of ponics. By Secondary Treated Sewage Waste Water (STSWW), we mean that this waste water is purified to secondary stage at sewage treatment plant, the steps involved for this will be mentioned further in the paper, which involves segregation, grit removal, settling, aeration, bacteria growth for purification, decanting and chlorination, (although chlorination was avoided by us in the water). Instead of using RO water, which takes plenty time for formation to attain its best quality, is later wasted due to the fish waste and plant extracts. So, we used the already treated waste water, which is later Tertiary Treated to make is potable for humans.*

Key Words: Aqua and hydroponics, RO water, secondary treated sewage waste water, Tertiary Treated.

1.INTRODUCTION:

The main purpose of using this is to make sure plenty of RO water is saved for drinking than used for aquaponics. Many a time this secondary treated water is directly supplied to the rivers this is done to avoid direct infusion of waste water with the rivers, and the primary source being the river for drinking water it is made sure that it is not polluted, so instead of even suppling it to river and then using it for farming practices through pumping, it can directly be used for farming practices or for the aqua / hydroponics. What we have done is combined both the hydro and aquaponics together. Hydroponics generally is carried out with chemical nutrition supply, and additives used for the growth of the plant, instead of using the chemical nutrition one can use the same concept of aquaponics for hydroponics and both can be nurtured simultaneously without chemical additives for plant growth. The ammonia (NH_4) rich water received from the fisheries can be first supplied to hydroponics growing vertically in pipes, and then this water can be fed to the aquaponics system through gravity, which can later be again fed to the fish pond, so whole of system involves lifting of the water for the single time, so energy is saved and economy is achieved.

1) NH4 + ↔ NH3 + H+ reaction which takes place for the ammonia

(This NH3 is consumed by the plants, also many a times this converted NH3 gets back to its original form of NH4 so maintain the equilibrium.)

2)Nitrosomonas spp. NH3 + 1½ O2 ↔ NO2 – + H2O + H+ + 84 kcal·mol–1

(10 % of the protein in the fish feed becomes ammonia nitrogen)

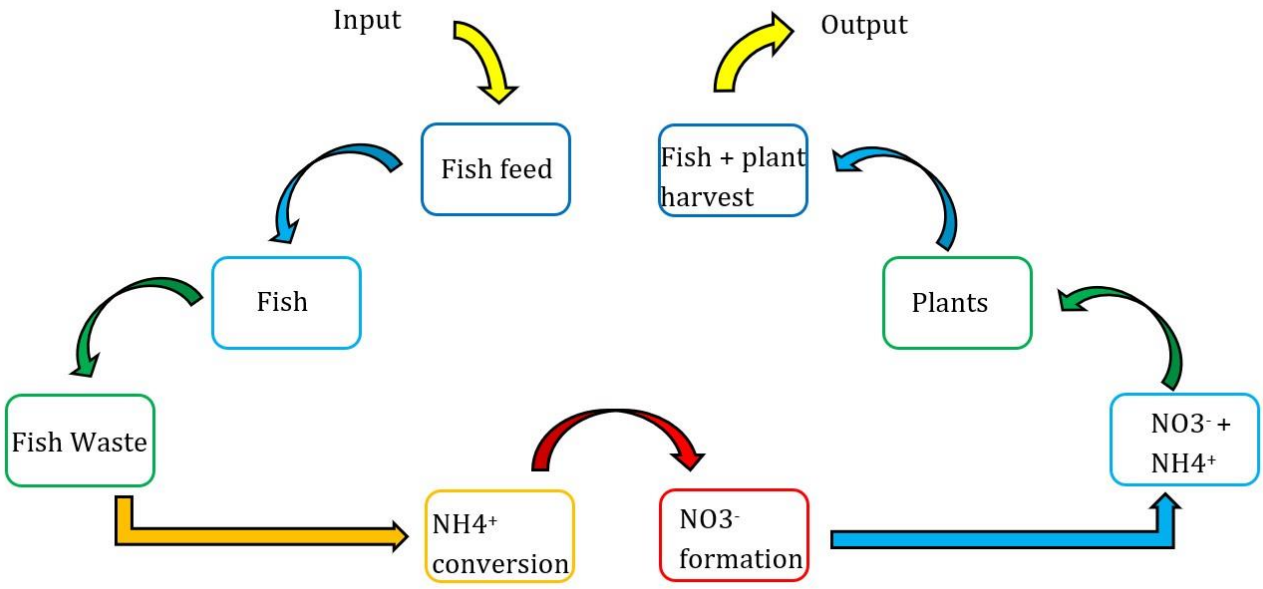
3)Nitrobacter spp. NO2 – + ½ O2 ↔ NO3 – +17.8 kcal·mol–1

(NH3 is substrate for nitrification & is converted to nitrate)

These are the chemical reactions which take place in the system, along with this if the roots alone don't purify the water, then MBBR is used to clean the water MBBR (Moving Bed Biological Reactor), this system is typically used to purify the municipal waste used for industrial applications, it separates organic substances, performs nitrification and denitrification. It consists of high aeration, which helps in its process. The Ecologix MBBR is a highly effective biological treatment process based on a combination of conventional activated sludge process and biofilm media. The MBBR process utilizes floating High-Capacity Microorganism Biochip media. Small palettes are introduced in the MBBR, it involves high aeration, growth of the bacteria takes place on this.

Three main types of aquaponics and hydroponics system present are:

1) NFT (Net Flow Technique),
2) Media based technique,
3) Raft system.



1.1 Plants:

Nutritional Requirements for plants:

All plants may have different nutritional requirements; for instance, leafy green vegetable require more nitrates than fruiting plants. However, all plants in aquaponic systems need 16 essential nutrients for maximum growth. These come in the form of macronutrients, which in addition to carbon, hydrogen, and oxygen, which are supplied by water, carbon dioxide, and atmospheric air, include nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg), phosphorous (P) and Sulphur (S). There are seven micronutrients necessary as well and they are chlorine (Cl), iron (Fe), magnesium (Mn), boron (B), zinc (Zn), copper (Cu), and molybdenum (Mo).

Crop Selection:

Many types of plants can grow successfully in aquaponic systems. Originally it was thought that only leafy green vegetable and herb crops could be grown, but it has since been proven that a wide variety of fruiting crops, beans, and flowers can be grown effectively.

