NEW BIOSPHERE AGRICULTURE

HYDROPONICS

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THE WORLD OF HYDROPONICS

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WHAT IS HYDROPONICS?

Hydroponics is an agricultural technique through which one can cultivate plants without the need for soil as a source of the necessary nutrients needed for their development.

Hydroponics, a word of ancient Greek origin, is formed by the words HYDOR (water), and by PONOS (the end result of work, as the book of a writer).

The Hydroponic method of cultivating plants can be done by suspending the root system in water - Water Culture, suspended in a mist of humid air - Aeroponics or , with the root system anchored in an inert or non biodegradable Substratum, or Growing Medium - Hydroponics in Substrata.

In fact, in this technique, soil may be used as long as it has no biodecompostable materials, no mineral, organic-mineral or purely organic salts that can be dissolved and ionised in water.

As a result, hydroponic cultivations are common in desert sands.

The origins of this technique are found in ancient Egyptian and Chinese civilizations, and is thought to have been used by the Aztecs of Central America. In modern times, it is considered to be the only method for producing fresh food for astronauts in space travels.

The development of Chemistry and Hydroponics has occurred together with man's attempts to understand **"why and how plants grow"**.

In studying plants, it was proven that besides water for survival, they depended on mineral salts dissolved and ionized in the same water used for their growth.

Since Antiquity, many philosophers and scientists have participated in the History of Hydroponics including Aristotle, Theophrastus, Dioscorides, Leonardo da Vinci, Andrea Cesalpino, Luca Ghini, John Woodward, just to name a few.

However, the word "Hydroponics", to describe this technique, was first used in 1935 by Dr. William Frederick Gericke, professor and researcher of Plant Nutrition at the University of California. He is considered the Father of Hydroponics.

Before 1935 this technique was used by many researchers in plant nutrition in laboratory experiments, but it was Gericke who first developed hydroponics commercially.

Nowadays, hydroponics is used worldwide to cultivate a wide variety of plants of all sizes.

In many countries the standards used to measure plant quality are based on plants cultivated hydroponically, and that quality is very difficult, if not impossible to attain, in the majority of cases, in normal conventional soil culture.

Other countries cultivate specific plants exclusively by using hydroponics, as is the case of the production of orchids in New Zealand, one of the world's leading exporters of these plants.

WHY USE HYDROPONICS?

It is very difficult to cultivate a normal agricultural soil in such a way that its nutrients may be readily available in quantities required by the plants.

Even if it is properly fertilized, the nutrients contained in the soil are leached away by rainwater or by irrigation, to the uncultivated areas, under the soil, and even to underground waterbeds.

The effects of water on soils not only cause it to loose enormous quantities of fertilizers, but also unbalances its chemical makeup. In addition, soil doesn't exist solely for plants; it also provides the habitat for innumerable species of minute organisms such as larvae, insects, and millions of saprophytic and pathogenic bacteria.

Larvae and insects also leave the soil, and install themselves on crops to feed off them, thus often devastating an entire harvest. Bacteria do likewise, feeding off of crops directly or indirectly.

Saprophytic bacteria feed off of dead animals and plants, small and large, that constitute organic matter, decomposing it into mineral, organic-mineral or purely organic salts that can be dissolved and ionised in water, and which are generally not considered as being a health risk to man.

However, pathogenic bacteria feed off organic matter of live animals and plants, and constitute the larger number of illnesses that affect humans and other beings, including plants.

Fortunately, however, Nature maintains a perfect balance among living beings. In this state of equilibrium, pathogenic bacteria are a minority and are dominated by the majority of saprophytic bacteria.

Whenever this balance is disrupted, pathogenic bacteria may get the upper hand causing diseases not always easily treated by modern medicine. Sadly, human activities, more often than not, disrupt Nature's equilibrium. Unfortunately, humans are expert in provoking such disruptions in Nature's balance.

In hydroponics, crops are not in physical contact with the soil, thus being free of larvae, insects and bacteria derived from it, resulting in high quality crops for human consumption.

On the other hand, the nutrients fed to the plants via water, will always be perfectly balanced, free from the effects of rain and irrigation, and in the exact quantities required, avoiding waste of fertilizers, so common in conventional farming.

As a result of this, crops grown in very clean surroundings, with the ideal sugar, vitamin and protein content, always produce higher yields than those under soil culture.

Although not necessarily, hydroponically cultivated crops are usually grown in greenhouses which vary in sophistication according to the climate, region and plants. As a result of this, the plants are protected from insect attacks and air pollution.

Hydroponic plants and fruits are harvested clean and ready to be consumed, although it is advisable to sterilise them due to handling from time of harvest. Due to the fact that hydroponic plants are very clean and healthy, their post harvest shelf life is ten to twenty times longer than soil tilled crops.

Many plants, as is the case of lettuce, are supplied to the consumer with their root system intact and therefore can be left in a basin full of water for fresh consumption.

ARE PESTICIDES USED IN HYDROPONICS?

Nowadays, it is impossible to cultivate crops intensely without the use of pesticides.

In order to cultivate crops, be it on subsistence level, as a hobby or commercially, we will always be disrupting the environment due to our forcing the predominance of one plant species over others. And each time that we provoke an imbalance, we will be subject to the infestation by a wide variety of species of pests from different sources. In order to minimize these insect attacks, it is up to us to curtail the changes provoked in the environment. Nevertheless, insects will always be present, and to eradicate them or at least reduce them to a minimum, we have to use various tools, among them, pesticides.

It is a mistake to take the position that all pesticides are harmful to human health.

We must remember that as long as properly used, poisons that kill also cure. Snake bite poisoning is cured by the controlled ingestion of the same snake's poison. There are natural and artificial pesticides, and the natural ones are not usually hazardous to men.

The most natural pesticides found are those pertaining to the plants themselves, for example the Mexican Marigold (Tagates minuta L.), a member of the Marigold family, or the Neem tree of Indian origin.

For centuries, it has been common to plant insect repelling plants in the middle of orchards. Neem trees are also planted in orchards as they exhale basic substances which have insect repellent properties.

It is also very common to spray teas and or infusions prepared from insect-repelling plants.

The tea or infusion extracted from Neem leaves is a very strong insect repellent both on plants and animals. From the Neem tree one can also extract various basic substances used for medicinal purposes, so much so, that in India this tree is known as The Villages' Pharmacy. Besides the Neem tree, teas or infusions extracted from tobacco or pepper, used together or otherwise, repel and kill many insects.

However, today, one should no longer use tobacco leaf extracts as its basic substance, nicotine, has been proven to be cancerous when used without restrictions.

We must remember too that tobacco tea or infusion can spread the Tobacco Mosaic Virus. In addition to artificial pesticides however, we need to consider the organic and the inorganic ones. The inorganic ones, when used sparingly, are generally not hazardous to human health or other superior animals, and are easily washed off plants with water. Thus, they cannot be considered as residual and in fact, many of these are made of metal salts often necessary to humans in minute quantities, known as micronutrients.

On the other hand, the majority of organic pesticides leave some residue on plants, and over the long run, even small quantities are hazardous to humans and other warm-blooded animals.

Unfortunately, these are the most widely used in extensive agriculture, and in an uncontrolled manner.

Hydroponic plants, besides being very healthy and resistant to many insect attacks, are usually harvested before such insects can do any harm. However, when insects cause damage to hydroponic crops before harvesting, the use of pesticides becomes necessary. The natural ones are preferred by hydroponic farmers; when necessary, artificial inorganic pesticides may be used in minute quantities.

On those very rare occasions when pesticides have to be used in hydroponics, they are used in such small quantities, ranging from a tenth to a hundredth of a percent less when compared to Organic Agriculture or to Conventional Agriculture. It is exactly for this reason that it is generally said that in Hydroponics pesticides are not used, which up to a certain point is true.

DOES HYDROPONICS "USE CHEMICALS"?

We have often heard, especially from farmers dedicated to Organic Agriculture, that “Hydroponics uses chemicals”. These comments demonstrate many farmers’ lack of knowledge of plant nutrition, and even of the kind of agriculture that they practice.

Let us see: - Chemicals or Chemical Products are industrialized and even natural products, and Hydroponics is an Agricultural Technique, and we don't know how one can place a chemical within a technique, as if this one could be bought in a shop and mixed with those ones in the most convenient way. Hydroponics is a technique which one learns and researches, and is based on scientific knowledge often pertaining to the Science of Chemistry. It is often mentioned that for a plant to be healthy and to have quality it has to be fed with Organic Matter.

Perhaps, whosoever affirms this may be following the theory on the Principle of Vegetation put forward by Rudolph Glauber c.1635, but corrected in 1840 by Justus Von Liebig, the father of Organic Chemistry. We do not know of any plant, not even carnivorous ones that can feed off organic matter or from the majority of organic compounds.

Nature constitutes the biggest chemical and biochemical lab known, and in it, all activities are processed through chemical, biochemical and photochemical reactions, in addition other types of reactions. Plants are autotrophic beings, that is, they produce their own food by using 16 elements of the approximately 100 known to exist.

Some of these elements they retrieve from the air, whilst the rest is extracted from the Growing Medium in which their roots are submerged, which in the case of conventional agriculture would be the soil. The chemical elements contained in the soil are retrieved by the root system, and in order to do so, it is necessary that these elements be in the form of very small molecules, dissolved and ionised in water.

Inorganic salts are the only molecules that present such characteristics. Organic compound molecules or organic salt molecules are too big and are unable to cross the roots' cells walls or move through their intercellular spaces.

This means that plants cannot feed off of organic matter as their cellular structure and absorption mechanisms do not permit them to do so. However, today, we know that there does exist some very small molecules of organic compounds that can be absorbed by plants.

On the other hand, these particular compounds are normally produced by the plants themselves for their own use, and up to this date it has not been proven that plants use those compounds absorbed by the root system, although one would expect such a thing to occur.

