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Introduction of Attractive Organisms as Robust Photo-Bioreactors for Support of Life in Space

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ABSTRACT: At the present era, planetary researches draw vast attention toward foundation of efficient life support systems to establish a suitable living condition while human flies into the space. So setting up such an appropriate system need to consider the status of the refining and recycling of air and water, and define of efficient food continuum on various planets and on the space stations. Although we should exploit the evolution flow of biogenesis in the earth, which was mainly originated from the bacteria, cyanobacteria, and eukaryotic microalgae, many of researches were conducted toward chemical and physical means of O2 and H2O production or in the case of food, we have to transport it from the earth. Superior to many of these modalities, recently the biological life support system like using special plants, establishment of greenhouse, and using of genetically modified plants proposed as promising systems in the space missions. However all of the above mentioned systems are in bench-scale if they would not be a theory as well as they would not responsive in a lengthy mission of astronauts, so we need to develop an efficient bio-regenerative system to work independently for a long period of time. Therefore in the present review, we will discuss inherent biological features and biotechnological potential of flexible organisms which belong to the early stage of evolution including: Spirulina, Probiotic bacteria, Dunaliella and Artemia. Further, this paper describes the potential of these organisms as a spontaneous photo-Bioreactor for production of Biohydrogen, green electricity, as well as waste management and mass production of food, and bioactive compound. Eventually this paper offers a construction of bioreactor with modified component for efficient Milking of Microalgae Dunaliella, Spirulina and Probiotic bacteria in the space.

Keywords: Space Life support system, Photo-Bioreactor, Dunaliella, Spirulina, Probiotic bacteria, Artemia

INTRODUCTION

Curiosity sense of mankind makes him step on other globes and surge to conquer them, Hence new investigation have been conducted toward finding an ideal life supporting system as a fundamental need of space travels and even colonization or establishment of a new civilization up there. It is worth noting that the essential demand of space such as water, food and energy supply could be obviated in three ways, i.e. by providing supplies from the earth for the short duration of the mission, by affording the necessities by physical/chemical methods, by regenerating the habitat using biological methods. Reviewing many of capable approaches and considering the NASA hint, the Advanced Life Support (ALS) system should be based on the most promising modality of bioregenerative life support technologies in the foreseeable future. Obviously the way en route to the human biological autonomy should go through the gate of photosynthesis, i.e. photosynthesis at least in the earth is the foremost generative part of the food continuum, however its establishment demands finding a superspecies or genetically modified organisms to adapt the harsh condition of the space (de Micco, *et al.*, 2009, Gitelson, 1992, Häuplik-Meusburger *et al.*, 2011, Sychev, *et al.*, 2008). To reach this goal the space organizations granted many of relevant investigation like NASA salad machine project, and hydroponic greenhouse, but there is little or no success until now. Authors surmise that, making the counterpart of earth in the space will go up in smoke if we didn't mimic the genesis of the creation in the earth. The species localization concept seem to be practical by looking for creatures which appeared first on the earth or came into existence in older eras because early earth was very different and inhospitable compared to the earth today. Life on the earth now is a result of organisms' evolution in millions of years.

According to fossil records, Cyanobacteria were the earliest residents of the earth and their age almost refer to 3.5 billion years ago; furthermore they exhibited brilliant capabilities growing in the simulated condition of moon and mars these microorganisms could tolerate unfavorable conditions of early earth and even made it suitable for rise of subsequent eukaryotes. Presence of Cyanobacteria and unicellular photosynthetic eukaryotes in the crucial conditions of early earth is a witness to their excessive ability for surviving in harsh situations. So why couldn't we mimic the same for expanding life to space? A Bacterium That Can Grow by Using Arsenic Instead of Phosphorus (Olsson-Francis, and Cockell, 2010, Wolfe-Simon*et al.*, 2010).