Plant aquaponics:

In this the roots of the plants are set into the water bed, which consists of dissolved waste of fishes, in this the roots have much more space to grow vertically, with significant space between the plants i.e., 7 to 10 cm space between each plant, and a hole of approx. 5 cm diameter can meet the desired requirements. Rich effluent water helps the water to grow, without inclusion of other growth nutrients. The roots of plant help in purifying the ammonia enriched water, which is the waste product of the fishes. The main point to be noted here is that, the fish waste which is useful for the plants, that same ammonia enriched water when circulated in fish tank, is harmful for the fishes. The purification of this ammonia enriched water is done by the roots, also inclusion of MBBR can result into the purification of the water, MBBR is Moving Bed Biofilm Reactor in this the palettes, are immersed and when the water is circulated through this MBBR the palettes act as growing media for bacteria, and hence purifies the water. This water when circulated through various stages is enriched with oxygen and the aeration of this water takes place, making it fit for the fishes to survive, enriched with DO.

Different aquaponic application of hydroponic system include:

- Recirculating aquaponics: solid media such as gravel or clay beads, held in a container that is flooded with water from the aquaculture. This type of aquaponics is also known as closed-loop aquaponics.

- Reciprocating aquaponics: solid media in a container that is alternately flooded and drained utilizing different types of siphon drains. This type of aquaponics is also known as flood-and-drain aquaponics or ebb-and-flow aquaponics.
- Deep-water raft aquaponics: Styrofoam rafts floating in a relatively deep aquaculture basin in troughs.
- Other systems use towers that are trickle-fed from the top, nutrient film technique channels, horizontal PVC pipes with holes for the pots, plastic barrels cut in half with gravel or rafts in them. Each approach has its own benefits.

The use of this system can mainly be done for the growth of green leafy vegetables, many of them include the cabbage, all types of lettuce, fenugreek, spinach, cherry tomatoes, basil, roses, okra, cantaloupe and bell peppers. Not only these varieties but many more such as, beans, peas, kohlrabi, watercress, taro, radishes, strawberries, melons, onions, turnips, parsnips, sweet potato and herbs. The growth period of different species of plants requires different time period, depending upon the harvesting time, crops with nearly equivalent harvesting time can be used together to harvest. In this system, the seeds are not directly inserted in the net pods, the saplings are inserted in the net pods, for this the sapling need to be cultivated in standard controlled temperature, when the off shoot of the crops appears after a week or so, these saplings are then implanted into the net pods.

1.2 Fish:

Fish varieties:

Tilapia is by far the most preferred fish variety, the main reason why it is preferred is as given: 1) low oxygen, 2) good for breeding, 3) high survival rate, 4) low water quality & hygiene does not affect its survival rate, 5) best for any climate, 6) flesh quantity is also good.

With this being said we tried cultivating **Rohu, Katla, Mrigal Fishes**, and with a fatality rate of 11%, these fish species have shown great growth, and the feeding pattern being the conventional, the effect of these species on plants such as lettuce, fenugreek, spinach is phenomenal.

Aquaculture:

Filter water from the hydroponics system drains into a catfish tank for re-circulation. Freshwater fish are the most common aquatic animals raised using aquaponics, although freshwater crayfish and prawns are also sometimes used. In practice, tilapia are the most popular fish for home and commercial projects that are intended to raise edible fish, although barramundi, silver perch, eel-tailed catfish or tandanus catfish, jade perch and Murray, cod are also used. For temperate climates when there isn't ability or desire to maintain water temperature, bluegill and catfish species are suitable fish species for home systems. Koi and goldfish may also be used, if the fish in the system need not be edible.

Feeding of fishes:

Feeding the fishes processed fish food can be very useful, it consists of all types of necessary nutrients which the fishes will require, meat proportion and all other values are well taken care of in these kinds of feeds. Although organic fish feeding can also be very much beneficial to owners who want to have the produce in large scale, this can be also very sustainable. Some examples of fish feed (organic) are: a) duckweed, b) worms from vermiculture, c) groundnut cakes. Etc... can be useful.

Size of fish (grams)	Amount of daily feed (% of fish weight)
0 – 1	30 – 10
1 – 5	10 – 6
5 – 20	6 – 4
20 100	4 – 3
Larger than 100	3 – 1.5

1.3 Bacteria:

Nitrification, the aerobic conversion of ammonia into nitrates, is one of the most important functions in an aquaponics system as it reduces the toxicity of the water for fish, and allows the resulting nitrate compounds to be removed by the plants for nourishment. Ammonia is steadily released into the water through the excreta and gills of fish as a product of their metabolism, but must be filtered out of the water since higher concentrations of ammonia (commonly between 0.5 and 1 ppm) can kill fish. Although plants can absorb ammonia from the water to some degree, nitrates are assimilated more easily thereby efficiently reducing the toxicity of the water for fish. Ammonia can be converted into other nitrogenous compounds through healthy populations of:

- Nitrosomonas: bacteria that convert ammonia into nitrites, and
- Nitrobacter: bacteria that convert nitrites into nitrates.

In an aquaponics system, the bacteria responsible for this process form a biofilm on all solid surfaces throughout the system that are in constant contact with the water. The submerged roots of the vegetables combined have a large surface area where many bacteria can accumulate. Together with the concentrations of ammonia and nitrites in the water, the surface area determines the speed with which nitrification takes place. Care for these bacterial colonies is important as to regulate the full assimilation of ammonia and nitrite. This is why most aquaponics systems include a biofiltering unit, which helps facilitate growth of these microorganisms. Typically, after a system has stabilized ammonia levels range from 0.25 to 2.0 ppm; nitrite levels range from 0.25 to 1 ppm, and nitrate levels range from 2 to 150 ppm. During system startup, spikes may occur in the levels of ammonia (up to 6.0 ppm) and nitrite (up to 15 ppm), with nitrate levels peaking later in the startup phase. Since the nitrification process acidifies the water, non-sodium bases such as potassium hydroxide or calcium hydroxide can be added for neutralizing the water's pH if insufficient quantities are naturally present in the water to provide a buffer against acidification. In addition, selected minerals or nutrients such as iron can be added in addition to the fish waste that serves as the main source of nutrients to plants. A good way to deal with solids buildup in aquaponics is the use of worms, which liquefy the solid organic matter so that it can be utilized by the plants and/or other animals in the system.