What has been described above are some of the basic concepts of Plant Nutrition. So, how can one explain how plants survive and develop fully as happens in Nature by fertilising soils with organic matter?

It so happens that organic matter, along with mineral salts and other compounds in air provide the food for the bacteria that live in the same soil. These bacteria while feeding, breakdown these compounds and emit excess or unused mineral salts and or elements that have already been used in their metabolic functions. These salts, once dissolved and ionised in the soil's water are then absorbed by the plants. Thus, Organic Agriculture which nowadays receives so much attention by the media, is in reality Inorganic Agriculture, or as they say about Hydroponics, "Uses Chemicals".

Furthermore, it must be emphasized that plants produced in soil in Organic Agriculture present very serious sanitary risks which are not commonly mentioned by those who practice it. Organic matter is a huge deposit of pathogenic bacteria which cause numerous diseases in humans, such as cholera, and many others. In order to be used as fertilizer, organic matter has to be turned into compost, which is the result of the decomposition of organic matter by the action of a series of bacteria.

This decomposition occurs in two phases, where during the first, fermentation takes place, raising the organic matter's temperature to a maximum of 70ºC. After this, the organic matter cools off and the final phase known as humification begins. It is a common belief among many farmers and technicians that all pathogenic bacteria are destroyed in the high temperatures obtained in the first phase of decomposition. This is not true. There are pathogenic bacteria that when submitted to temperatures exceeding 150ºC mutate and do not die, simply remaining inactive because of unfavourable conditions, awaiting a return to a less hostile environment, to resume normal functions, thus posing an imminent threat.

Thus, humifying organic matter does not sterilise it neither does it destroy pathogenic bacteria. It is advisable therefore to "chemically" sterilise or at least cook agricultural produce, for example vegetables, before they are consumed. The end result is that all plants, be they hydroponically or

organically produced, feed and develop in the same manner or, a term frequently used, they “have Chemicals” in them.

What truly differentiates them is the degree of healthy and aseptic qualities, which are far superior in hydroponic plants.

IS HYDROPONICS AN ESSENCIALLY INORGANIC TECHNOLOGY?

Hydroponic technology began in 1680 when John Woodward cultivated mint plants in various aqueous solutions enriched with different kinds of soils bearing decomposed organic matter. In truth, these experiments were the embryonic stages of Hydroponics, and the aqueous solutions used contained nutrients of organic origin. Today we can consider three types of hydroponics: - Inorganic, Organic-Inorganic and Organic.

In Inorganic Hydroponics, plants are fed with an aqueous solution containing highly soluble and extremely pure mineral salts, like those for pharmaceutical or laboratorial use. This aqueous solution is called the Nutrient Solution or Solution of Nutrients, and the mineral elements that constitute it are dosed in a balanced form according to the plants’ needs and their stage of development. Up to a certain point the nutritient solution reproduces artificially the Soil’s Solution provided by Nature.

Today, in fact, we can say that Inorganic Hydroponics does not exist. On looking at and touching the roots of plants cultivated in inorganic hydroponics one can notice a slimy, jelly-like film on the surface which is a part of the residues emitted by the roots. Under microscopic observation, one finds colonies of bacteria living off these residues by breaking them down and in turn emitting other organic and inorganic compounds.

The majority of these new compounds are in turn dissolved in the water that makes up the nutrient solution. The inorganic compounds are ionized and are reabsorbed by the plants and presumably some very small chains of organic compounds are also absorbed. Organic-Inorganic Hydroponics is essentially a form of inorganic hydroponics where one adds to the nutrient solution some mineralised organic compounds extracted from Nature in order to increase productivity as well as improve the nutritive value of the plants.

This practice is one of several that are researched and applied in Bioponics. Organic Hydroponics is a very recent technique with scientific research still in its initial phases. Nevertheless, its use is widespread with excellent results and, within its technical limitations obviously, often much better than those obtained in inorganic hydroponics. In a nutshell, in Organic Hydroponics the nutrient solution is obtained from biologically decomposed organic matter through a system of conventional composting or through Biodigestion in Biodigestors and Biofilters.

Organic Hydroponics proves to traditional farmers, especially to those that practice conventional organic agriculture, that Hydroponics is not an essentially inorganic process. Organic hydroponically cultivated crops present a marked difference when compared to those of conventional organic agriculture.

With regards to eventual contaminations by pathogenic bacteria, they are extremely clean and aseptic, and can be freshly consumed by people or animals.

Finally, we can conclude that Hydroponics is not essentially an inorganic technique.

HYDROPONIC SYSTEMS

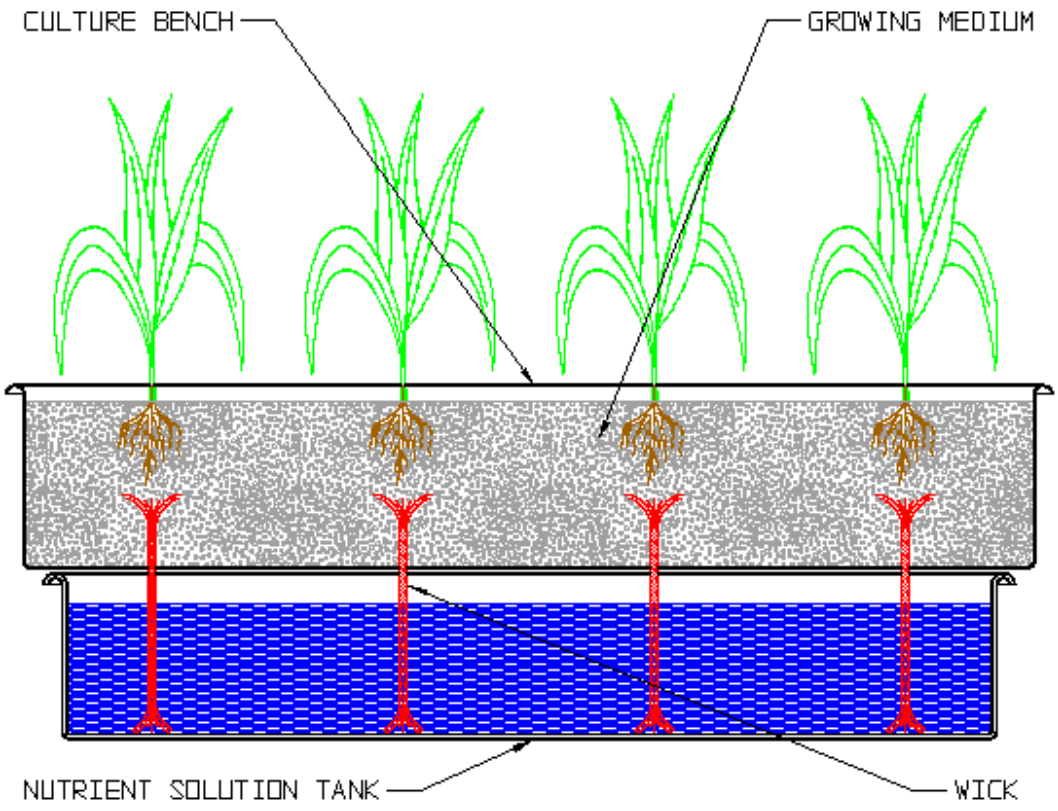
There are different methods of practicing Hydroponics which we call Hydroponic Systems. Hydroponic Systems can be divided in two basic groups; these are the Passive Systems and the Active Systems. In a passive system, the nutrient solution remains static in a recipient from where it is conducted to the plants' roots, usually by capilary action.

This is attained by using a growing medium of high capillary capacity together with a wick, like those used in oil lamps.

When using a wick, the system is called the Wick System. In one way or another, all Active Systems require circulating the nutritive solution by using a pump, and the majority of them need a parallel system in conjunction with it in order to aerate or inject oxygen in the solution.

Considering passive and active systems, there are a total of six basic systems that are known as the Wick System, the Floating Bed System, the Ebb and Flow System or Flood and Drain System, the Nutrient Film Technique System or NFT System, the Drip System and the Aeroponic System. There are hundreds of hydroponic systems, but all of them are variations or combinations of one or several of the above.

THE WICK SYSTEM



The Wick System is probably the simplest hydroponic system.

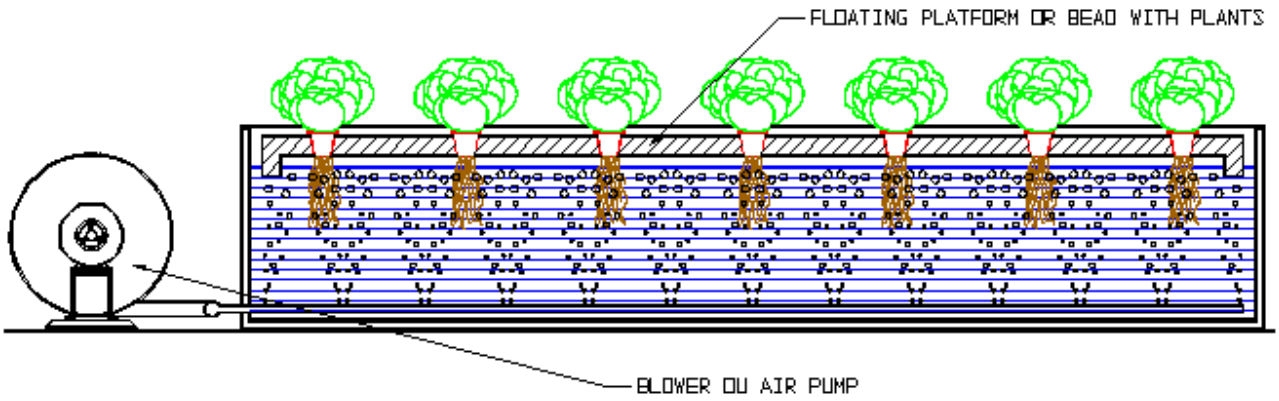
It is a passive system by virtue of there being no moving parts and where the nutrient solution remaining static in one place. The solution is taken out of a container and led to the plants' roots through the growing medium by capillary action, conducted through one or more wicks.