Dunaliella as an unicellular eukaryotic microalgae is another candidate for localization in the harsh condition of the space due to its extremophile habits which makes it suitable to thrive in habitats with a wide range of salinity, pH, heavy metal, light intensity, UV radiation and temperature. Moreover this microorganism produces almost 90% of oxygen in the atmosphere of the earth in accompany with eukaryotic micro alga and Cyanobacteria. In comparison with plants, this microorganism more efficiently removes carbon dioxide which is the most dominant and interfering gas intensity in many of planets. It should be noted that, milking this microorganism for nutritional, pharmaceutical and industrial application in the photo-bioreactor meet the demand of market in the earth and absolutely it would do the same in the space (Rothschild and Mancinelli, 2001, Cheng, *et al.*, 2006, Pulz, and Gross, 2004).

Although Dunaliella and spirulina (cyanobacteria) due to their high capacity in food and third generation energy production could be consider as a backbone of autonomic photobioreactor, we could furnish the space mission with Artemia as a tangible and direct food with high nutritional value in which many of feature for bearing the harsh condition of the space was already taken into account. Furthermore the probiotic bacteria or euphemistically forgotten organ of human body owing to its recuperative effect on human health care could be served in space preventional medicine.

In the present paper relying on the introduction of special features and capability of mentioned organisms, the authors try to describe in detail the different component of new generation of space bioreactor. This kind of bioreactor seems to be superior than existed one because of its special features such as close connection between the different components (i.e., the self-oriented innate of the different part), efficient waste management, seem to be feasible because this model was adopted from the evolution process and food continuum of the earth, capability of biohydrogen production. Eventually we discuss the coordinate combination of these organisms in association with space Photo-Bioreactor as backbone of life support system which provide food, water, oxygen, energy while removing carbon dioxide in the harsh condition of the space.

A. Importance of photosynthesis as a base of life

Envelope of gases that surrounds the earth now have been produced by living organisms from a reservoir of chemical compounds in the early earth that are found in other planet too. These organisms survive extremely hard harsh living conditions and utilize a main part of compounds which are sometimes poisonous to produce necessary matters for other beings. The foresaid gases also exist in mines and the surfaces of the other planets. If you expand the living conditions to these planets, the establishment of an atmosphere like that of the earth will be possible. Although this takes a very long period of time but founding of a closed environment like earth atmosphere for long term is feasible. Fossil evidence indicates that the thickness of the earth atmosphere has been increased by inception of photosynthetic organisms and at the same time the concentration of CO_2 was mainly lowered. Above 90 percent of atmospheric oxygen is produced by the photosynthetic organisms which live in oceans and seas. This level of oxygen production is much more than of forests and all plants on the earth. Therefore, it's certain that photosynthesis has played a crucial role in creation of an adapted atmosphere. The importance of Photosynthesis can be understood with respect to our breathing process. The breathing process keeps us alive and Photosynthesis provides us oxygen to breathe in. Then the next generation of organisms constructed food chains on the earth. We can create this condition in other planet, if we can use of photosynthesis systems. But the evolution in base of photosynthesis cannot accrue in few time and plants full-fledged in million years and if we want the use of plant in space condition we have to manipulation to improve new super species plant that can be grow in space condition in cloud: Technological improvements in lighting efficiency and the genetic engineering of crops that are better suited to a spaceflight environment (e.g. crops that are dwarfed, have high harvest indexes, and grow well under artificial light, reduced atmospheric pressures or elevated CO_2) remain promising areas for advances in the long term (Ciferri, 1983, Brechignac, and Schiller, 1992). The importance of photosynthesis for creation of atmosphere in space stations and other planets has been demonstrated although plants have mainly considered for this purpose. But utilizing plants in space stations is not profitable because they need plenty of room and artificial light. Also nutrition and irrigation of them in space is difficult. Plants are not capable of making big changes in atmospheric compound or living conditions in space. On the other hand, they weren't the primary creatures to survive harsh conditions of early earth and they lack the ability for sufficiently construction of atmosphere.

Despite the fact that the scientists have been trying to improve plants to cope with these circumstances but because of several difficulties, there is no considerable achievements so creation of suitable plants for space missions still remains as an idea and in pilot level.