1.4 Economy:

Market analysis:

Demand and supply chain needs to be studied in order to maximize the profit. Many large-scale producers dominate the market by shorting the market, they reduce the production or stop it completely in order to hike the prices of the plants grown, particularly in summer the rates of green leafy vegetables are increase drastically, while for the same crops the prices are reduced by 30 to 40 % in winter season.

Use of decreased labors:

skilled labors are required for this system to operate, but w.r.t conventional farming the amount of labors required is 75 % less, so the overall profit range lies much, also there is no need of ploughing, weeding, etc. before every harvest that we are going to make. Once the roots of the plants are well enriched and spread across a significant area, with required girth, you just have to take the harvest no need of physical time-consuming activities unlike in conventional farming.

Advantages of aqua ponics:

1) The system uses the same water from the day one, there is no need to change this water, only the water needs to be refilled from time to time, to meet the necessary water level requirements.
2) The produce from the aqua ponics is more healthy, toxic free, artificial pesticides are not used in this unlike traditional farming, making it more sustainable for the future upcoming generation to have rich diet, healthy proteins and irons, as required.
3) Conventional farms require more water to produce yield, on the contrary the aqua ponics and hydro ponics use 10% of the conventional farms.
4) Another value-added point to be noted is that, no or less land is required for the erection of the system, regions with less land productivity can make use of this technique, also people with less land can make use of hydro ponics vertical cultivation to produce more yield in less or no land availability.
5) The fish waste being an important problem to aquaculture cultivators, this problem is hugely beneficial for the plants to have their nitrate sources of energy for their growth.

6) Studies have also shown that aquaponics nutrient solution has complex organic nature which is beneficial to the consumer than the chemical based conventional system. It also has shown pro-biotic properties, which has high nutrient uptake and provides resistant against diseases. Some limited researches tend to show that the taste is enriched in these systems, and veggies shelf-life is also prolonged. Higher sources of anti-oxidants are also found in these aquaponically grown plants, nevertheless the percentage of anti-oxidants also depend upon the fish extract and fish food, fish food enriched with necessary nutrients can show huge anti-oxidants output in the plants.
7) Two things are produced at the same time, as plants as well as the fish are harvested. In the traditional hydroponic system nutrients are added externally to feed the plants, this system being in-organic, in the aquaponics only fish waste is generated which is later used up by the plants, the cycle for this goes as follows: fish > ammonia > nitrite > nitrate > plants. The breaking down of the ammonia is done by the bacteria.

Disadvantages:

1) Maintenance of controlled environment is required, and not many farmers or small-scale business people may be able to uphold such high costs, even after providing subsidies.
2) Not everyone producing these plants, with this technique may be literate about this technology or the science behind it. The one who is going to implant this should have primary knowledge of how this thing works, and for this session or online portals should be formed to help illiterate people.
3) Timely checking of water quality parameters, is not ordinary man's job, it requires at least a single skilled person on the site.
4) Which plants to harvest and at what time period, & in which season should be also considered in order to make maximum benefit from the system (for e.g., plants which require less water to grow or which can sustain moderate to high temperatures without affecting the yield should be taken in summer season, on the contrary plants sensitive to high temperature can be cultivated in the winter, and plants with high humidity should be taken in the rainy season). Although the seasonal pattern and rotation of the crops should be looked after more in the traditional type farming, because the main reason to shift to hydro and aqua ponics is the freedom to take variety of exclusive crops without having to worry about the surrounding climate, temperature, favorable conditions etc. The rotational crops or temperature factors should be considered by the local small-scale farmers who can't afford green houses.
5) Another major issue to be noted in these systems is the attacks of pests and diseases. Due to temperature control systems, foggers are installed in the green houses to reduce the temperature, as a result it forms a humid climate favorable for growth of various bacteria, some beneficial while some lethal for the plants. If the yield is once destroyed, it becomes impossible to recover the crops, as no pesticides can be used, as it may pollute the water which is eventually supplied to fishes, affecting their health. So, care should to be taken at the primitive stages of the plantation itself, also many times some worms are also involved in the system to make sure the plants do not get infected with various diseases.

More yield in short times:

As the title suggests, the yield produced is more than the conventional farms, and the yield is more frequent than the traditional farming, also the vertical cultivation allows the farmers to make more profit in limited space. The important factor in this system is that, the essential nutrients are mixed in the water, and roots are exposed to such water 24/7 as a result, the growth of such plants is more than the conventional farm crops. Also, the farmer doesn't have to reach each and every root of the plants to supply necessary nutrients, as the water carries all the nutrients, it is therefore more sustainable to use this system.

1.5 Environment:

Energy requirements:

Making use of solar panels for the production of energy is very much essential and economical, use of electricity for the foggers and pumping is essential step in this farming, so using renewable sources of energy for this energy production recommended. Industrial electricity rates being much high these days, installation of solar panels is fruitful as government provides subsidies for it.

Energy consumption:

No doubt the energy consumption is much more than the conventional systems, because of:

1) the inclusion of foggers (to maintain temperature),
2) pumps, water circulation,
3) fans for optimization of surrounding,
4) aeration techniques,
5) MBBR,
6) Green house maintenance.

With this being said, excluding some reasons, many of the energy consuming techniques can be achieved by solar panels, wind mills, and many other renewable sources of energy. Many more techniques can save energy consumption, such as:

1) Use of siphon,
2) Reducing the no. connections (to mitigate the leakage chances),
3) Shortening the distances between tanks,
4) Use of gravity for circulation of water,
5) Using right power pumps to minimize energy consumption,
6) Proper utilization of space to hike the profit,
7) Step formation at places which allows aeration without inclusion of aerators.
8) Pipes of bigger dia. can save the user from blockages,
9) Electrical wirings should be concealed to avoid short circuits,
10) Risk management at site from fire, leakage, electric shorting, these all things should be taken care of.

Water consumption:

In comparison to the conventional system, which involves use of land for the cultivation of land for the plants, these plants are instead cultivated on the water, which is circulated, purified in the system itself, the water consumption is much less i.e., about 98% less. Only the water in the system is replenished as and when required, sources of water loss are:

1) Plant roots,
2) Evaporation,
3) Transpiration by the plant.
4) Miscellaneous loss by system leakage etc.