Normally in this system a mixture of various growing media are used in order to increase to the utmost their capillary capacity. This system is also commonly used for ornamental plants in pots containing conventional soil supplemented with fertilizers, with plain water in a container solely for irrigation.

As a hydroponic system, it is widely used with medium and small plants, especially in small home gardens for growing vegetables as it can be set up on a small scale. This system's biggest limitation occurs with large plants which need large amounts of water which the wicks are unable to supply in adequate amounts.

In this case, the number of wicks has to be properly dimensioned.

THE FLOATING BED SYSTEM



The simplest of all of the active systems is the floating bed system. In it, the plants are anchored in a floating platform placed directly on the surface of the nutrient solution contained in a container while the roots remain completely or partially submerged in this solution.

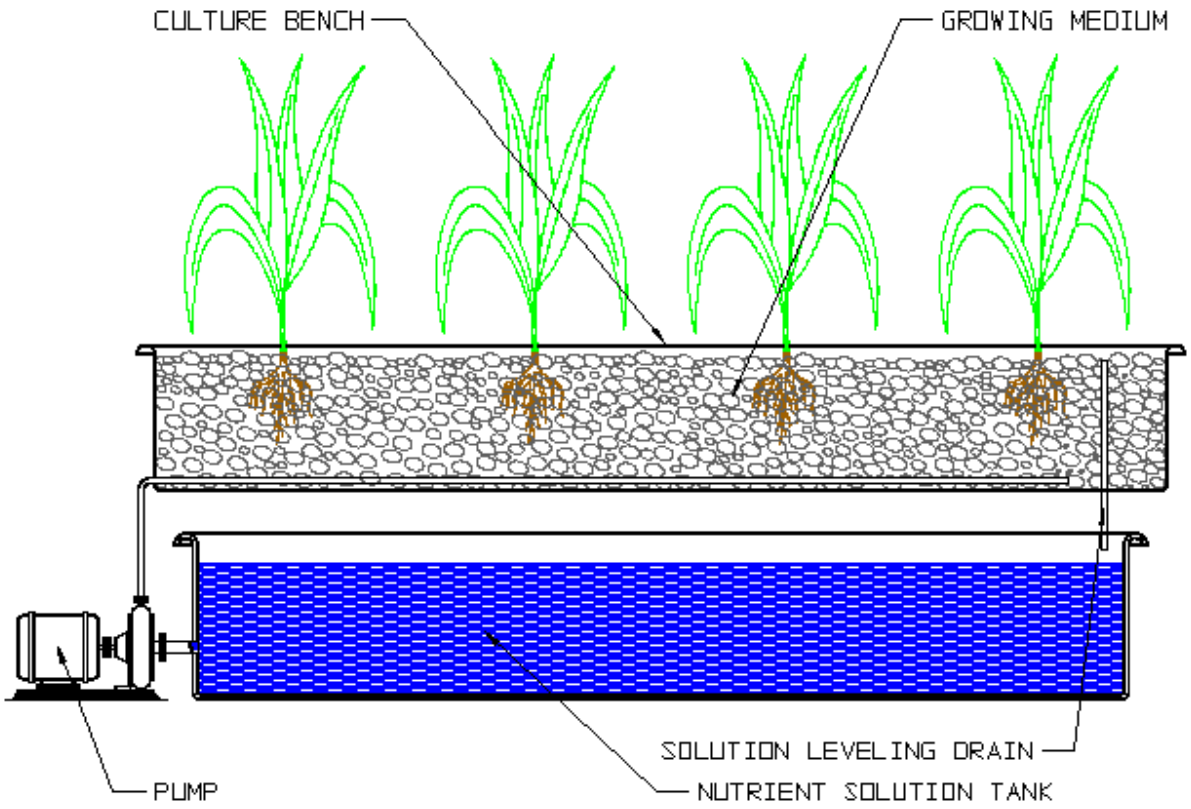
It is necessary to oxygenate the solution by bubbling air through an air pump, a blower or even by reticulating the solution periodically. When oxygenating the solution by bubbling air through it, this system is considered a passive one.

However, as mentioned previously, oxygenation can be accomplished by reticulating the solution by means of a pump, sometimes using an air injector, in which case, this system is considered an active one. This system is generally used for small plants that need very large quantities of water, as is the case of lettuce, which produces enormous productivity yields when cultivated in the floating bed system. It is also ideal for demonstrative purposes in schoolrooms where it can be mounted using fish

aquariums. The biggest limitation is its inadequacy for medium and large sized plants that have long life cycles.

When cultivating larger plants it is common to attach the platform over the sides of the solution container, in which case it becomes known as the Fixed Bed System or Gerike's System. It is very commonly used with medium sized plants, such as tomatoes, where an auxiliary structure is added in order to guide and support the tomato plants. Today, it is more commonly used in external domestic orchards, in plant nutrition research labs and for school demonstrations.

THE EBB AND FLOW SYSTEM (FLOOD AND DRAIN SYSTEM)



The Flood and Drain System or Ebb and Flow System, works by temporarily flooding a tray and then draining it immediately afterwards. This operation is conducted by using a pump controlled by a timer, which makes it an Active Hydroponic System.

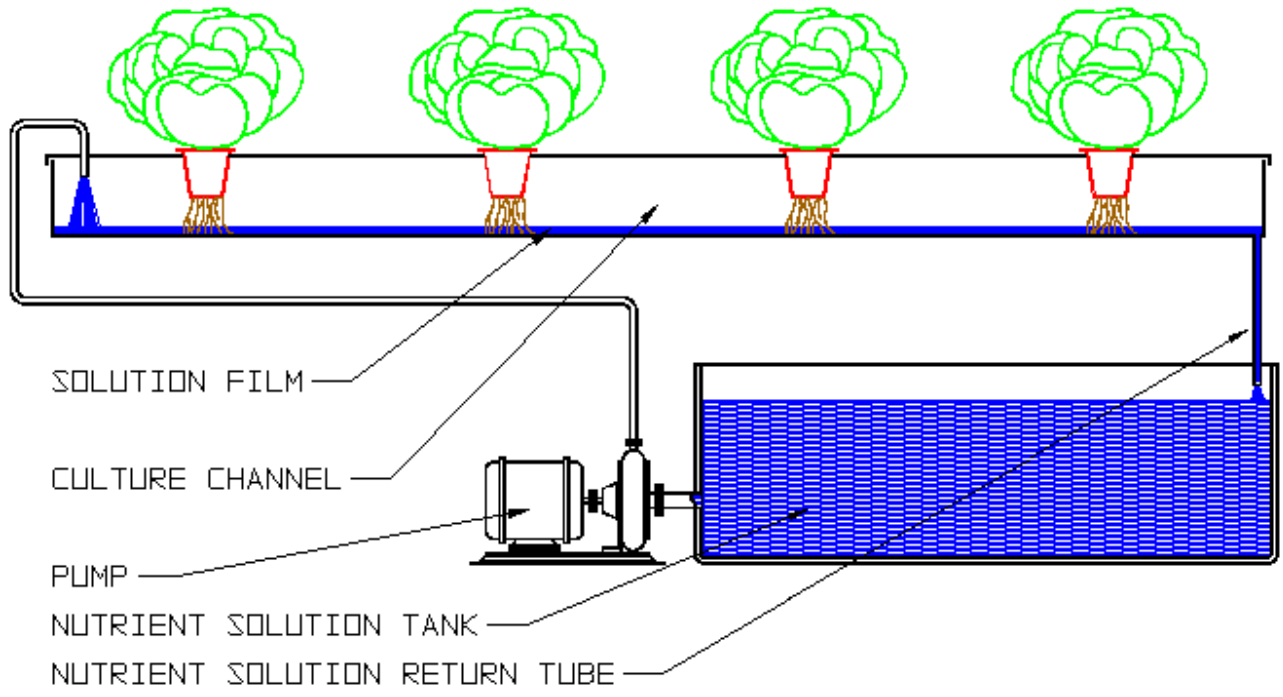
The solution is drawn out of a container by a pump, led to the bench or tray where the crops are being cultivated, and once the pumping has ceased, it returns to the container usually by draining through the same pump.

The timer is calibrated to repeat this cycle various times a day as necessary, according to the type of plant, its size, temperature and humidity and the type of growing medium being used, as may be the case. The growing bench or tray can be made in two ways.

In the first case, one uses a platform fixed to the edges of the bench on which the plants are anchored, and where the root system remains suspended in air or, where only the roots' extremities are dipped in a thin film of solution left permanently inside that tray. Today, this setup is outdated, although many still use it. The second and more common case consists of filling the tray or culture bench with a growing medium in which one anchors the plants' roots.

The growing medium must be biologically sterile and not decomposable.

THE N.F.T. SYSTEM (NUTRIENT FILM TECHNIQUE SYSTEM)



Today this is the best known system, and when many individuals talk about hydroponics, they are actually referring to the NFT System.