B. Impressments organism in Hobson's choice photo-bioreactor

Microalgae Dunaliellaw. Dunaliella is single-celled green micro-algae that is found in water ranging from fresh to saturated salt water include coastal waters, brine rock pools and lakes that lose water to evaporation. It could establish tolerance against different ranges of pH, temperature, carbon and nutrition deficiency, excessive radiation and UV ray. Dunaliella Sam as plant is a photosynthesis organism but it can photosynthesize in stressful condition too, it is not sensitive to low and high light. When Dunaliella confront with undesired environmental conditions, like high concentrations of salt, heavy metal, UV-radiation, it could move to safer areas or tolerate this condition. Plants haven't got this kind of flexibility. Dunaliella has some special proteins that make it extremely tolerant against harsh condition. Today we use from this organism as a model to study tolerant process to stress and transfer gene from Dunaliella to breed a superior plants. One of these proteins is Carbonic anhydrase which plays an important role in this organism and plants. This kind of enzyme is supposed to be more efficient than other plant type carbonic anhydrases. Dunaliella has a particular CBR (carotene biosynthesis related) protein which appears upon photooxidative damage and repairs possible photodamages of PSII. In spite plant Dunaliella Nether high nether low condition is tolerate and can use from toxicity to an essential for live. In space Dunaliella can use as an open photo-bioreactor.

Because Microalga Dunaliella has many enzyme and producing antioxidants like ascorbic acid, lycopene and carotenoids that play a significant role in damage restore. Light is the most essential factor for photosynthesis. However exposure of plants to excessive light leads to photodamage and photoinhibition of photosynthesis (Melis, 1999), furthermore the production of reactive oxygen species (ROS) such as hydrogen peroxide (H_2O_2), superoxide radicals (O_2), and singlet oxygen ($1O_2$) (Niyogi, 1999, Apel, and Hirt, 2004). The produced ROS can inhibit photochemical reaction center P680 (Szathmáry and Demeter, 1987), and led to oxidation of lipids, proteins, and enzymes necessary for the proper functioning of chloroplasts and cells. Photo system II is particularly prone to such damage. And so, Dunaliella can photosynthesize in very low light that plant cannot photosynthesize in this condition. So that Biological characteristics of Dunaliella make it an extremely tolerant organism to harsh environmental conditions. And so if we investigate the earth evolution we found the Dunaliella in head of this evolution of eukaryotic organisms. So that it can interest and major reason, for select Dunaliella as an attractive candidate to space photo-bioreactor. The second reason, Dunaliella can be a cell factory to produce feed, food, and bioeneregy that we need in space life supports. Under stress conditions (e.g. high light intensity, high salinity and nutrient deficiency) Dunaliella can produce and accumulate high concentrations of β-carotene (up to 10% of its dry weight) (Ben-Amotz, 1995).

Carotenoids are chemicals with high commercial demand that are used as coloring agents in neutraceuticals, pharmaceuticals, cosmetics and food. On account of their antioxidant properties, these materials have been considered as potential agents in chemoprevention of cancers (Leach, *et al.,* 1993), aging and free radicals effects.

Fig. 1. Dunaliella, with high lycopene and beta-carotene concentrations, isolated from uremia- the second salty lake of world (containing above 300 grams per litre salt)- located in the north-west of Iran (Isolation by Abolfazl Barzegari).

Beta-carotene has beneficial effects including: protecting skin from UV damage, fighting early cancer cells, improving immunity and preventing cataract formation. It also stops the creation of free radicals (oxidants) which are DNA-damaging molecular fragments in body of astronauts.

