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A REVIEW ARTICLE ON SOIL-LESS CULTIVATION.

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Abstract:-

Due to high urbanization and industrialization, soil based cultivation is now facing a major problems such as unexpected and sudden natural disaster, change of climate, depletion of qualitative soil fertility. Due to such circumstances it is impossible to feed our entire world, Hence our scientists has developed an alternative method of cultivation which were named as soil-less cultivation. Soil-less cultivation include Aeroponics, Aquaponics and Hydroponics. The quality of yield through soil-less cultivation is much higher than the soil based cultivation. Nowadays soil-less cultivation became more relevant to overcome these circumstances. In soil-less cultivation plants are grown without soil. Soil-less cultivation has became one of the most promising result throughout the world as they produce a nutritive product.

Key Words:-

Soil-less Cultivation, Hydroponics, Urbanization, Industrialization.

1. Introduction:-

One of the most important primary media for growing plant is soil as they provide nutrients, air and water for the successful growth of plants[1]. Plants on open field cultivation are now facing major problems such as soil compaction, soil erosion, poor drainage system, growth of pathogens in soil etc. In addition to this open agriculture is difficult as it requires large space, high number of labours, high amount of water and many more. Moreover places like Metropolitan area soil is not available for the growth of plants and in some places due to scarcity of fertility of soil and due to their geographical and topographical conditions all plants are not grown. On the other side due to continuous urbanization and industrialisation, the agricultural land are being shrinked which indirectly affect the total production of agriculture and horticulture. When unfavorable condition and such circumstances arises in open field agricultural system then alternative method of soilless cultivation was justified by our scientist. The recent scientific invention has proved that it is possible to produce nutritive and qualitative end product of plant and crops without soil.

Soilless cultivation is the method of growing plants using without soil as a routing medium. In soil-less crops the fertilizers which is to be supplied to the crops are dissolved in the appropriate concentration in the irrigation water and that resultant solution is named as “nutrient solution”. Many of the countries are focusing towards soil - less cultivation to overcome the circumstances of soil based cultivation. Soil-less cultivation includes Hydroponics, Aquaponics and Aeroponics. Nowadays soil-less cultivation is gaining energy and popularity throughout the world and became one of the most fastest growing sector in agricultural field.

Hydroponics is one of the most popular techniques in soil-less cultivation. The term Hydroponics is derived from Greek word “hydro” meaning water and “ponos” meaning labour [2]. The word Hydroponics was coined by Professor William Gericke in 1930’s. Hydroponics is the method of growing plants in soil-less condition with the roots fully immersed in the nutrient media[3]. W J ShaloDuglas was the first English scientist to introduce hydroponics in India in the year 1946. He had established a lab in the state of West Bengal in Kalimpong Area and he also written a book on Hydroponics which was named as “Hydroponics-The Bengal System”.

2. Techniques of Hydroponics cultivation:-

Hydroponics doesn't requires soil to grow plants. In this method roots are being immersed in the prepared nutrient medium. In this method, plants are grown in natural or man-made substrates. The different method of growing Crops are as Deep water culture(DWC), Drip System, Aeroponics, Nutrient Flim Technique(NFT), Ebb and flow and Aquaponics. Types of the systems are being illustrates in Figure 1. The types of system include:-

2.1 Deep water culture or Floating Root System.

In this system, the root of the plants are being immersed in the nutrient media as shown in Figure-1a.

2.2 Drip Culture.

In this system, the nutrient solution is being pumped directly to the roots of the plants with the regulated flow as shown in Figure-1b.

2.3 Aeroponics.

In this system, the roots are being hanged down in the air and the nutrients are being supplied periodically through sprinklers as shown in Figure-1c.

2.4 Nutrient Flim Technique.

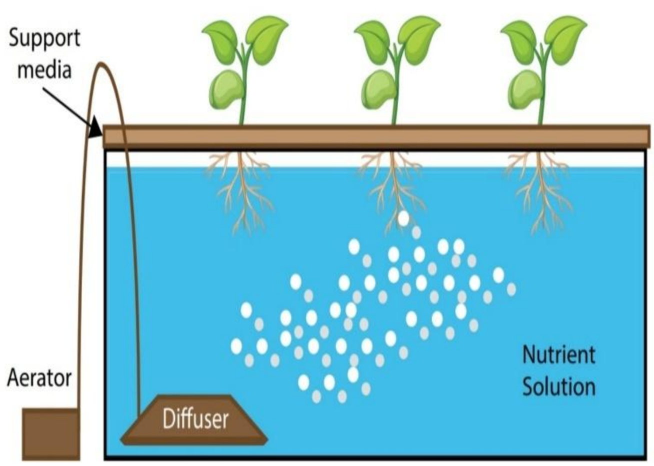
In this method the roots are being allowed to floated and the roots of the plants are not completely immersed in the nutrient solution but the liquid flows through the pipes as shown in Figure-1d.