In this system, there is a constant flow of nutrient solution and, because of this, there is no need for a timer to switch on and off the pump that controls its circulation. The nutrient solution is pumped from a container to a channel or gully, inside and on the bottom of which the solution flows continuously in the form of a very thin film in which the roots are partially submerged. The remaining part of the root system is above this thin film in contact with humid air from which they derive their oxygen supply.
After running through the whole length of the channel, the remaining nutrient solution returns to the container. With small sized plants, the channel or gully is usually replaced by a rectangular shaped

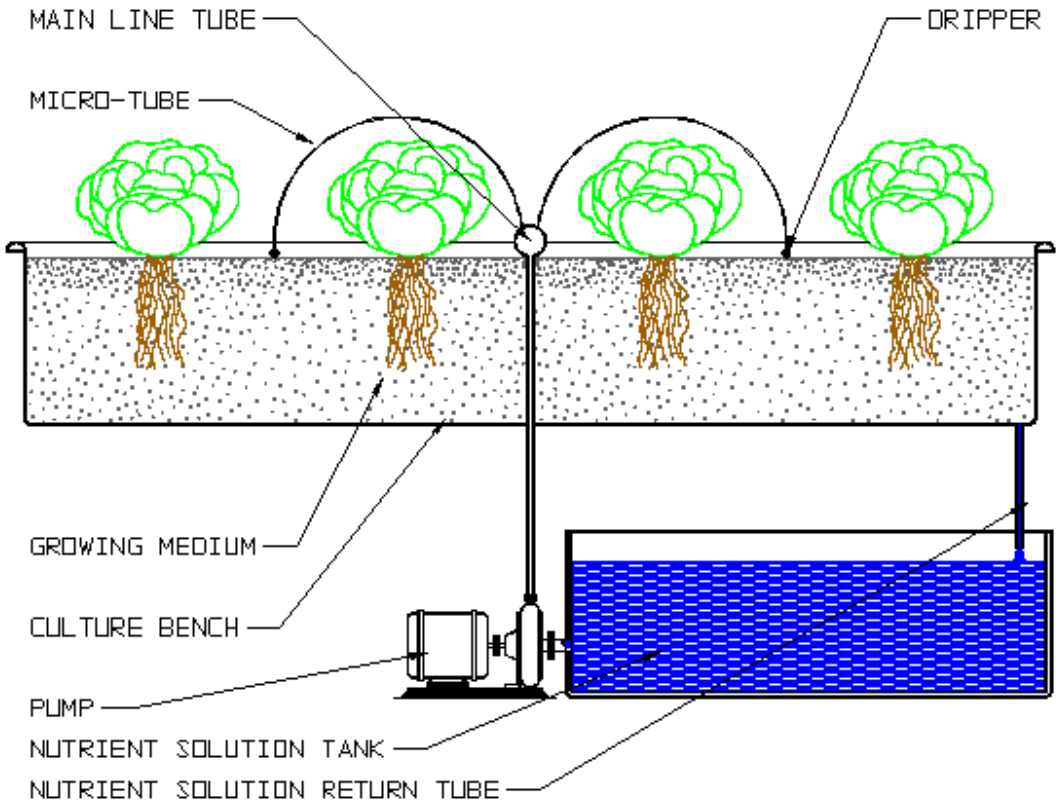
tube.

Normally, in this system, there is no growing medium, and the plants are generally kept upright in germinating pots or nets from which the root system is suspended in the air inside the channels or gullies with their extremities immersed in the solution.

The great problem with this system is that an eventual electrical power or pump failure would provoke the interruption of the flow of the film of nutrient solution, causing an extremely rapid drying out and death of the plants. That is why in the design of N.F.T. systems we must consider a backup power supply, like an electrical generator, or a DC powered pump.

Properly designed and constructed, it can be utilized for small and medium sized plants like lettuces and tomatoes.

THE DRIP SYSTEM



The Drip System is probably the world's most common hydroponic system. Its operation is very simple. The nutrient solution is taken out of the container by a pump controlled by a timer, and conducted through tubes and micro-tubes to the base of each plant where it irrigates it drop-by-drop, by means of a small mechanism known as dripper.

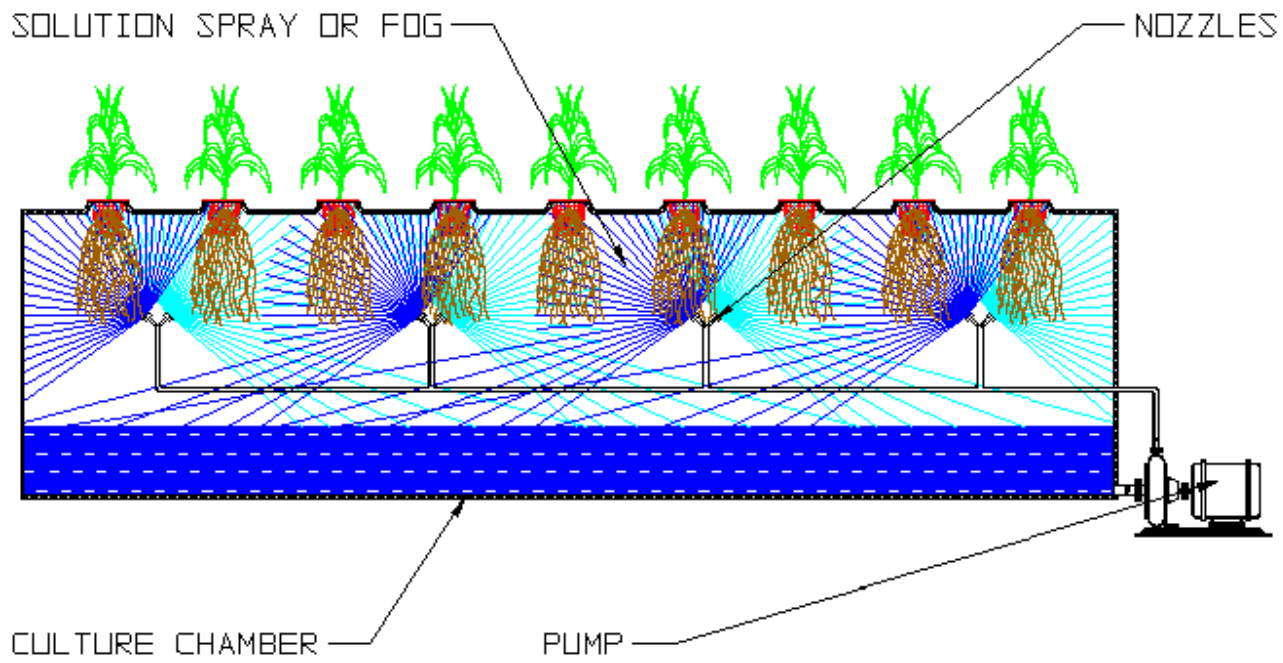
There are two kinds of drip systems which are normally used: - The Lost Solution System or Run to Waste System, and the Recovery Solution System or Reticulating System.

The run to waste system is an open system, and requires less maintenance work, as the excess nutrient solution is discarded after use, generally by infiltrating them into the sub-soil. Thus, plants are always irrigated with a new fresh solution, so there is no need to constantly monitor the solution's pH and Electrical Conductivity levels, except when filling the container with a new solution.

In the solution-recovery system, which is a closed system, the excesses of nutrient solution are recovered, returned to the container and recycled. This requires a timer of greater precision and is therefore more expensive, in order to obtain very precise irrigating cycles, which is beneficial to the plants. In addition, while recovering the solution, the pH and electrical conductivity levels will always fluctuate, requiring more careful control over them.

Electrical power failures and pump problems are common with this system, as well as the drippers' susceptibility to clogging with dirt, making daily inspection a must.

THE AEROPONIC SYSTEM



The Aeroponic system is probably the most technologically advanced of all of the hydroponic systems. Up to a certain point, it is similar to the N.F.T., with nutrients supplied through Humid Air, or as a fine mist.

In this system, the roots remain suspended and immersed in a Culture Chamber, or Growing Chamber, where they are sprayed with a mist of nutrient solution at short intervals, usually every few minutes.

As in all hydroponic systems, the solution is taken from its supply tank by a pump controlled by an extremely precise timer calibrated for very short irrigating cycles, ranging from seconds to minutes. Like the N.F.T system, the aeroponic system is highly susceptible to energy and pump failures. If energy or pump interruptions occur, the plants' roots will dry extremely quickly resulting in total loss.

The spraying of the nutrient solution can be done by medium or high pressure nozzles, by high pressure foggers, by ultra-sonic foggers or even by centrifugal foggers. Another major problem in aeroponic systems is the blocking of the orifices in the nozzles and high pressure foggers. Its primary application is in the production of shoots and edible sprouts.

THE ORGANIC HYDROPONICS

It has been proven that hydroponics, at least the one carried out on a commercial level, does not function as a totally inorganic process.

Even so, nowadays this technology is established, and by using it, we develop plants in much shorter periods, obtaining better crops, with superior quality to those produced though traditional agricultural systems. Such an affirmation is not one that most of us would like to hear as flattery, but a simple fact and scientifically truth.

In any event, sooner or later, any and all scientist or educator dealing with agricultural, chemical or biological technologies will have to accept these facts. In order to prepare the nutrient solution for conventional hydroponic systems, we use industrially produced mineral salts with extremely high levels of purity and solubility. We also use water with a high purity level, not only chemical, but also biological.

Unfortunately many farmers who want to start working with hydroponics do not have easy access to such products. And how would already established hydroponic producers cope with a sudden or gradual interruption in the materials they need? Such situations are not unheard of and may occur during natural catastrophes or wars, when specialized chemical industries could suffer interruptions in their production lines. Even so, in such extreme occurrences, we affirm that it is possible for hydroponic farmers to establish new operations and/or continue their activities.

Our affirmation is based on the knowledge that we have today on the relationship between certain bacteria with plants, within hydroponic systems. This relationship is being researched and is called Bioponics.

Bioponics involves a collection of practical knowledge and experiments of various dedicated hydroponic practitioners and scientists, that not only foresaw difficulties like those we pointed out, but also considered defending many ecosystems with the objective of maintaining their natural equilibrium while at the same time generating a profit.

In Bioponics, we integrate also the study of various systems to produce more nutritious food, always using natural processes and products. Thus, from this research, there have emerged two new hydroponic technologies or systems, called Aquaponics, and Geo-Hydroponics.

The original studies in the area of Bioponics, led us to the practice of Aquaponics and Geo-Hydroponics, and from these has evolved the practice of Organic Hydroponics.

What is Organic Hydroponics?

In terms of their mechanical operation, Organic Hydroponic systems present no difference in relation to common inorganic systems, as they are based on the six basic systems we have already described in these pages.

The difference lies in the nutrient solution.