In figure 1 we can see two superior species of Dunaliella that isolate from Iranian salty lakes. This Dunaliella can produce lycopene same as tomato and other species produce high concentration of beta carotene same as carrot. Thus, an astronaut can uses Dunaliella in food or as alternative medicine. Another reason for select of Dunaliella in this photo-bioreactor is Renewable energy potential of Dunaliella. It has recently received a lot of attention as a new biomass source for the production of renewable energy. Some of the main characteristics which set this microorganism apart from other biomass sources are that Dunaliella have a high biomass yield per unit of light and area, can have a high oil, do not require agricultural land, fresh water is not essential and nutrients can be supplied by wastewater and CO2 by combustion gas. Dunaliella uses sunshine, carbon dioxide, waste or brine water with natural nutrients. It can use green energy for supporting biomass growth such as solar or wind. This organism is reported to have oil yield of about 37% (organic basis). Dunaliella is a fast growing and that means it has a high CO2 sequestration rate as well. Dunaliella fuel, also called third-generation biofuel. Yet can theoretically yield between 10 and 100 times more energy per unit area than other second-generation biofuel crops. In result, Dunaliella is the most interesting cell factory with which many added-value compounds can be produce for application in food, feed. Cosmetics and feedstock for chemical industry, and they also have potential as Biohidrogene energy carriers. And so, there are many photo-biorector to milking of Dunaliella in the earth that we can improve to space conditions.

Cyanobacter Spirulina. Spirulina is a ubiquitous microscopic blue-green alga in the shape of a spiral coil. Spirulina have been found in a variety of environments: soil, sand, marshes, brackish water, seawater, tropical warm waters, salt pans power plants, fish ponds, etc. Thus, the organism appears to be capable of adaptation to very different habitats and colonizes certain environments in which life for other microorganisms is, if not impossible, very difficult (Ciferri, 1983). Spirulina is a cyanobacter that is region of oxygenic life in the ancient earth. Algae, such as Spirulina, are primary candidates for the CELSS because they grow rapidly with a high ratio of edible to non-edible biomass, contain a lot of nutrients, and have gas-exchange characteristics compatible with human typical requirements (Brechignac and Schiller, 1992). Spirulina contains an unusually high amount of protein with, between 55% and 77% by dry weight, depending upon the source. It is a complete protein, containing all essential amino acids, though with reduced amounts of methionine, cysteine, and lysine when compared to the proteins of meat, eggs, and milk. It is the nature's richest and most complete source of nutrition. Spirulina has a unique blend of nutrients that no single source can offer. The alga contains a wide spectrum of prophylactic and therapeutic nutrients that include B-complex vitamins, minerals, proteins, Beta-linolenic acid and the super anti-oxidants such as Beta-carotene, vitamin E, trace elements and a number of unexplored bioactive compounds. Because of its apparent ability to stimulate whole human physiology, Spirulina exhibits therapeutic functions such as antioxidant, anti-bacterial, antiviral, anticancer, anti-inflammatory, anti-allergic and anti-diabetic and plethora of beneficial functions. Spirulina consumption appears to promote the growth of intestinal micro flora as well (Kulshreshtha*et al.*, (2008).

Artemia (Brine shrimp). Brine shrimp is the common name for any of the small, salinity tolerant, aquatic crustaceans comprising the genus Artemia, the only genus in the family Artemiidae of the order Anostraca (fairy shrimp). They inhabit inland saltwaters, such as brine pools and other highly salty habitats. Despite their small size-adults reaching only about 15 millimeters in length-brine shrimp have offer commercial, scientific, and educational values. They are sold as fish food for aquaculture and aquarium hobbyists. And some are even consumed by people for their nutritional value. This short life span of brine shrimp, and other characteristics such as their ability to remain dormant for long periods, have made them invaluable in scientific research, including space experiments. Because brine shrimp can tolerate varying levels of salinity. They have a rudimentary nervous/spinal system, which leads researchers to believe that they may be used in experiments without concern for animal ethics.