2.5 Ebb and flow.

In this system, plants are being placed in the tray and nutrient rich water is being pumped periodically from the below reservoir as shown in Figure-1e.

2.6 Aquaponics.

In this system, the fish affords the nutritional requirements of plants. By the process of nitrification and denitrification the water from fish tank is being supplied to reservoir of plants as shown in Figure-1f.



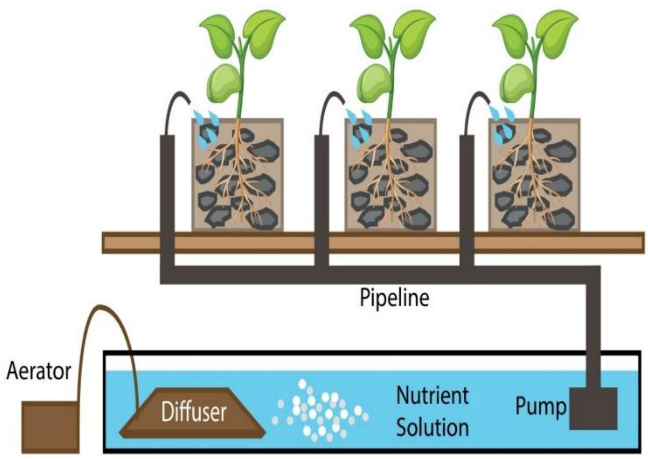


Figure-1a. Deep water culture or Floating Root System.Figure-1b. Drip System.

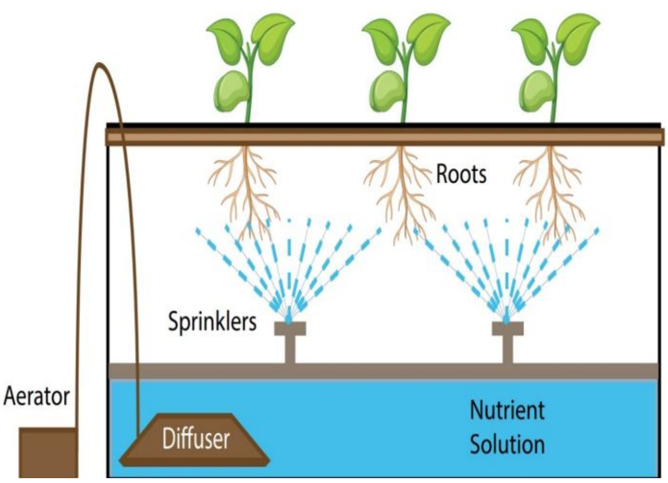


Figure-1c. Aeroponics.

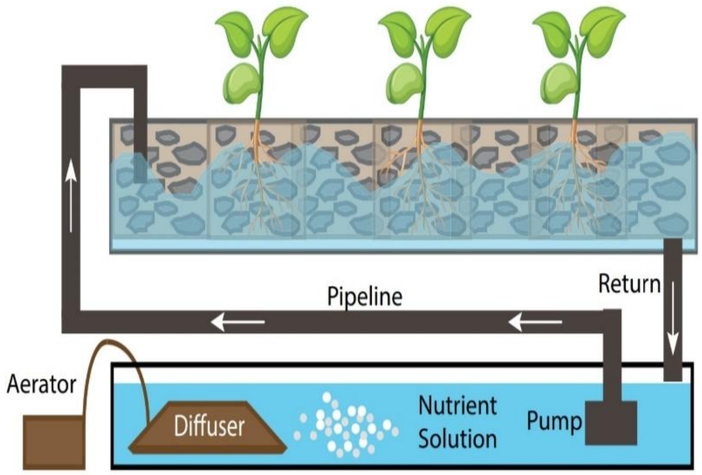


Figure-1d. Nutrient Flim Technique.