This, instead of being prepared based on industrialized mineral salts, is made from animal excrements and animal or vegetable residues, biodigested in special equipments called Biofilters and Biodigesters. The Biofilters, by means of biological processes, convert waters polluted with fish excrements, into a solution of diluted and ionized salts that can be used as a nutrient solution in hydroponic systems.

From Biodigesters, we get the Biofertilizer, and from this, we can prepare a nutrient solution. Organic Hydroponics, differs radically from Organic Agriculture as we know it.

First, because it is a hydroponic system, and thus, uses no soil, and second, because we can produce high quality plants with a high degree of sanitation. One of the most important characteristics of organic hydroponics, is that it provides us the opportunity to build closed ecological systems, where all used elements are recycled, and so, causing no degradation to the surrounding environment. At the same time, we are disposing of waste products from other agricultural processes, reducing pollution of the environment.

THE AQUAPONIC SYSTEM (AQUAPONICS)

Aquaponics, or the Aquaponic System, is a hydroponic system where we integrate fish bred under captivity or in confinement, with hydroponics.

By using this system, we can produce not only vegetables, but also fishes. The basic system is very simple, as the various nutrients which the plants need are supplied by the water in which the fishes breed and defecate. In the process of taking up the nutrients, the plants purify the water. This is a mutually beneficial environment which reproduces the Nature conditions, with the advantage of being under our total control.

The aquaponic system is ideal to be maintained in homes and apartments. It can also be established in large commercial units, where one can generate profits not only from fishes but also from vegetables. There are two distinct aquaponic systems.

In the first one, fish faeces are maintained dissolved or in suspension in water, which is then circulated through a Biofilter, which in reality is a kind of Biodigester, where two biodigestions take place. The first biodigestion takes place at the upper level of the biofilter, in an aerobic surrounding. Here, aerobic bacteria convert the nitrogen in form of ammonia (NH3), into nitrates. This ammonia (NH3) is

expelled by the fishes' gills. In contact with water, part of this ammonia reacts, forming ammoniac or ammonium hydroxide (NH4OH).

The second biodigestion takes place at the bottom of the Biofilter, in an anaerobic surrounding, where fish faeces are converted into various mineral and organic-mineral salts. The salts resulting from both bio decompositions, dissolve and ionize in water, and are absorbed by plants, producing clean water, free of dissolved salts and various impurities, which then returns to the fish rearing tanks. In the second system, fish faeces are separated from water by a mechanical filtering operation, and the water full of ammonia (NH3) and some ammoniac (NH4OH) which was originated from ammonia (NH3) emitted by fishes, passes through a biofilter.

In this biofilter the ammonia is transformed into nitrates by the action of aerobic bacteria, and these nitrates, dissolved and ionized in water, are absorbed by plants. Thus, we get pure water, which is returned to the fish rearing tanks. Fish faeces retained in the mechanical filters can be used in two different ways.

The simpler one is to use them for the production of organic compost, by aerobic decomposition. This compost can be used to fertilize soils. The other way of using fish faeces, is by treating them in Anaerobic Bio digesters, and using the resulting Biofertilizer in the hydroponic system, or in the fertilization of soils as above. We can note that in this system the only losses we have is the water used by plants and fishes for their development, the water lost through evaporation on the surface of the rearing tanks and culture benches, and the water lost by plants transpiration.

Though it seems to be a very simple system, it is quite complex, as we are working with two different biomasses that are completely antagonistic, on the one hand, the fish biomass (essentially aquatic), and on the other, the plant biomass (terrestrial). To maintain these two biomasses in equilibrium is a difficult task that demands specialised knowledge and research.

So, to build such a system on a commercial basis, proficient technical support is advisable. Besides, it is also advisable the reading and studying of books which provide basic knowledge of hydroponics, as this technology is based in scientific knowledge, extracted and developed from thousand-year-old agricultural practices. The integration of pure Organic Hydroponics with Aquaculture constitutes a mini closed ecological system, environmentally friendly, where all elements that participate in the process are recovered and recycled.

THE GEO-HYDROPONIC SYSTEM (GEO-HYDROPONICS)

The Geo-Hydroponic System, or simply Geo-Hydroponics, was recently developed in Brazil, and though it is still being studied, it has already demonstrated its efficiency and economy. As in Aquaponics, it uses animal excrements, but from terrestrial origin, bred under captivity or in confinement.

We can use many types of animal manure, ranging from cattle to caged birds, such as laying hens. It is very important that those excrements are originated from animals bred in complete confinement, to avoid undesirable contaminations in them. That is why manure from laying hens has been the most commonly used, not only because they are very easy to collect, but also because many parallel benefits

can be obtained using them. For instance, one can't help but despise the sanitation and odour problem that large quantities of hen manure represent on egg farms.

In this situation Geo Hydroponics provides the ideal solution for that problem. Regardless of the manure utilized, it must be processed in an Anaerobic Biodigester, in order to obtain complete biodigestion.

The final product obtained from biodigestion is the Biofertilizer, a highly concentrated solution of mineral and organo-mineral salts, of highly nutritious value for the plants. The biofertilizer is submitted to a series of controls, dosed, diluted with water, thus producing a nutrient solution, that can be used in any hydroponic system. On the surface, this process appears very simple, but it requires a series of controls, which must be carried with extreme diligence. The critical element of the system is the construction and proper handling of a Biodigester, a type of equipment which unfortunately is not commonly used today.

As with Aquaponics, this system is very friendly to the surrounding environment, as it is not destructive to it. On the contrary, it helps to keep it clean. Each of the steps of this process, is absolutely natural, and is under our complete control.

In contrast to Aquaponic System, our nutrient solution is not subject to the control of the equilibrium of two antagonistic biomasses; therefore this simplifies our tasks. Regardless, all the controls needed for properly maintaining inorganic nutrient solutions should be observed here.

WHAT IS BIODIGESTION?

The word Biodigestion, is derived from the Greek word Bios, meaning Life, and from the Latin word Digestione, which means Digestion or Decomposition, or even the transformation of non absorbable matter, into other materials absorbable by living beings.

Scientifically, Biodigestion is a process of degradation, transformation or decomposition of vegetable and animal substances, (known as Organic Matter), carried out by living beings, like man, or even by micro-organisms and bacteria. Many synthetic products made by man, can be biodigested, and these are known as Biodegradable Products. The apparatus or implement or even the place where biodigestion can be processed, is called Biodigester, and depending on the type of system, biodigestion occurs in one of three different ways.

In the first one, biodigestion occurs inside the organism of an animal, which eats and digests food, assimilates part of it, and excretes the other part in the form of faeces. This is the Animal Biodigestion. Faeces are the result of an incomplete biodigestion inside an animal biodigester. Ultimately, these excretions end up in the soil, where, by means of millions of bacteria, they are digested again, until they reach the state of chemical products soluble in water. This solution, known as Soil Solution, is very rich in mineral salts, which are ionized in water, and readily absorbable by plants.

In this manner, it is established and completed a biological circle as follows:

PLANT - ANIMAL - DEGRADATION - SOIL - DEGRADATION – PLANT

In this INSTANCE, the biodigester is an animal. In the second method, or biodigestion process, Organic Matter and or Organized Matter, is not processed through the organism of an animal, but are spread directly over the soil.

Once over the soil, it is submitted to the action of wind, rain, and other forces of nature, including the action of various animals treading upon it. It is also affected by the chemical action of air oxygen, assisted by the catalytic action of sunlight. Though the mechanical action of the forces of nature and animal treading, the organic matter comes into greater contact with the soil, becoming incorporated into it, and mixing with it, where it suffers the action of animal and vegetable macro and micro-organisms.

Slowly, this organic matter is decomposed, until it reaches the state of chemical composts soluble in water. This is the Soil Solution, which is in turn absorbed by plants. And so, once again, we complete the biological circle we have mentioned above. This is called the Natural Biodigestion, and our biodigester is the soil.

The third way of biodigestion, is quite similar to the second one, but here, we consider the man as an integral component of the process. In this instance, animal wastes, eventually including those from man, as well as synthetic products manufactured by man for it's own use, are deliberately discarded on rivers, lakes, ponds, or over soil, and incorporated into it or spread over it. In soil or in water, those wastes are exposed to the action of macro and micro-organisms, are bio-decomposed in a relatively short circle, and once in the form of soluble chemical composts, they dissolve in water, and become the Soil Solution.

In this case, our biodigester is the soil, a river, a lake or even a pond.

ORGANIC MATTER AND ORGANIZED MATTER

It is of general knowledge that vegetable and or animal substances, once dead and sometimes partially dead, or even alive (as it happens with many plants), constitute what we call Organic Matter.

The elements that constitute organic matter which can be decomposed, normally have no more active life, and when this still exists, is in a final stage, as it happens with many plants. Even after being separated from its roots, they maintain a residual life, likewise with animal bones, which maintain partial life during very long periods.

We adopted the new term Organized Matter, to define organic matter, or organo-mineral matter and even mineral matter, ordered in such a way as to be able to assume life. So, we can have Organized Matter immediately before an ordered mass of chemical compounds assume shelf life, and so, become a "live being". We have Organized Matter too, immediately after that ordered mass of chemicals, looses shelf life. After life is extinguished, organized matter can still be maintained during very short periods, after which it becomes simply organic matter, which can be bio-decomposed.

We must remember that though this last complex of chemical composts is called organic matter that does not mean it is solely composed of organic compounds. In its constitution there are inorganic compounds like water, as well as unitary chemical elements, like oxygen and hydrogen. In addition to

these, there are organo-inorganic or organo-mineral compounds, like Sodium Citrate, an organo-mineral salt, derived from Citric Acid, an organic acid, and Sodium, which is an inorganic or mineral element.

THE BIODIGESTER

The apparatus or implement or even the place where Biodigestion occurs, is called Biodigester. In addition to the countless types of natural biodigesters, like soil, stagnant waters and rivers, we have those biodigesters developed and implanted by man, with distinct finalities, whose objective is to accelerate the process of Biodigestion.