Probiotic bacteria. For hundreds, possibly thousands, of years people have recognized that the consumption of dairy products, especially yoghurt, can have a positive effect on gastrointestinal health (Culligan*et al.*, 2009). During his life, human being has encountered with various diseases. With emerge of medical science and development of knowledge, many of these diseases have been cured and in the current age, humane is searching for ways to enhance his life both qualitatively and quantitatively. One of the most important of these ways is to utilize the so-called Probiotics. Today the uses, mechanisms of action, and safety of probiotics are discussed by scientists. They concluded that the microflora of the intestinal as a member of my body has important protective, metabolic, and trophic functions (Canny, and McCormick, 2008).

Probiotics offer us the choice of a natural means of overcoming certain illnesses and, at the very least, maintaining good health. They are living drug in us intestinal so that Probiotics will be to medicine replace with antibiotics use. This finding has sparked interest in the use of these microorganism for alternative Medicine, as an living drugs (Elmer, 2001). The human distal gut is the highest density natural Probiotic bacterial that estimate to be 10 times greater than the number of human cells. Furthermore, the number of genes in the representative species probably exceeds the number of human genes by 100 fold that called Human metagenome. In the space it is possible the crow loose the metagenome and the astronaut in space expose the many disease immunodeficiency and etc. so that the Probiotic bacteria that is a member of human body can carry to space and consumption by astronauts. Beside this, we can produce many natural components by acid lactic bacteria too.

C. Design a Bioregenerative photo- bioreactor in space

Technology available today is capable of supporting human crews in space for short duration as long as resupply is readily available. All crewed space missions so far have relied on resupply from Earth for some or nearly all of the required consumable resources (oxygen, water, food), as will the International Space Station. However, no space-qualified technologies are capable of recycling food or oxygen from waste materials, CO_2, and solar energy and wastes will have to be discarded or stored for return to Earth. In addition to reducing dependence on resupply, advanced life support (ALS) systems must also be more reliable and self-sufficient enough to ensure crew health and safety. Here, we're going to present a novel kind of photo - bioreactors base of tree microorganism that makes astronauts mainly independent from the earth and provides major part of requirements in long time in space (Fig. 2). This photo-bioreactor has much more advantages in comparison with other BLSS systems which are solely based on greenhouse systems. Although designing of space greenhouses is one of the most recent attempts of scientists but because of numerous problems is still in pilot levels. Today the space greenhouses are mentally beneficial but from the view point of nutrition they can't be considered as a promising supplier of food.

Table 1: Comparison between photobioreactors and plant Green House.

Variable	Greene House	Greene House
Productivity	Low	High
Water losses	Low losses	Never losses
CO2 inhibition	Strong	Weak
Biomass concentration	Low	High
Operating costs	High cost	Very cheap
Space requirements	Large	Low

The management of water, nutrient and light delivery is an obvious challenge to the use of plants as life-support machines in space. Nutrient delivery and water recycling will be most difficult in systems operated in microgravity, whereas the gravity existing on planetary surfaces (e.g. on the Moon or on Mars) should allow more conventional watering and cultivation practices.

Providing sufficient light is probably the single largest physical challenge to the development of successful plant-production systems. Photosynthetic rates and biomass yields for most crops increase linearly with light across low irradiance ranges. The comparison between this photo-bioreactor with green house showed in Table 1.

The most attractive of this photo-bioreactor is the direct use of solar energy. Besides the already mentioned technological advantages this technique best of all matches the principles of ecology. Installation of the photo bioreactor outside the spacecraft that can return on the inner wall of the spacecraft at night cause to we can use by solar energy. But anyway, the BLSS of this photo-bioreactor cannot perform the function of food regeneration with single-cell organisms. This made us consider in the Photo bioreactor pisciculturing of Artemia in Dunaliella section then feeding the prawn in Spirulina section by Artemia. A unique advantage of this photo-bioreactor is more robust production of oxygen and also CO_2 absorption than plants even in high or low irradiance of light. Manufacturing of this photobioreactor as an open photo-bioreactor in order to utilize sunlight could result in an increased efficiency. In designing of this photo-bioreactor, an ideal living condition in space stations and mars is simultaneously considered and by making some modifications on it we can be hopeful to extend life to mars.