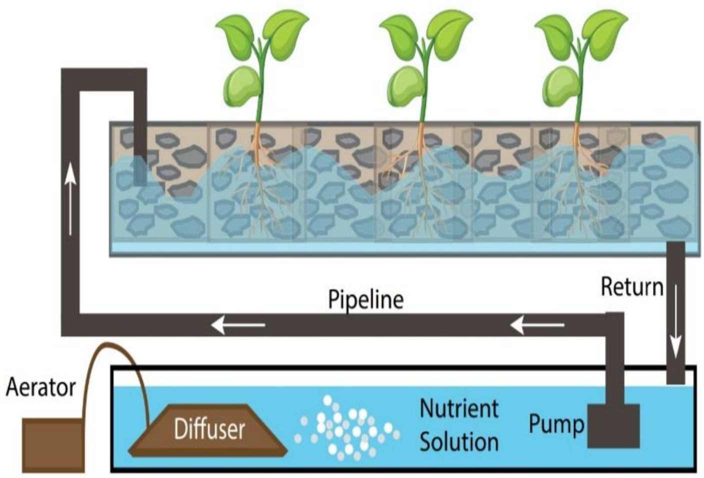


Figure-1e. Ebb and flow.

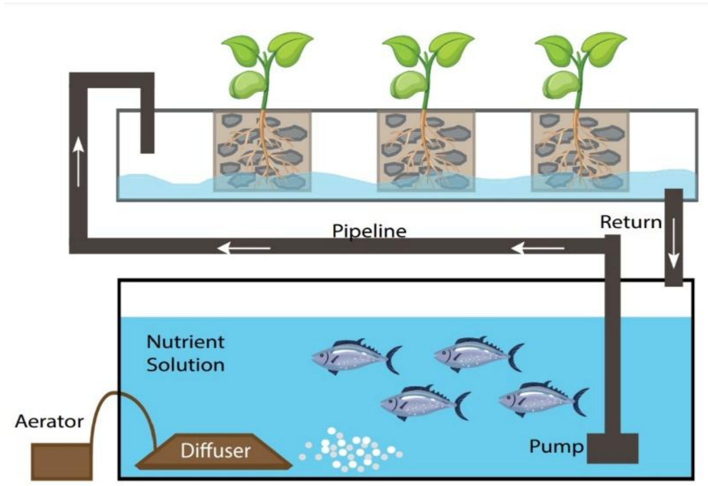


Figure-1f. Aquaponics

3. Merits and Demerits of Hydroponics.

Hydroponics is one of the most popular soil-less cultivation. As like other agricultural techniques they provide us some good opportunities and some bad drawbacks. Some of them are listed below:-

3.1Merits:-

- Maximizes the space.
- We can assure quality and quantity.
- They are not in contact with soil.
- Conserves water.
- Produces higher yield.
- Requires less labour.
- High quality products are produced.
- Crops are grown Faster.

3.2 Demerits:-

- Expensive to set up.
- Vulnerable to power outage.
- Requires constant monitoring and maintenance.
- Waterborne diseases.
- Plants affects quickly.

4. Substrate

A physical media that supports the plant under appropriate growing condition by providing Aseptic condition with good oxygen and adequate flow of nutrient is termed as Substrate[4]. Table-1 summarizes the different Substrates Used In Hydroponics[6,7,8,9,10and11].

Factors of choosing substrates are listed below:-

- Should hold water and require adequate airspace.
- Must posses durable structure.
- Should maintain a suitable pH.
- Must posses the capacity of buffering.
- Good nutrient retention is required.
- Should be free from diseases.
- It should be in standard quality[5, 6 and 7].

Table-1. Different Substrates Used In Hydroponics[6, 7,8,9,10and11].

S.No	Material	Advantage	Disadvantage
1.	Sand	• Economically viable. • Supports the plants.	• High Density. • Low water retention.
2.	Perlite	• Low Density. • Biologically Inert.	• High Expansive. • Low water retention.
3.	Vermiculture	• Low Density. • High Nutrient holding capacity. • Good water holding capacity.	• High Expansive. • Energy consuming
4.	Rockwool	• Low Density. • Inert. • Sterile.	• Negative impact on human heath.
5.	Coconut coir	• Low Density. • Good water holding capacity. • pH ranges from 5 to 8.	• Energy consuming

5. List of Crops That Can Be Grown In Soil-Less Medium.

It is an appropriate method to grow variety fruits and vegetables.Table-2. Represents Crops name with their technique of cultivation in hydroponics[12].