Typical examples are the biodigesters used to produce antibiotics in pharmaceutical laboratories, the vats for the fermentation of sugar cane juice to produce brandy and alcohol, the stone vats for the fermentation of grape must in the production of wines, the septic tanks for sanitation of human faeces, and many others.

The biodigesters can be classified into one of three major generic categories depending upon its use:

1	-	Industrial biodigesters,
2	-	Urban biodigesters
3	-	Agricultural biodigesters

Here we will speak only about agricultural biodigesters, whose purpose is not only the decomposition of organic matter, but also the production of a product with a high concentration of nutrients for vegetables, which is used as a fertilizer, and is called Biofertilizer.

This isn't the place to tell the history of biodigesters, as many of its facets are well known, but it is interesting to provide an overview of the evolution of those which are currently in use. When man evolved to the stage of needing to plant vegetables for his subsistence, he slowly noted that these vegetables developed better, when planted in soils that had or appeared to have signs of residues of organic matter in a state of putrefaction or even completely putrefied. From these observations, the man developed the idea of digging pits (or cesspools) to deposit those decomposed matters, (the dung-hills or manure-heaps), constituted not only by vegetable residues, but also by animal ones, and even human residues.

These residues fermented, and produced a dark product (the compost), which when added to soil produced better crops. In handling the cesspools, it became apparent that it was more practical to make them impermeable, and, as they produced bad odours they found that it was better to cover them.

Soon, it became apparent that from those enclosed pits, emanated combustible gases that eventually could burn, producing a blue flame, similar to that of the fatuous fire of the swamps and cemeteries.

We know today that those gases are essentially composed of methane (CH_4), carbonic gas or carbon dioxide (CO_2), and sulphide gas or sulphide acid (Hydrogen Sulphide - H_2S).

It has been verified too, that on the impermeable bottom of dung-hills a viscous and concentrated liquid was accumulated, and when this liquid was sprayed over soil, it "burned" plants. Through trial and

error, experiments were performed in using diluted forms of this liquid before spreading it over soil. And the result was very good, as plants watered with the diluted liquid developed very well, strong and healthy.

Today we know that this liquid is the result of an Anaerobic Biodigestion, which has been named Biofertilizer.

Keeping stride with the scientific developments, including the understanding of the of different phases of Biodigestion, biodigesters evolved to incorporate this new knowledge. Now, armed with this knowledge, it is possible to plan and build Biodigesters to fulfil our various needs.

Within a biodigester, the biodigestion of organic matter is processed in various phases. The principal ones can be summarized as follows:

1 - ENZYMATIC REACTIONS - Assisted by mechanical actions, enzymes act as catalysts in those reactions that transform complex organic compounds, changing them into simpler ones, hydrolyzing them, thus facilitating the action of acids and bacteria, making digestion more simple and easy, as it happens within gastric system of animals. It is useful to recall here, that the food digestion process in animal, including man, is a biodigestion, as nearly all of it is processed by bacteria. One of the most important reactions in this phase, is the transformation of amylaceous compounds (ex.: starch) present in organic matter, into sugars.

2 - ACTION OF OXYGEN AND BACTERIA - In this phase, organic matter (partially digested and partially not digested), yet treated by enzymes, is exposed to the action of oxygen, aerobic bacteria and aerobic/anaerobic bacteria, proceeding from animal manure, resulting in the formation of water soluble composts with single chains.

3 - THE BACTERIAL ATTACK - In this phase, partially decomposed organic matter, undergoes the action of alcoholic leaven, and all sugars proceeding from amylaceous compounds during the first phase, are transformed into alcohols. Through bacterial action, these alcohols are transformed into acetic acid. This acid reacts with various compounds which are present, and form acetates. This phase is still predominantly an aerobic one, as it occurs in the presence of oxygen from the air.

4 - THE MIXED ACID PHASE - During this phase, we have an essentially bacteria work, with aerobic and some anaerobic bacteria, in an environment that changes periodically from acid to neutral and from neutral to acid, and is one of the most critical during the process. As the culture medium, gradually becomes neutral, it is favourable to the action and total predominance of anaerobe bacteria, like methanogenic bacteria, still in an acid ambient. The continuous action of anaerobe bacteria, neutralize the culture medium. As the ambient changes completely too neutral, it receives a new charge of biomass from the former phase, and becomes acid again, becoming once more favourable to the action of aerobic bacteria. This new charge of biomass is very little, compared to the total biomass in this phase, and the aerobic phase here, is very rapid. The part of the biomass that goes to the next phase will begin a total anaerobic bacterial phase.

5 - THE NEUTRAL ANAEROBIC PHASE - The principal characteristic of this phase, is the complete predominance of anaerobic bacteria, as the medium conditions are more favourable to them than to the

aerobic or aerobic/anaerobic bacteria. Through the action of anaerobe bacteria, our culture medium is converted into a biomass essentially composed of Humus colloidal solutions, and ionized molecular solutions. In this phase, the biomass becomes completely neutral, and its "DBO" (Demand of Biological Oxygen) is minimum (generally zero).

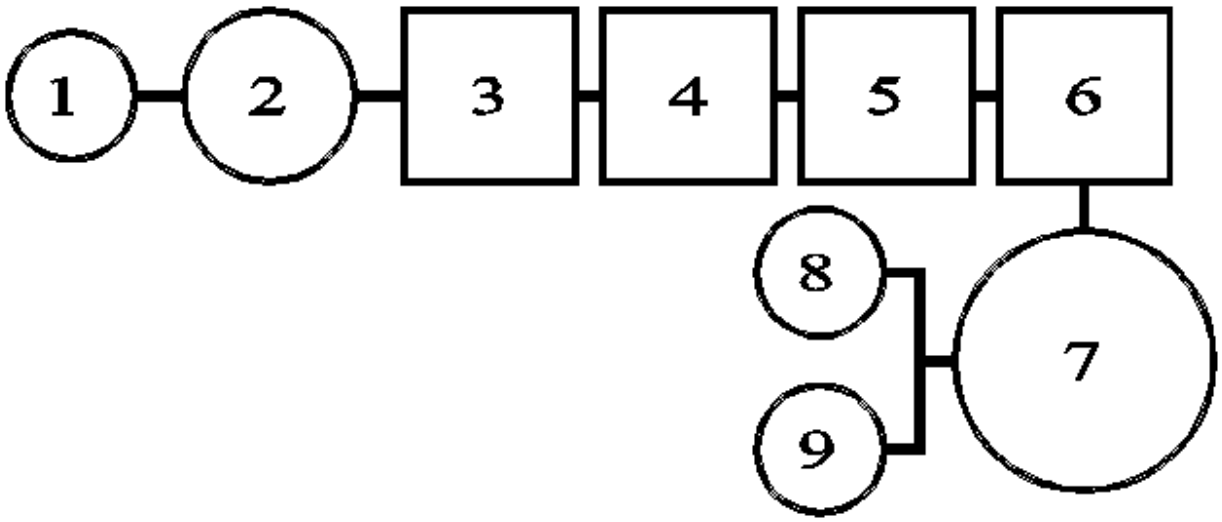
6 - OXYGENATION OR AERATION PHASE - This is the last phase of the process, and with it, we reduce or eliminate the "DCO" (Demand of Chemical Oxygen)

Beyond the fact that it disciplinants or puts in order and accelerates Biodigestion, the biodigester also stores the gases proceeding from it, which can be used to generate thermal energy, and even for bottling for future uses.

An agricultural biodigester, must be designed as to constitute a series of interconnected chambers, in such a way that inside each chamber, one individual phase of biodigestion can take place independently, as we can see in the scheme below.

We can describe the functions of each chamber, as follows:

1 - RECHARGE CHAMBER - In this chamber organic matter is loaded, shredded and mixed with additional water as needed. In this chamber the mass of organic matter is aerated and undergoes physical and chemical changes, catalyzed by enzymes, carried out by bacteria. The most important reaction in this chamber is the transformation of amylaceous compounds into sugar. Generally, this chamber can retain organic matter during 5 days.



2 - AEROBIC TREATMENT CHAMBER - Here continues the process of aeration of organic matter, and through the action of alcoholic leaven, in a process of aerobe acid fermentation, all sugars are transformed into alcohols, and then into acetic acid. This acid reacts with other compounds, forming acetates, and at the same time, "DCO" (Demand of Chemical Oxygen) is drastically reduced. This chamber is generally designed for the whole mass to be retained here for a period of 15 days.

3 – AEROBIC / ANAEROBIC TREATMENT CHAMBER - In this chamber we have the action of aerobic and aerobic/anaerobic bacteria, in an acidic environment, which begins shifting into neutral anaerobic digestion. "DBO" (Demand of Biological Oxygen) begin lowering, and we have the initial formation of Biogas and Humus. This chamber is generally designed for the whole mass to be retained here for a duration of 15 days.

4 - ANAEROBIC TREATMENT CHAMBER - In this chamber, anaerobic digestion completely dominant, and we have a high level production of Biofertilizer, Humus and Biogas. The biomass is retained here for at least 15 days.

5 - ANAEROBIC TREATMENT CHAMBER - This chamber is identical to the previous one, and anaerobe digestion continues in it.

6 - AERATION TANK - In this tank, the biomass is subjected to an intensive aeration, to encourage the action of nitrifying bacteria. At the same time, "DCO" (Demand of Chemical Oxygen) is reduced to zero.

7 - PURE BIOFERTILIZER STORAGE TANK - In this tank we store the finished Biofertilizer. It needs to have a capacity for about 30 days' production of the biodigester. It is connected to the mineralization tanks.

8 - MINERALIZATION TANK - They are generally designed with a capacity of 10 m^3. Here, when necessary, we correct the chemical composition of Biofertilizer.

9 - MINERALIZATION TANK - This tank is the same as the previous one, and has the same function.