The present photo-bioreactor consists of an entire food chain including: Human Sub system (1): each person needs 10 m^2 of photo-bioreactor to survive. (2); Microorganisms producing Lactic acid and Probiotics which are human symbiotic and lack of them may cause problems in immune system for astronauts. A small fermentor is employed for production of Lactic acid to induce the consequent production of hydrogen by Spirulina. (3); Dunaliella photo-bioreactor: this section possesses a high concentration of salts and is capable of sterilization of human wastes. Dunaliella could also be used as food for Artemia. This section has capacity of production of Beta-carotene and other supplementary nutrients. The mentioned salty water container could be used as swimming pool for astronauts. This prevents disorders such Osteoprosis and muscle atrophy. Transporting of this quantity of water to space is difficult however installing of suggested photo-bioreactor in Mars which contains adequate sources of water is cost effective and economically feasible. (4); Spirulina subsystem: This unit supplies the main part of food for astronauts. Production of hydrogen fuel also is carried out in this subsystem. This section is mobile and can be moved in and out and use sunlight directly or indirectly. For the best performance this unit should utilize proper amounts of irradiance and temperature while evades unsuitable quantity of mentioned factors. Designing such a dynamic system makes this possible. (5); Artemia subsystem: Farming of Artemia could be carried out isolated or in blended manner with Dunaliella. Artemia could also be used directly as food or to feed lobsters. (6); Hydroponic greenhouses: these farms are considered for production of crops like tomato and tolerant species. Algal photo-bioreactor removes the excessive amounts of CO2 which is poisonous for plants. Also production of electricity by means of shuttle fuel cells and making use of LED lamps will help improvement of mentioned greenhouses. (7); Shuttle fuel cells: are used for water and electricity production. Nowadays this system is being used and can be integrated with other systems. (8); Sabatier reaction system: this system is being used by NASA and could be more efficient combining with present photo-bioreactor.

A principal flow diagram of a open and closed bioregenerative life support system is depicted inFig. 2.