Table-2. Crops Name with Their Technique of Cultivation in Hydroponics[12].

S.No	Crop Type	Crop Name	Scientific Name	Technique
1.	Fruits.	• Tomato. • Squash	• Solanumlicopersium. • Sechium education.	• Drip Irrigation, NFT. • Drip Irrigation.
2.	Tuber Vegetables.	• Sweet Potato. • Potato.	• Ipomoea batatas. • Solanumtuberosum	• Drip Irrigation. • Drip Irrigation.
3.	Stem Vegetables.	• Swede. • Asparagus	• Brassica oleracea var. Gongyloides. • Asparagus officinalis	• Drip Irrigation. • NFT, DWC
4.	Inflorescent Vegetables.	• Broccoli • Cauliflower	• Brassica oleracea var. Italian. • Brassica oleracea var.	• Drip Irrigation, NFT. • Drip Irrigation, NFT.

			botrytis	
5.	Root Vegetable.	• Beetroot. • Carrot.	• Beta vulgaris • Daucuscarata	• Drip Irrigation, Aeroponics • Drip Irrigation, Aeroponics
6.	Leafy Vegetables.	• Spinach	• Spinach oleracea	• NFT, DWC
7.	Pulses.	• Pea	• Pisumsativum	• Drip Irrigation

6. Nutrient Media.

The nutrients which are required to plants are supplied to plants through Nutrient Media other than Carbon, Hydrogen and oxygen as they are transported through air and water. The rest of the nutrients are produced from underwent Media In case of Hydroponics whereas in case of soil based cultivation they are produced from soil. Nutrients which are required to plants are broadly classified into Macronutrients and Micronutrients. These nutrients are essential for the development and growth of plants. Macronutrients requires higher in amount than Micronutrients to plants. Macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium. Micronutrients include iron, manganese, zinc, boron, molybdenum, chlorine, copper, and nickel[12].Table-3. Lists the elements used in nutrient media of Hydroponics[13].

Table-3. List of elements used in nutrient media of Hydroponics[13].

S.No	Nutrients	Chemical Symbol	Approximate content of plant % dry weight	Roles in plant	Source of nutrient available to plant
1.	Carbon, hydrogen, oxygen	C, H, O	90+%	Components of organic compound	Carbon dioxide (CO_2) and water (H_2O
2.	Nitrogen	N	2–4%	Component of amino acids, proteins, coenzymes, nucleic acid.	Nitrate (NO_3^-) and ammonium (NH_4^+)
3.	Sulfur	S	0.50%	Component of sulfur amino acids, proteins, coenzyme.	Sulfate (SO_4^-)
4.	Phosphorus	P	0.40%	ATP, NADP intermediates of metabolism, membrane phospholipids, nucleic acid.	Dihydrogen phosphate ($H_2PO_4^-$), Hydrogen phosphate (HPO_4^{2-})
5.	Potassium	K	2.00%	Enzyme activation, turgor, osmotic regulation.	Potassium (K^+)
6.	Calcium	Ca	1.50%	Enzyme activation, signal transduction, cell structure.	Calcium (Ca^{2+})
7.	Magnesium	Mg	0.40%	Enzyme activation, component of chlorophyll.	Magnesium (Mg^{2+})
8.	Manganese	Mn	0.02%	Enzyme activation, essential for water splitting.	Manganese (Mn^{2+})
9.	Iron	Fe	0.02%	Redox changes, photosynthesis, respiration.	Iron (Fe^{2+})
10.	Molybdenum	Mo	0.00%	Redox changes, nitrate reduction.	Molybdate (MoO_4^{2-})
11	Copper	Cu	0.00%	Redox changes, photosynthesis, respiration.	Copper (Cu^{2+})
12.	Zinc	Zn	0.00%	Enzyme cofactor-activator.	Zinc (Zn^{2+})
13.	Boron	B	0.01%	Membrane activity, cell division.	Borate (BO^{3-})
14.	Chlorine	Cl	0.1–2.0%	Charge balance, water splitting.	Chlorine (Cl^-)

15.	Nickel	Ni	0.000005–0.0005%	Component of some enzymes, biological nitrogen fixation, nitrogen metabolism.	Nickel (Ni^{2+})