For such losses the system needs to replenished with water. With this being said, in the rainy season the rain water can be collected in the ponds which can be later used to replenish the system, also make sure to not collect water from first 2 to 3 rains, that water can be toxic with the air pollutants being mixed with water, can bring adverse effect on aqua life and plants. The advantage of this system lies in the water consumption rate, about 2% in comparison to the conventional farming.

Pollution:

The rate of the pollution is much less in this system, as the traditional one uses heavy machineries for harvesting, removing weeds and ploughing, that is not required in the aquaponics. Also, the oils spilled on the farm lands pollute the land, making it unfit for the future use for many months, pollution caused due to machines not only pollutes the land but also the air and water sources nearby.

As the system is self-sufficient to grow, there is no need of petroleum-based fertilizers, which causes heavy pollution, thereby affecting the health of the users. As the plants are grown on the water bed or coco pit or round gravel media, no such thing for removal of dirt from the soil or weeds is required, this makes the system more environment friendly.

Saving of fuel:

As majority of the population lives in the city, so the maximum consumption is supplied to the cities, but as the city don't have huge land places to cultivate the demand of crops, so the harvests are imported from hundreds of kms from the place of origin, this consumes tons of petrol and diesel. So, in order to reduce the consumption of fuel, we need to cultivate the crops in the city itself, and this is possible only with aqua/hydro ponics, as vertical cultivation of the hydroponics allows

the producer to reap a harvest 8 times more than what can be originally cultivated with traditional fashion. So, this can meet the needs of the city in the city itself instead of cultivating it faraway places and then spending money on fuel to satisfy the city demands.

SOIL:

What kind of soil? What should be done to increase the productivity? Low space lands? No water to harvest? All such questions can be solved with the sustainable erection of hydroponics and aquaponics. Whatever the soil is, it does not matter to producer once he has introduced himself to the aqua/hydroponics. Frequent flooding problems can also be dealt with this, the initial setting of the whole of the system can be done on higher elevations, in the regions with frequent flooding situations, which on the contrary can't be done in traditional farming, you can't shift your farm land up on higher elevations.

Nutrient rich effluents:

It is observed that, the water that circulates into this system is rich with nutrients like nitrates, etc. so it is advised you never replace this water with fresh water, instead add nutrient rich water to replenish the system with lost water. These losses are in form of plant transpiration, evaporation, etc. This whole of the system used less than one tenth of the water than the normal soil-based system. Another major thing is that with time the water system only gets more enriched, so longer the water is in the system the better. The building of the toxins is no to less, so one doesn't have to worry about the system cleanliness. Also, the installations are added advantage to filter your filter. This kind of water when poured into some soil, will only increase its harvesting rate and capacity. Nothing in this system is inorganic, making it completely healthy for human consumption.

Adverse climatic change:

As everyone is aware of the traditional practices being carried out in the conventional farming, it involves use of various pollution causing agents:

1) Production of CO2 is the major concern these days due to the machinery advancements made in the traditional farming.
2) Production of methane gas due to cattle rearing.
3) Production of NO2 due to over use of fertilizers.

These sources of pollution are not present in the aqua/hydroponics, as rearing of fisheries only produces ammonia, which is used up by the plants, which is later converted into nitrite and nitrates without causing pollution, as it is self-sufficient system, without inclusion of any other extra inorganic fertilizers, this system can function efficiently.

Environment friendly, eco-friendly:

This system produces healthy food for individuals who are health cautious, being organic allow the individual to consume toxic free vegetables grown on their own. One of the best things about hydroponic farming is that it requires little or no pesticides as weeds, soil-loving bugs and plant diseases that spread in soil are eliminated. The uptake of nutrients by plants grown in hydroponic systems is also higher compared with plants grown in soil, so the use of fertilizers can be reduced dramatically. All of this means cost-savings to hydroponic farmers, but also cleaner food and a cleaner environment.

1.6 Requisites:

Working: Main essentials of the system of aqua and hydroponics are:

A) Water,
B) Sunlight,
C) Fish feed,
D) Ambient temperature,
E) Pumps for water circulation,
F) DO, (Dissolved Oxygen)
G) Electricity,
H) Pest control,

I) Inclusion of nutrients for better growth of plants,
J) Primary filters for TSS (Total Suspended Solids),
K) MBBR (Moving Bed Biofilm Reactor),
L) Shade for obstructing direct sunlight entry.

Every 4 L of water can sustain a growing area of 0.65 to 1.2 SqFt. With 0.25 to 0.5 kg of fish aquaculture. This being a standard rate, variations accordingly can be made suitable for the cultivator.

Preliminary Perks to be noted while raising the aqua/hydro ponics are:

1) Filtration primary/ secondary/ biological. (solids/ammonia, etc.)
2) pH control,
3) Biological pest control,
4) Right amount of feeding to fishes,
5) Loading the fish feed at constant rate, (fishes adapt to the feeding habits)
6) DO level maintenance with aeration.

Requisites for (Aqua & Hydro) ponics systems:

1) Use of solid waste filters,
2) Aerobic and anerobic filters,
3) Aeration techniques,
4) MBBR (Moving Bed Biological Filter) for fish waste removal,
5) Water Quality Detectors,
6) Safe-systems for fish to have a backup if the system fails or is compromised due to some physical damage or technical glitch, so exit safety tanks for fish is must in order to shift the fishes directly into the safety tanks, once the water reaches critical level or the toxicity level of the system exceeds beyond permissible limits,
7) (Aqua & Hydro) ponics Plants should have DO sensors installed in for timely checking of Dissolved Oxygen, also water quality parameters are also needed to be checked once in a week to ensure substantial growth of the plants.