A Biodigester is complex equipment, and to build it, we need a well designed project, which requires the participation of an engineer, and must be carried out by professionals with a high degree of experience in this area. So, it is recommended, if not necessary, that those who want to build such equipment consult with professionals with training in this area. An Agricultural Biodigester is a piece of equipment like a tractor, a harvesting machine or irrigation equipment. It requires a trained operator and ongoing maintenance, and for that, we need people who have been trained by qualified professionals.

THE BIOFERTILIZER

During the energy crisis of the 1970's, the Biodigester was presented as an alternative for the generation of thermal energy, as it produces Biogas. In reality however, a biodigester produces gas is in very small quantities, and it is not feasible to justify the construction of a biodigester for the sole purpose of it's production and use for thermal energy, and much less for the obtainment of carbon dioxide of even sulphide acid. The real value of a biodigester, is in the fertilizer it produces, known as Biofertilizer, and in the hygienic alternative it provides to us to conventional organic fertilizers.

The end product of the various phases of Biodigestion, is a liquid which is dark in colour due to the presence of Humus in it. We call this Pure Biofertilizer, and it can be used on soil as a high quality organic fertilizer, or even as a corrector of pH, bacterial life and texture. The Biofertilizer has a relative high nutrient concentration, and even so, it can be used directly over soil before planting. It is very

valuable when it is used as an additive in the preparation of Nutrient Solutions for Organo-Inorganic Hydroponics, and here, it promotes extremely high crop levels.

Once diluted, it constitutes a high quality foliar fertilizer, and in this form, it is known as Diluted Biofertilizer.

Diluted Biofertilizer also has all the needed conditions to be used as a complete Nutrient Solution in Organic Hydroponics. The advantages of using the biofertilizer are enormous, not only it is very economical, but also for the high agricultural yields which it produces. It is possible however, that the biofertilizer may not be the most adequate fertilizer for all kinds of plants. Its composition can present many variations, depending the types or organic matter used to feed the Biodigester that produces it.

So, to get a consistent composition of the biofertilizer, we must maintain consistency in the kind, quality and composition of the Organic Matter used in its production. The correct use of a biofertilizer, is the principal key for us to get the highest rates of agricultural productivity, and for that, some rules should be observed, as follows:

1 - To carry periodically Chemical and Physical analysis of the biofertilizer, to determine it's chemical composition and it's water solubility. If we have not too many variations in the composition of the organic matter we feed the biodigester, a monthly analysis is sufficient.

2 - To conduct a Chemical and Physical analysis of the soil which we plan to cultivate, to determine the components of that soil, and their solubility degree.

3 - To identify in specialized literature or by means of chemical analysis, the characteristics of the plants we plan to cultivate.

With this information, we can correct the chemical composition of the biofertilizer, adding to it the various soluble nutrients required. We call this operation the Mineralization of the Biofertilizer. It is likely that the process of mineralization is not an easy operation for many farmers, and for those, it is advisable to obtain the assistance of an agronomist. These procedures should be observed when we use the biofertilizer to prepare Nutrient Solutions for hydroponics.

THE BIOGAS

Biogas is a by-product of Biodigestion, and consequently, of the Biodigester, as the quantities produced are no more than 2.0% to 4.0 % of the weight of the initial Organic Matter used in the process.

It is a mix of gases, whose composition is:

Methane (CH_4) - 60.0 %
Carbonic Gas (CO_2) - 38.0 %
Sulphide Gas or Acid (H_2S) and other gases - 1.5 % to 2.0 %

As a consequence of its high methane content, it is a very good gas to generate thermal energy, and even as a combustible for internal combustion engines. To raise the thermal power of Biogas, and to eliminate its corrosive characteristic because the presence of sulphide gas, it is advisable to treat it.

Thus, sulphide gas can be eliminated by washing Biogas in a solution of potassium hydroxide, and the resulting salt, can be added to biofertilizer to enrich it with sulphur and potassium. Carbon dioxide can be eliminated by washing the Biogas with water under medium or high pressure. The dissolved carbonic gas can then be recovered and bottled for use in fire extinguishers. We can eliminate carbonic gas by washing Biogas with calcium hydroxide, and the resulting salt (calcium carbonate), can be used to correct the pH of acid soils. After purifying the Biogas, we will have pure methane, a very good flammable gas, that can be used under low pressures in stoves, fireplaces and ovens, and, under high pressures it can be stocked in special cylinders, like those used to stock oxygen or hydrogen.

I AM HUMUS

Those of you, who are familiar with me and live with me, be sure that besides you, I feel like the luckiest entity in the Universe. As always, with my humility, I will continue to allow you to obtain the highest harvest yields possible, at the lowest cost imaginable. To those of you who know of me and don't yet live with me, I beg you for just one chance to help you. Is it possible that some farmer would pass up the opportunity to harvest twice as much for half the cost? That would be difficult to believe

For those of you who are not familiar with me, let me introduce myself: My name is HUMUS, at your service, personalized by the author of these pages as the cartoon that appears frequently in these pages.

My father is The Great Architect of the Universe. My mother, well, she is the Organic Matter. My home, when they don't send me away or destroy me, is the soil. It can be any soil. Even the one on your farm. My existence begins when organic matter, my mother, begins to decompose by the action of biochemical processes caused by microorganisms and by strictly chemical and physical phenomena.

Basically, organic matter is a mixture of various plant and animal residues which all farmers, sometimes involuntarily incorporate into the soil, or leave abandoned on its surface. Due to its plant and/or animal origins that matter has incorporated into it an immense variety of microorganisms which decompose it in order to survive. They remove from it energy and elements which are essential not only for their formation and survival, but also for their reproduction. For this reason, the soil appears to us as a mass in a state of continuous evolution.

It is a living thing. And it is precisely this organic matter and its constant decomposition which provide the soil with chemical and biological characteristics which are of an extreme importance to the life of the plants. Organic matter can be therefore being considered to be composed of two parts or fractions. The first consists of vegetable and animal residues in a constant state of decomposition which is identified as Non-Humic Matter or Non-Humic Substances, which by mineralization, produces carbohydrates and releases fertilizing elements.

That is why it is often identified as Nutritive Humus.

Non Humic substances play a very important role in soil dynamics as they provide the food for the vegetal microorganisms, and for microscopic animals in addition to more highly developed species such as the Annelids (ex.: earthworms). The second part or fraction of organic matter, is dark coloured, and is highly resistant to biological decomposition. It has been identified as Stable Humus, Permanent Humus or Active Humus. That is ME.

Yes, here I am. A black substance formed in soil by the decomposition of organic substances under the combined action of the air, the solar spectrum, humidity and micro-organisms. I am Living Matter, and don't like to live alone. I am always accompanied by micro-organisms such as bacteria, earthworms, algae, fungi and others.

I must confess, just between us, that without them, I could not exist. The author of these lines chose to personify me as the cartoon that appears several times on this page. I hope that he did not make me not too ugly. My chemical composition consists, in a large part, of humic acids (you can say humic acid to make things easier for you) and insoluble humus, in addition to other more or less complex substances, such as amino acids, nucleic acids, phospholipids, phospholipids, phytin (thiamin phosphate), vitamins, hormones, enzymes, antibiotics,organometalic complexes and numerous other substances.

If somebody mixes me with ammoniac (NH_4OH) at cool temperatures, I am transformed in a black liquid and in an insoluble precipitate. That black liquid, is a colloidal substance called Ammonium Humate, formed by the combination of my humic acid with ammonium. That insoluble precipitate is

called Insoluble Humus. My humic acid resembles a colloid in its behaviour, which is similar to clay, however it is not technically a colloid. Even so, it is more stable than clay.

Thus, it provokes the same absorption phenomena, but with much more intensity. As I told you, I don't like to live alone. And so, I am also associated with colloidal minerals in the soil, and in this fashion, I play a key role in maintaining the equilibrium of the retention and release of fertilizing elements, and even in water retention in the soil. If someone were to compare me to colloidal mineral, I can guarantee that you could not determine which of us is more beneficial to the soil.

Together we are complete, and our presence is essential to the maintenance of agricultural productivity. In the case of heavy or compacted soils, I produce a mechanical effect of disintegration, I increase the lacunary spaces, I stabilize the aggregates, increasing the soils, water retention capacity, and preventing the formation of surface crusts. In this manner I improve water drainage and aeration, in this way reducing erosion caused by water. Also as a result of these properties, I facilitate the activity of micro-organisms, and I create good conditions for the diffusion of plant roots and root hairs.

Because my presence the apparent density of soil is decreased. In light soils, my colloidal composts have the opposite effect, agglutinating them and granulating them, giving them more body. Lacunary spaces and consequently the permeability of the soil are reduced, while at the same time I increase its ability to retain water.

I also absorb water at a rate of 5 or 6 times my weight. When I absorb water, I increase my volume, and when I loose it, my volume diminishes. In this way, I change the soil structure, as a result of the mechanical movement that I cause. As a consequence of my effect of granulation upon light soils, I avoid some of the erosion caused by the wind (aeolian erosion). Since I reduce the plasticity and cohesion of the soil particles, in turn it is easier to work the soil. Due to my dark tint, I darken the colour of the soil, and as a result, as it is obvious, it absorbs a larger quantity of radiant energy.

In this way, the soil heats up more rapidly and cools more slowly, reducing the germination time for seeds. This also reduces to a great extent the thermal oscillations to which soils are normally subjected. I have an enormous Cation Exchange Capacity (CEC), and when I’m in the soil, its CEC also increases. As I've already explained, although I am not a colloid, I have a colloidal behaviour, which is especially beneficial for sandy soils, since, I can increase in them the contents of colloidal elements. Acting as a colloid, I have cohesive properties, and I cause the coagulation of sandy particles. In this way, I facilitate the formation of aggregates, especially in the presence of bivalent cations, such as calcium or magnesium.

Just like a colloid, I am electronegative, and in this way, I absorb and retain nutritional elements in the form of cations, such as Calcium, Magnesium, Potassium or Ammonium, and I keep them from being leached, as a consequence of my electromechanical action. However, I leave these elements sufficiently free as to be easily absorbed by the plants.