7. pH of the nutrient media

pH is one of the most important chemical property of nutrient medium. pH Scale ranges from 1 to 14, where 1 to 6.9 are said to be acidic and 7.1 to 14 are said To be basic and 7 is said to be neutral solution. The best example of neutral solution is water because at room temperature they are neither acidic nor basic. The nutrient media which are made for soil – less cultivation ranges from 5 to 7 because the nutrients are readily soluble at these range [14]. If the pH is greater than 7 then the Fe and $H_2PO_4^-$ solubility decreases which gives to the precipitation of Ca and Mg. If pH is below 5 it inhibits the adsorption of phosphorus, calcium, nitrogen, potassium, molybdenum and magnesium[15]. Figure-2. Shows the effect of pH of nutrient media in soil - less cultivation [16].

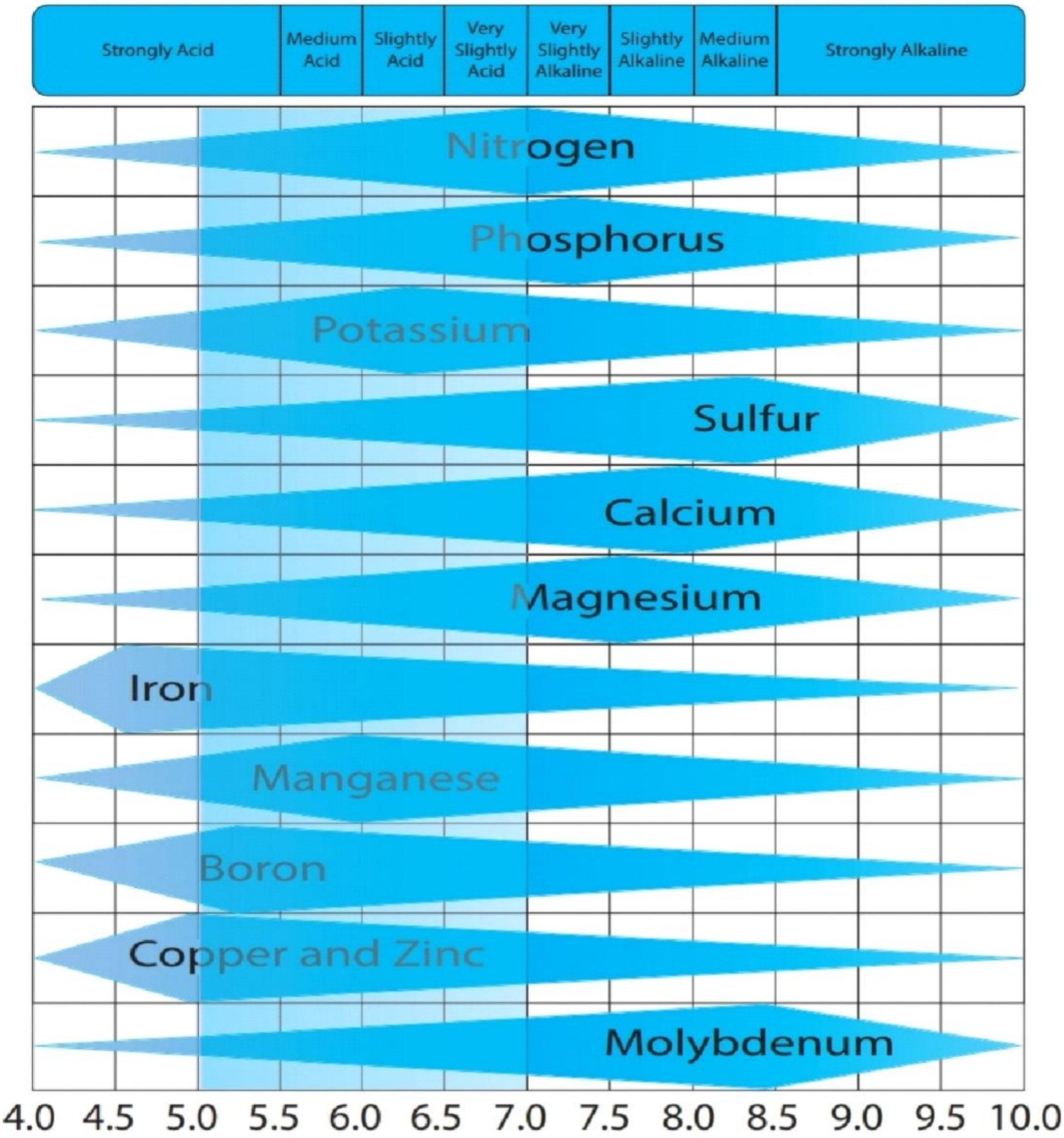


Figure-2. Effect of pH of nutrient media in soil-less cultivation [16].