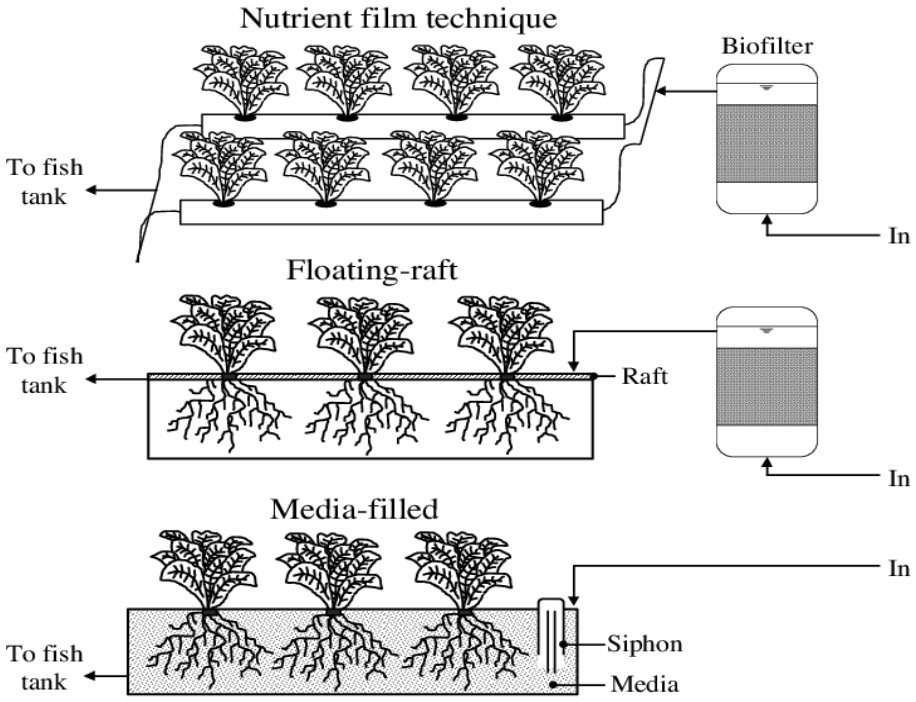
Aqua/Hydro ponics or Traditional farming:

As the title goes, which farming is more useful to us whether it is traditional ones or aquaponics? Let's discuss it over here

Aquaponics:	Traditional
Use of limited supply of water for growth of plants	Making use of tons of water, out of which only 30% is used by crops on land
Using little or no pesticides	Using harmful pesticides to save crops
No need to plough, reap, harvest every time the crop is cultivated	Each harvest requires, farming activities like ploughing, reaping, pruning, etc.
No need of worrying about heavy rains due to the greenhouse	Heavy rains can damage the crops at great extent
Additional income of aquaculture is obtained	Single source of income
Export quality, exclusive leafy veggies can be grown	Location and surrounding friendly crops can only be grown
Marketing of these products is much easy, international markets can also be captured	One has to rely on the regional and rural market due to less variety of crops
Organic farming sector is much at boom these days	Harmful pesticides make the crops inorganic
Shelf life of these leafy vegetables is much more than traditional ones	Shelf life is less as compared to the aquaponics
Necessary nutrients can be added according to the crop being cultivated	One has to rely on the soil nutrients primarily, and even inclusion of the nutrients if done, many of it is wasted, as consumed by the soil itself
Income is drastically boosted even in small spaces	One has to rely on large lands to boost his income
Density of crops is more than conventional	Density is less than aquaponics

It is perfect for places with little or scarce water availability	It needs great amount of water to have significant amount of produce
Not only one can grow fishes being consumed but also one can grow show fishes	Aquaponics and traditional farming are rarely mixed together
One can grow this system in his house itself to produce his own food without having to depend on market produce	Terrace gardening can be done at home, but the growth rate in comparison to the aquaponics is much less

Categories of Aquaponics:



Category	Perks of the system	Capital/ Interest/ Profit/ Gain	Loss/ Debt
1) (Aqua Hydro) Ponics	Commercial startup or business	High profit yielding with maximum profit and high market demand.	High initial investment, which might take couple years to recover
2) Aquaponics	Commercial small-scale business	High margin, subsidies available for the green houses and fisheries as well	Space consuming, with temperature control required for effective harnessing of the yield
3) Hydroponics	Entrepreneurial and startup	Space effective, vertical gardening boosts the yield.	Heavy plumbing costs and frame maintenance due to humid climate in the system.
4) Agriculture farm fisheries	Side hustle for conventional farmers	Additional benefit annually by the production of fisheries, use of fish waste as natural manure for farms.	Land availability for the formation of the pond, pumping system provisions, and shade provision for avoiding water loss.
5) Aquaculture	Small business for land owners with low land productivity.	Annual benefits or quarterly benefits primarily based on the fisheries.	Yield through the system is not what one expects only 30 to 35 % percent of the fishes are obtained at the end of the year of the initial harvest.
6) Hydro and Aqua ponics equipment suppliers	These are ones who set up the system for those wishing to move to hydroponics and aquaponics (technical experts of this field).	Medium to high benefit by selling concepts, ideas, products, and services to the end users, this can be a good startup with 15 to 20 % marginal profit.	Depending upon the supply chain and area of the coverage, one has to find the market and then start looking for investors, till this point it is hectic journey.
7) Society developments	Local startup, funded by NGOs for improvement of the society, with whole and sole purpose to produce high quality yield mainly for societal use.	Fund based system, with low initial investments, and high margins of profit.	Funding from the NGOs is main concern in this, if the NGOs dissolve, the further running of such organization is difficult without capitals.
8) Research oriented	This is done in small plot area with different batches to maximize the benefit obtained from the system	The whole and sole purpose is to find advancement in the conventional systems and later introduce it to the system.	Failures of some vague ideas is possible, if the study to the new system is insufficient.
9) Small scale gardening	This is hobby-based cultivation of the new techniques in the small front yard or backyard of the home. Leafy veggies can be produced.	The yield from this can be used for personal utilization, can also be circulated with people nearby and gain some weekly profit.	Taking care of the system while you are away from home possess a great harm to the system. Needs timely maintenance and lookout for precise production.
10) Terrace gardening	This purely non-profit cultivation, hobbies of people to have home gardens to have pure air and green homes is the primary concern.	The production being limited, can be only used for personal consumption or for increasing the beauty of the terrace gardens.	Again, to look out for these systems is essentials, ignorance can be lethal for fishes as well as plants, organizing and placing of the gardens is important.

Traditional Farming:

So, this is where the discussion starts, the need for aqua/hydro ponics begins at this very point. Traditional farming in early ages was very much beneficial both to the consumer and the producer, but is it now beneficial to the user? This question arises due to the inclusion of harmful pesticides, insecticides and germicides used by the farmers lately, though

farmers are not to be blamed completely for this, changing climate, increased population needs, increased pollution, declined prices for the harvest, etc. these things have forced the farmer to reap his harvest early with high productivity, without having to worry about the diseases, and all of this is only possible when the farmer makes sure to use heavy, hazardous, non-healthy pesticides. So, this is where the aqua/ hydro ponics comes into the picture to make a positive change for the consumers.