In fact, the substances of I am composed, provide a very useful source of nutrients, since these are supplied to the plants in a slow and progressive manner. That is why when I am present in the soil; you require fewer mineral nutritive elements. I have mentioned before that I increase the Cation Exchange Capacity (CEC) and I am partially composed of organic acids, the humic acids. When these acids are

combined with Phosphorus and Calcium, they function as acidity buffers, and supply phosphates which are easily assimilated by the plants.

This most likely occurs in an amphoteric reaction similar to that which happens with milk. The more humus you have in the soil, the better will be its resistance to shifts in pH. Therefore, when the soil where I am present becomes acid or alkaline, there is no need to worry about adjusting its pH. Let me do my work first. If I am not able to do everything, I'll ask for help.

Why should I permit someone to needlessly use limestone or sulphur? As a consequence of my humic acids, mineral substances in the soil are dissolved, and are made available to the plants.

An example of this is what I do with fixed Potassium in the soil. As I already told you, and I will tell you again, I do not enjoy living alone, and if there is someone that I try to maintain nearby, it is that part of my mother, which I named Non-Humic Matter, Non-Humic Substance or Nutritive Humus.

Nutritive Humus is very important, as it is the source of nutrients for micro-organisms. And that is not all. It also contributes to the formation of composts useful for the metabolism of those organisms. Some of the nutritive humus, is consumed by micro-organisms in the process of respiration, during which carbonic gas (CO2) is formed.

And some of this gas spreads into the atmosphere, and is assimilated by green plants through the action of chlorophyll. Another part dissolves in the Soil Solution and forms carbonic acid, which dissolves nutritional elements which are in a form which cannot be assimilated. It also contributes to the formation of a more stable granular structure through the dissolution of calcium compounds. During the biological transformation of organic compounds, those in the state which are easy to attack, decompose, while the more resistant ones accumulate.

The disappearance of the former facilitates the transformation of the latter. As long as the conditions are favourable, these are transformed through self-oxidation, condensation and polymerization into dark-coloured humic compounds with a higher molecular weight. Due to the respiration of micro-organisms, these consume large quantities of oxygen which is removed from air pockets in the soil, resulting in a reduction in the oxygen levels in that air. What happens next is that elements such as Iron or Manganese, which in aerated soils are in an oxidized state (Fe+++ and Mn+++), and not available to the plants, are reduced to Fe++ and Mn++ form, which can be absorbed.

And I go on. In the process of my formation, other organic complexes are also formed, as those of Iron, Manganese, Boron, Zinc, and other ones. These elements are called microelements, and as they are maintained in the form of those organic complexes, they don't precipitate. Therefore, they are always available for the plants.

I've known how to do this for a long time, and I've always made that capacity available to whoever wants it. However only recently scientists have developed those synthetic organometalic complexes known as chelates, which prevent the precipitation of those elements.

Let me summarize for you my primary functions in the soil:

1 - I improve its physical characteristics, facilitating the development of a structure which is beneficial for plant growth.

2 - I am a source of nutritive elements

3 - I am a source of Carbon and I facilitate the formation of carbonic gas which, dissolved in the water of the soil forms carbonic acid, which improves its solubility capacity.

4 - I keep Phosphorus in a state which can be assimilated by plants, even in the presence of limestone and free Iron due to the formation of phospho-humic complexes.

5 - I am a very important source of Nitrogen.

6 - I reduce Potassium fixing (immobilization).

7 - I provide large quantities of micro-organisms to the soil, and I provide favourable conditions for their development.

8 - With clay, in the presence of limestone, I form the Complex of Absorption of the Soils, and I also contribute to its ability to retain nutrients.

9 - I improve the productivity of the soil, being justifiably considered to be the foundation of soil fertility.

Unfortunately, I slowly dissipate from cultivated soils. Why? There are many reasons, some of which I will tell you about in the following.

Organic matter, such as plant residues and any residue that stays on soil after harvesting are not present in sufficient quantities for me to be restored. I am consumed faster than I am replaced. Poorly aerated soil, either does not permit me to be formed, or prevents my fixation to the soil. Ploughing or tilling of the soil are the activities which most contribute to my destruction. I don't even want to speak about what happens when they burn the plant residues on the surface of the soil. What a crime they commit against me.

The temperature and the humidity conditions present in poorly structured soils destroy me, or they inhibit my development. Those soils from which I am depleted, become infertile, and make my restoration a very difficult task. Sometimes the topography of the soil makes it difficult for me to develop. And also, as with all living beings, the age of the soil doesn't make my life any easier. In a young soil, I am always present, although for no more than five years, if the soil is worked and they don't take care of me.

After people use the soil for agriculture, they forget me. They use me, and don't replenish the organic matter which is essential for me to be formed again. And finally, speaking the truth, they are sending me away. But I'm not human. I have no feelings. I simply exist. I don't get sad. I don't cry, I don't get happy, and the most important, I don't die, because somewhere, a small part of me still continues existing. I could say that I move to places where people want me.

Whoever created me also provided, somewhere, always, a small fraction of soil for me to settle into. Please, don't destroy this too. However, I am not as good a boy as some might believe. If one sends me away and wants me back, I must say that it takes a long time for me to return. In the end, any living thing requires some time to reach adulthood, and to be able to exercise fully the activities of its species.

And finally, in one form or another, I am Living Matter. If you want me to return, and you follow the natural processes, you would normally incorporate additional organic matter into the soil, maybe even using those known "organic composts" or "cured manures". However after 5 years you will only have 6.0% or 7.0% of the organic matter changed into my person.

It really takes a long time, doesn't it? Now, that is no reason for anybody to be sad, nor even to desist of the idea of having me. In the long run it is the best idea one could have. Some groups of academics and researchers, in the fields of Agronomy, Engineering, Biology, Biomedicine, and Biochemistry, were concerned about my gradual disappearance, and for being my friends, decided to help me. And they rolled up their sleeves and went work.

They researched Nature, they gathered data and information, they spent nights in their laboratories, and finally, they succeeded. They discovered simple, inexpensive and efficient methods to stimulate the natural processes which make me develop and appear rapidly. Based on the processes which have been discovered, after only 30 days, any organic material can have 40.0% of its total converted to Active Humus, and in no more than 90 days, 70.0% will be this friend of yours, the Humus.

That is a lot more than the 5.0% of Humus that nature provides after 5 years. You see? I still have friends. Well, my friends, this is ME, the HUMUS. I hope that now, that you know me a little better, you will value me. In this text, I've done my best to get you to know me a little better, showing you some of my main features. I hope you have enjoyed me. And if among yourselves, now that know me better, there is someone who wants me quickly in the soil of his farm, ask for that group of scientists I spoke you about. Somewhere you will find them. As for me, I'll go wherever I'm wanted.

May the Greatest Force of the Universe be with you always.

HYDROPONICS TODAY

If our reader got this far, we presume that he has therefore taken a good look at the preceding pages and therefore, has a pretty good idea of what constitutes Hydroponics, as well as the various technologies related to it.

Hydroponics is a fairly recent technique as it has only been used for commercial production for no more than 60 years. Many authors and researchers already consider it a Science. However, even in such a short space of time, it has been modified for a wide range of applications; from crops cultivated outside, to those grown in greenhouses; even for specific plants cultivated in atomic submarines, in space craft, and in outer space stations. While it is a science of the space age, it can be used in underdeveloped countries around the world to produce large quantities of food in small areas.

The only restrictions are clean water and nutrients. Where there is no drinking water, desalinated sea or stagnant pool waters may be used. Where there are no industrially produced nutrients, one can use those

extracted from residues and other organic matters treated in biodigesters. Because of this, it presents a huge potential for the production of food in areas where there are no agricultural soils available, as in natural or human made deserts.

Hydroponic units can be set up anywhere, along the sea coast, on top of tall buildings in big city areas and inside apartments, or in home gardens and back yards. By using hydroponics we can produce not only greens and fruits with high nutritional value to be used as a complement to salads, but also as fodder for milk and beef cattle.

In an area of 20 square metres, we can hydroponically produce every day 450 kgs of fresh fodder to feed not only domestic cattle but also animals in zoos (200 square metres will achieve daily 10 tonnes).

Hydroponically produced fodder increases milk production by as much as 30%, and the conversion to meat for beef by as much as 20%. It also increases considerably the fertility rates of males and females. In poultry farms, egg-laying increases by 40% and eliminates cannibalism among chicken. Aromatic and medicinal herbs are also produced with the same quality as those traditionally produced in soil.

Medicinal herbs can be produced in completely sterilised places, and according to the plant used, one can emphasize or encourage the development or growth of the roots or foliage. Any kind of plant, whose roots, leaves, branches, seeds, fruits or tubers are utilised, can be produced hydoponically.

Besides controlling the quality of plants, we can also control their sugar, vitamin, protein and other essential compound levels. Through hydroponic techniques, we can also enrich plants for human and animal consumption, as well as include certain microelements not essential to the plants but crucial to man, by managing accordingly and naturally, the plants' nutrient solution.

Hydroponics not only enables us to produce food, but also to purify air efficiently, as will be demonstrated by NASA testing for the future space stations.

Nonetheless, hydroponics still faces problems that hinder its development. One of them is the negative attitude that certain professionals and professors of agricultural schools have towards this technique, from lack of interest to open hostility, due to their reluctance to study new production systems that conflict with the traditional ones. As is typical of man, there is a fear of the unknown and unfamiliar. Fortunately, throughout the world, there are people sufficiently generous and open minded, always ready to help producers to install their hydroponic units.

For hydroponics, the future is promising. However, it must be emphasised that hydroponics is not THE SOLUTION, but ONE SOLUTION that can help reduce hunger that is so prevalent in various parts of our planet. Its application can be for commercial reasons or absolute necessity, when faced with the impossibility of using traditional farming methods. In either case, the application of hydroponics must never be undertaken without a thorough knowledge of its fundamental principles, followed by adequate and careful research and planning.