8. Electrical Conductivity Of Hydroponics.

Estimation of Concentration of ions in a solution is termed as Electrical Conductivity. If the EC value is low then it indicates the scarcity of nutrients and if the EC value is high then it may leads to salt stress in that plants. This is why EC is maintained within in the target range as it affects the quality and growth of crops [17].Table-4. Shows the adequate ranges of EC and pH of some major popular plants[18].

Table-4. Adequate Ranges Of EC and pH Of Some Major Popular Plants[18].

S.No	Crops	pH	EC (mS/cm)
1.	African Violet	6–7	1.2–1.5
2.	Bean	6	2–4
3.	Banana	5.5–6.5	1.8–2.2
4.	Cabbage	6.5–7	2.5–3
5.	Cucumber	5–5.5	1.7–2
6.	Peppers	5.5–6	0.8–1.8
7.	Rose	5.5–6	1.5–2.5
8.	Spinach	6–7	1.8–2.3
9.	Strawberry	6	1.8–2.2
10.	Tomato	6–6.5	2–4

9. Sterilization Of Nutrient Media

Aseptic condition is one of the most important condition in all soil – less cultivation as to produce qualitative and nutritive product. Sterilization has done just to clear and to stop the reproduction of harmful bacteria grown in that particular culture media [19]. It is most difficult to keep sterile always around the plant's root zone and the symptom of diseased Plant can be identified by the withering of leaf [20]. Table-5. Describes the several techniques to sterilize the nutrient media with their Merits and Demerits [8 and 21].

Table-5. Different techniques to sterilize the nutrient media with their Merits and Demerits[8 and 21].

S.No	Method	Merits.	Demerits.
1.	Filtration:- • Sand Filters. • Membrane.	• Low cost. • Operation is easy.	• Requires high space. • Expensive.
2.	Heat treatment:- • Pasteurization	• High effective.	• High capital cost. • Expensive.
3.	Radiation:- • UV Radiation	• High efficient. • Requires low space.	• Low efficiency in the presence of turbidity. • Expensive.
4.	Chemical treatment:- • Ozone • Hydrogen peroxide • `Chlorine	• Highly effective. • Low cost technique. • Useful for cleaning • irrigation systems	• Harmful to plant roots when the dose is greater than 0.05%Toxic residues are being generated. • Expensive.

10. Environmental impact of nutrient media

Plant nutrient that may harm the environment if they are not handled and dispossessed properly. The nutrient solution which are leftover from hydroponics contains large amount of Nitrates and phosphates which may promote some impact on aquatic animals, microbes, plants, humans and animals [22]. Figure-3a. Represents the fate of nutrient solution of Hydroponics on environment. On the other hand Figure-3b. Explains the implementation of water rescue system in hydroponics [23].