2. Ground Work:

Actual Aqua / Hydro Ponic model:

As you can see in the model given below, the red number indicates the sequential order with which the pipe connection flows in the system, and the blue words, stating the tanks show the sequence with which the water flows in the system.

Tank 1) is the tank with the fishes, pump is inserted into the system itself, precautions for the fish safety are taken, cage is provided for the pump, so that the fishes don't get caught into ugly situations.

Tank 2) it is basically primary filter to remove the TSS (Total Suspended Solids) from the fish tank, the pump pumps all the water, and this filter helps in removing the suspended solids from the system, so that ammonia rich water (useful for plant growth) reaches the roots of plants.

Tank 3) it is vertical Hydroponics, the water from primary filter is supplied to the Hydroponics, which then flows down due to gravity into the next tank. Significant growth of the plants can be seen.

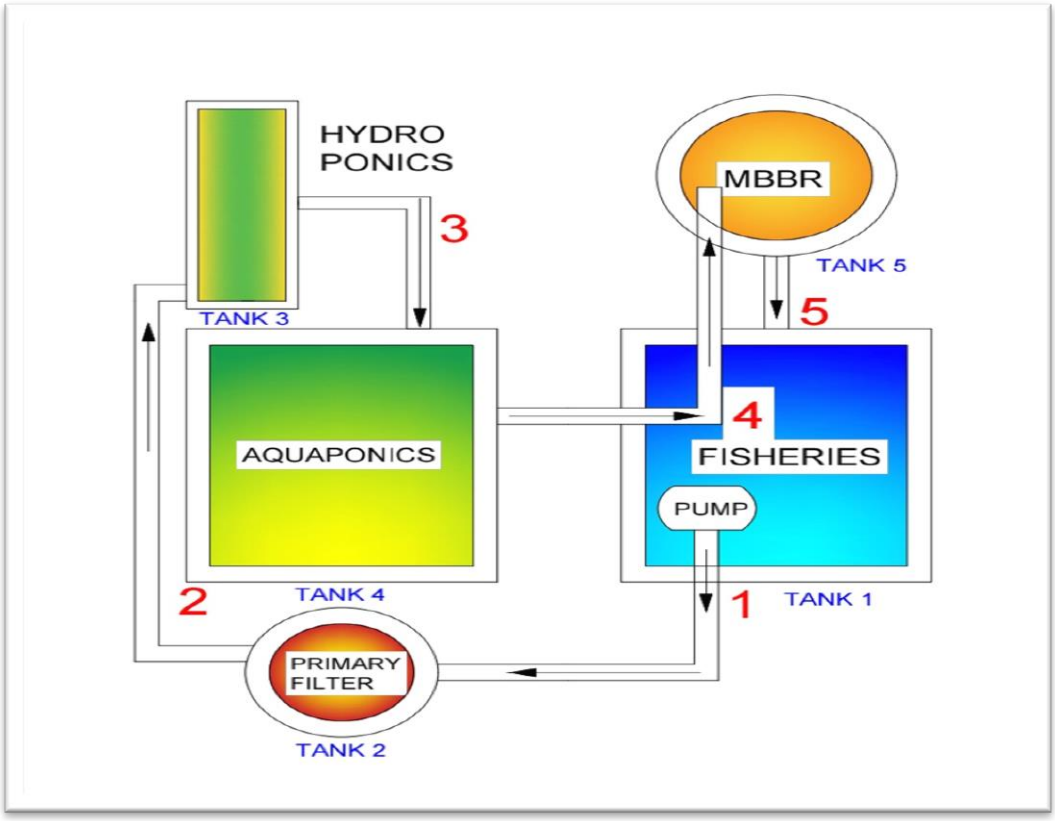
Tank 4) it the Aquaponic tank, in this water is received through the gravity from the hydroponic system, the aquaponic system has plants with big and lengthy roots, (will be showcased in the photo gallery) in comparison to the hydroponics system.

Tank 5) it is the MBBR used for biological cleaning of the water, dissolved wastes of the fish are well taken care of in this system. (Moving Bed Biological Reactor).

Essentials:

Pump and an aerator is important in the system, pump to circulate the water, and aerator is required for the MBBR so that the biological reactions take place effectively, also due to various stages and steps, the aeration takes place at multiple levels, so if the unit is small MBBR implantation can be avoided, so eventually the aeration can be avoided, continuous aeration makes the water fit and best for fish, the roots of the plants clean the water, and various bacteria like Nirtrosomos bacteria, and Nitrobacter bacteria help in breaking down the ammonia into nitrite and then eventually into nitrate later consumed by the roots of the plants.

The figure shows the top view of the system:



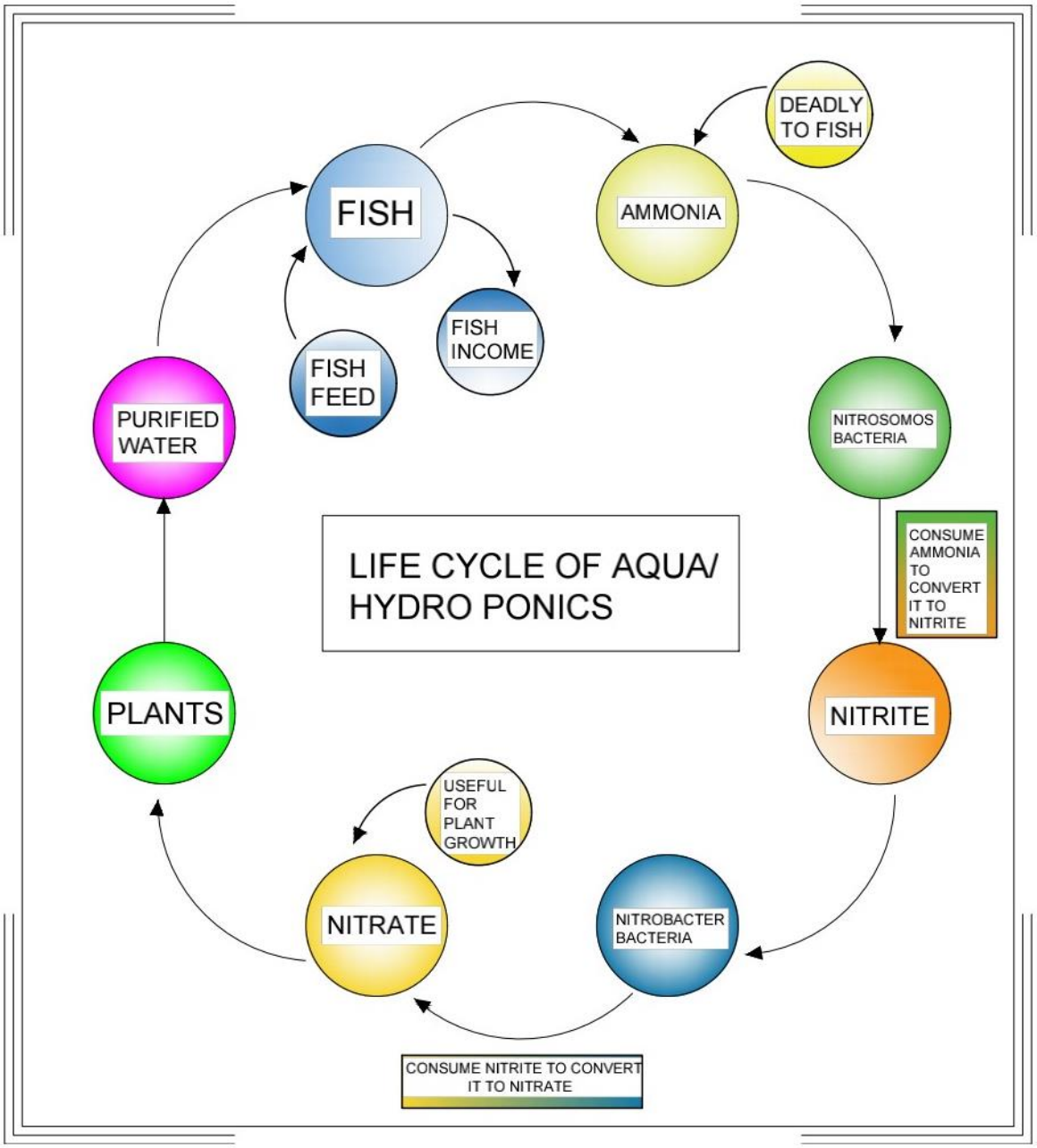
FISH (AMMONIA)

NITROSOMOS BACTERIA (NITRITE)

NITROBACTER BACTERIA (NITRATE)

PLANTS (CONSUME NUTRIENTS & CLEAN WATER)

Lifecycle Model of Aquaponics:



The whole system is supplied with the energy, for example,

1) consumption of electricity for the operation of pump,

2) Aerators (if any)

3) Use of fans and foggers to maintain the temperature

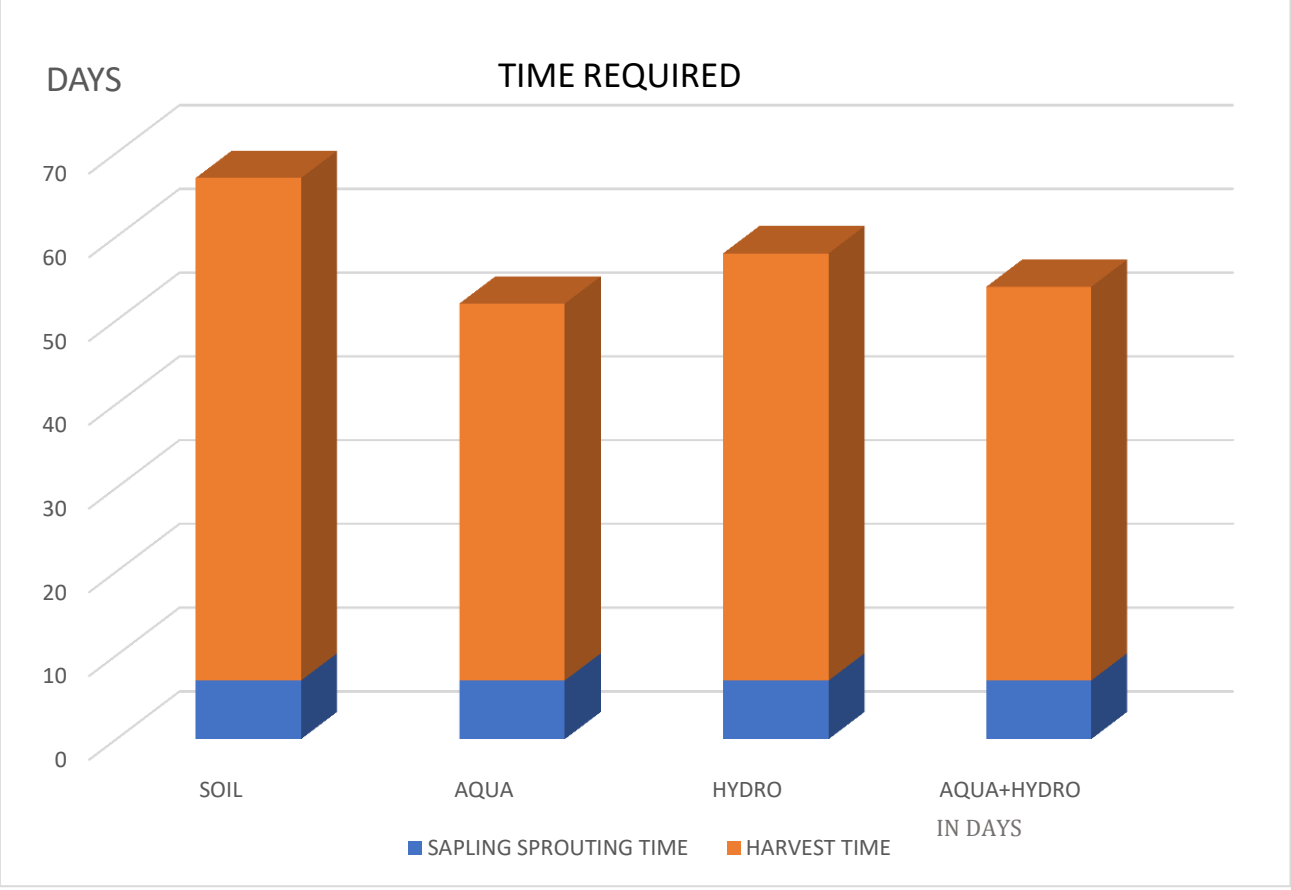
4) Fish food

5) Labors for maintenance and repair if any

6) Skilled labors for harvesting

7) Use of temperature, humidity-controlled stores for sapling formation and more come in terms of energy investment in this system.

PERKS	SEWAGE TREATED WATER	RO WATER
Usage of water	Allows use of water which is treated	Makes use of RO water, directly which can be used for drinking purpose
Harvest Period	1.5-1.7 months approx.	2 months approx.
Fish	Can sustain in sewage treated water	Can sustain in RO water, but the habitat favorable for fish is should not be too clean like RO water
Roots sprouting	Within a week of implantation	Within a week of implantation
Variety	All kinds of green leafy veggies, and some other mentioned above. It behaves same as RO water system.	All kinds of plants mentioned above
Fatality rate for fish	11% (observation)	About 10 to 15 %



Observations + Photo-gallery:

	**1.** The day we implanted saplings for first time, as spinach and lettuce sapling were not ready with us, we made sure to use fenugreek (often called as methi) saplings, and it turned out quite well for us, with 25% grown fenugreek it took about 21 days to reap the harvest.
	**2.** Initial growth of the plants was not as expected, the reason behind it is, the roots of the plants were not exposed to water directly, it took nearly a week for the roots to come out of the net pod, no doubt after that the growth of the plants was quite satisfactory.
	**3.** As shown in the figure, this was the root spread at day 21 of the implantation, the roots were thick, and had grown about 1.3 ft in length, what we observed that, roots depth generally depends on the depth of the container, with the effective depth of the container being 1.5 ft, the roots quite made a growth of 1.3 ft in case of fenugreek.
	**4.** This picture shows the net pod, it is filled with "Coco Pit and No Soil", vertical slits were cut into to pod to make sure the roots found their way out of the coco pit into the water. It was observed that, the growth of the fenugreek took vertically more, than laterally, while in case of the spinach the growth was wide and thick, and so was observed with roots.
	**5.** This figure shows the green algae development onto the palettes, which is kept into the MBBR, the cage is provided to keep the MBBR palettes contained into the system so that palettes don't run off. Aerator was introduced into the system, with its pipe fitted right at the mouth of the cage, so that the MBBR is well ventilated.

	**6.** This is how the roots looked at day 24 of the implantation of fenugreek into the system, shade provision was made so that the rate of evaporation is mitigated. Plastic translucent covering was used for providing shade to the system, it made sure to protect plants from harsh sun rays, and also heavy rainfalls.
	**7.** This is how the MBBR looked after 30 days of introduction to the system, it was all covered with green algae. Pipe fitted shown with red circle is the aerator pipe, while one shown with yellow circle is the feeding pipe from the aquaponic system. Right below feeding pipe, there is output pipe from the MBBR, which is supplied to the fish tank again.
	**8.** This is the growth of the roots after keeping the system running for one week. The thermocol sheet was used for planting the net pods into the system, holes were manually drilled into the system, the thickness of the sheet lies around 5 cm.
	**9.** Pic of us while setting whole of the system, carefully the coco pit was filled into the net pods, care should be taken while filling the coco into the system, filling the coco pit too tight will create problem for the roots to grow, also loose compaction can result into washing off of the coco pit the water.
	**10.** This is the initial implanting of spinach, these saplings were grown into the sponge pods, where one has to insert the seeds into the sponge pods, sprinkle gentle water, and keep it air tight for about 3 days.

	**11.** This is how the sponge pods look like, you have to wait for about 3 days to get off shoot from these, once you have the off shoot, remove it from the air tight container, and sprinkle or spray water, till the saplings get big enough to inserted into the coco pit net pod.
	**12.** This was the lettuce implantation (sapling), fenugreek was removed from the system, as soon as the lettuce and spinach crops were good to be implanted.
	**13.** Within a month or so, it was lush green, with spinach growth and girth the fastest and highest. The growth of the roots took place more laterally as compared to the roots of fenugreek, also the girth of roots was much more than the roots of the fenugreek.
	**14.** This is how the roots looked at day 34 after implanting the spinach and lettuce into the system, the base of the spinach was too big to be contained in the net pod, it is advised that, while planting the spinach make sure increasing the size of net pods, to contain the growth of spinach, allowing it to flourish more without restrictions.
	**15.** This is how the harvest looked like after around 1.2 months, no insecticides were used during the growth of these plants, also none of the plants were affected with diseases, only shade was provided, temperature controlling devices were not installed, as the system was small.

	**16.** These were the fish used by us, although rohu, katla, mrigal are also suited, even if one doesn't want to harvest fresh water fish for eating, you can also use the aquarium show fishes, they too survive well in this water. They too will serve the same purpose what these fresh water fishes will serve.
	**17.** This was the length of the fenugreek roots; its vertical growth was phenomenal.

3. CONCLUSIONS:

It can be concluded from the research paper that, traditional farming can successfully be replaced with aqua / hydroponics, also the economy achieved is much greater, with high yield, low to no pollution rates this system is very much environment friendly, and its mass production and awareness can boost economies at high rate. Being completely organic aqua / hydroponics is the new future of the farming industry, and soon revolution can be brought with this farming techniques, not only plants, but secondary sources of income are also formed in this system, making it more profitable, also vertical farming option available in this can produce 8x times more profit and yield what conventional farms harvest. Although the initial investments are high but within the span of 2 to 3 years the initial investments can be recovered. Not only Greenland but this system can be implanted in deserted regions also, as the same water is circulated in the system for years, this can be a major break-through for farming industry. Variety of fishes can be cultivated in the system, not only fresh water fishes but also the show fishes can be used to cultivate the crops. New innovative farming

option saves the transportation time in the metropolitan cities, which avoid farming due to restricted spaces, soil erosion and deterioration also comes to an end, less to no use of pesticides makes it healthy for the humans to consume, thereby reducing the chances of cancer, and stomach related ailments. Job employment is boosted, small startups are established, subsidies on greenhouse erection makes this farming a profitable deal.

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