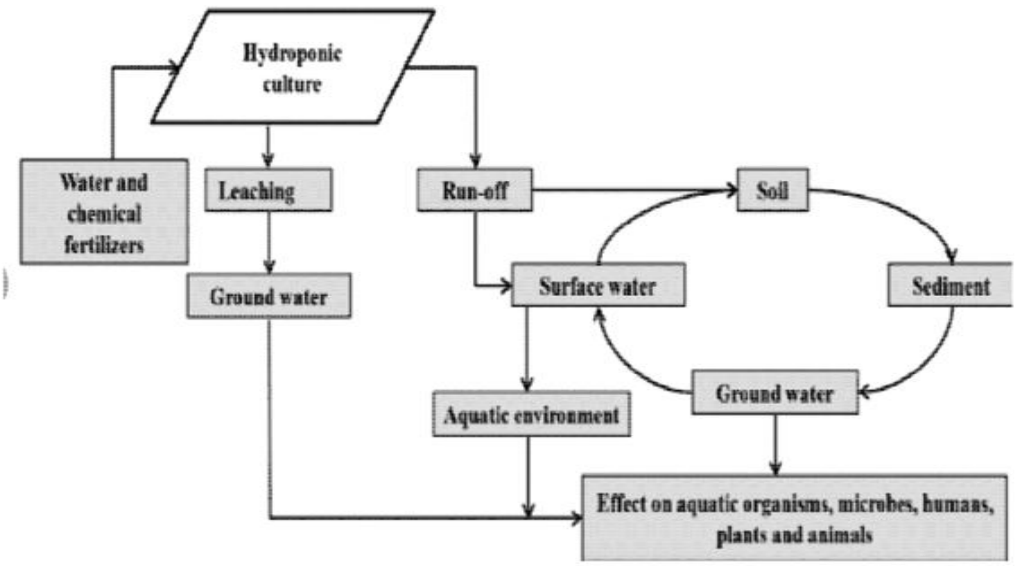


Figure-3a. Fate of nutrient solution of hydroponics on environment.

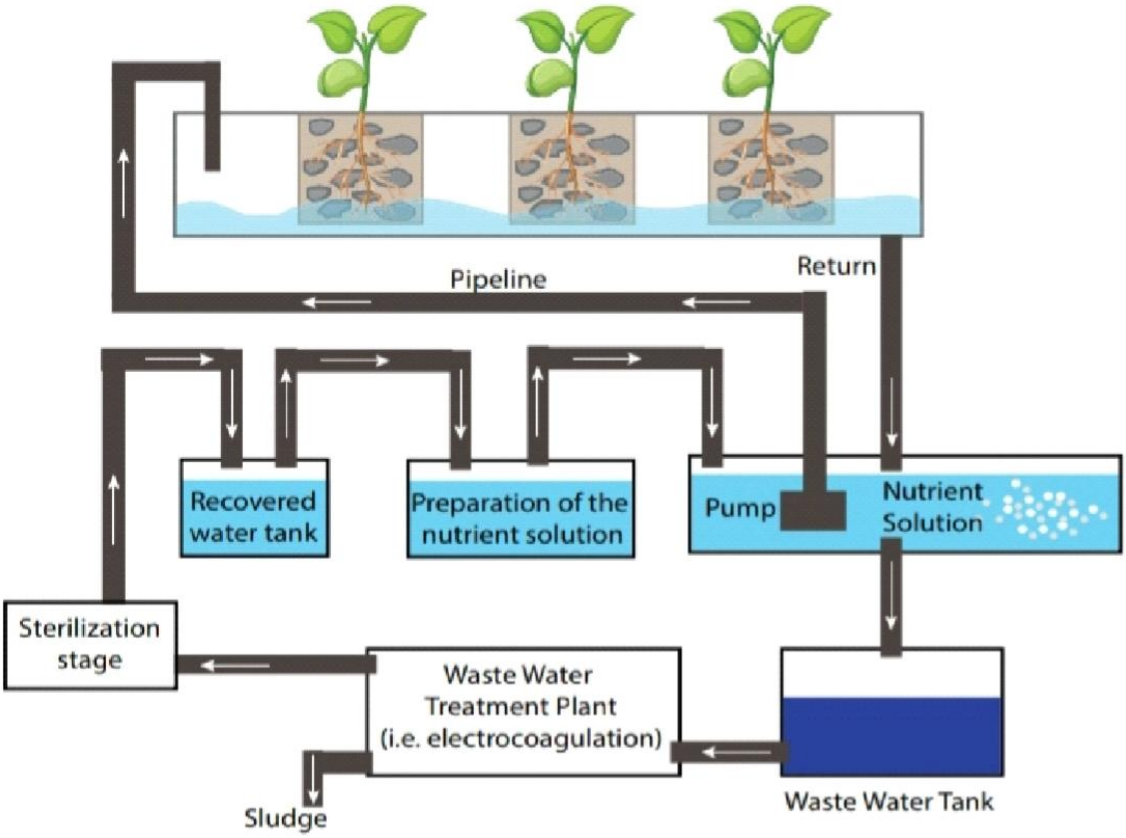


Figure-3a. Implementation of water rescue system in hydroponics.

Conclusion:-

Based on the Review Articles collected from Scopus, Elsiver and Web of science, we conclude that soil-less cultivation namely Hydroponics is one of the best method to provide the qualitative and quantitative yield to consumers as to meet their interests.

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