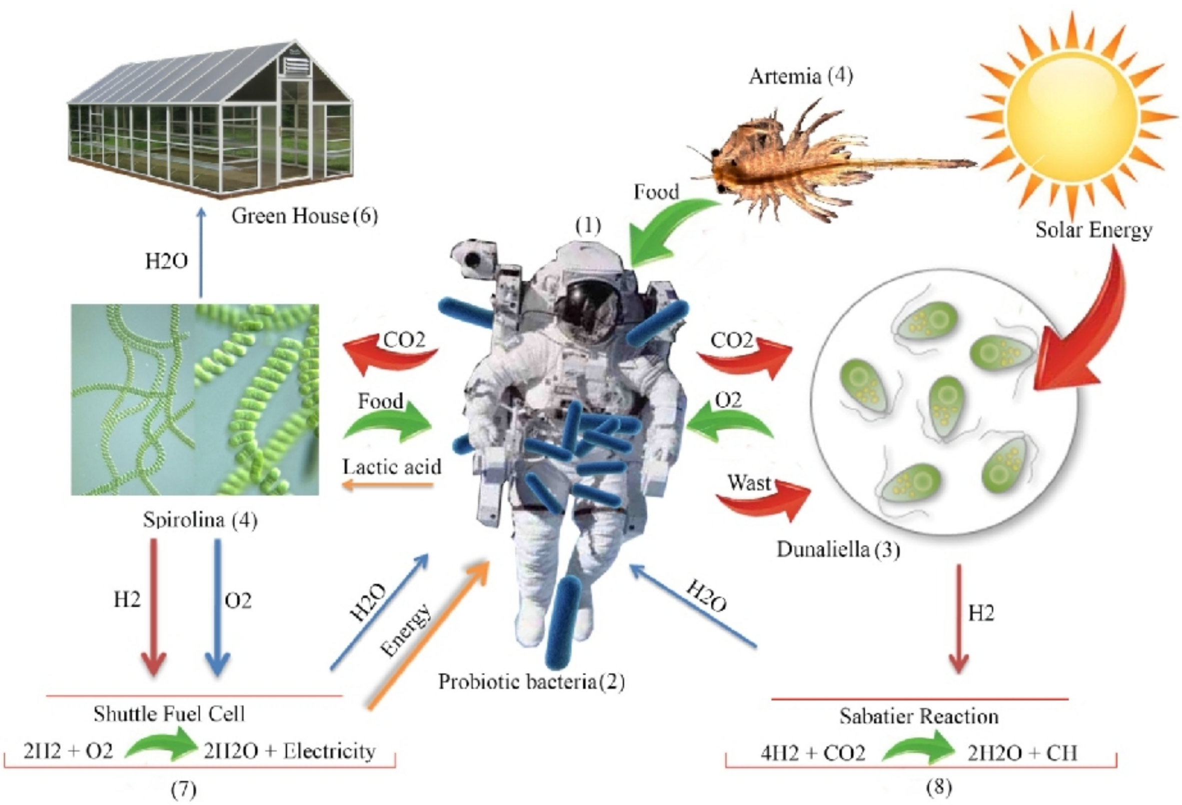

Fig. 2. Open and close bioreactor in space.

D. Procedure of photo-bioreactor

Making Artificial Biosphere. On Earth, we often take for granted the role that plants play in the oxygen production/carbon dioxide removal process. In space, other methods are used to remove these by-products and to reclaim water and oxygen. Reclaiming means to produce a new supply by combining or breaking down by-products of other processes.

NASA's life support system engineers refer to the recycling of water and air as "closing the loop." The by-products of human metabolism, carbon dioxide (lethal in high concentrations) and water vapor, present a challenge in terms of removing these from a spacecraft cabin atmosphere (a sealed environment). The following model illustrates how water, hydrogen, oxygen, and carbon dioxide can be utilized to supply crew members in space with vitally needed oxygen and water. There are no plants in this model (Fig. 2). It would not be practical to bring aboard the ISS the large number of plants that would be required to remove carbon dioxide from the air. Installation of a space green house for oxygen production and removing of carbon dioxide needs a large area to contain an acceptable number of plants. Establishment of such vast structures in space is not cost effective or feasible. Moreover, many plants cannot tolerate high levels of carbon dioxide as of Martian atmosphere. Although biotechnological efforts in order to develop of plants for this purpose is going on, but at the same time there are other problems like lack of adequate light in closed areas for photosynthesis so these plants will be less efficient for CO_2 fixation. Installation of a space green house for oxygen production and removing of carbon dioxide needs a large area to contain an acceptable number of plants. Establishment of such vast structures in space is not cost effective or feasible. Moreover, many plants cannot tolerate high levels of carbon dioxide as of Martian atmosphere. Although biotechnological efforts in order to develop of plants for this purpose is going on, but at the same time there are other problems like lack of adequate light in closed areas for photosynthesis so these plants will be less efficient for CO_2 fixation. Furthermore supplying of water and nutrients for plants is more difficult because of microgravity condition. Under these terms micro alga Dunaliella can play a vital role in Oxygen production and CO_2 removal. Dunaliella can easily grow in salty waters and because of lowered solubility of CO_2 in this type of culture media, inhibitory effects of CO_2 for these creatures becomes blocked. Besides Dunaliella has a paramount type of carbonic anhydrase enzyme which helps it to more efficient CO_2 bio-mitigation. This property makes Dunaliella suitable for operations like Martian missions which atmosphere contains large amounts of carbon dioxide. Dunaliella is a fast growing organism and that means high CO_2 sequestration rate as well. Along with Dunaliella, Spirulina as a photosynthetic cyanobacterium will be helpful to this aid. Utilizing such efficient system for effective removal of CO_2, helps to release of methane through Sabatier Method which can be used as fuel source for production of energy and electricity. Considering the above diagram which indicates the system in which required water and oxygen is produced for astronauts, we face some imperfections. First, Production of the oxygen to inject in the crew compartments (cockpit), needs electricity and energy that is generated in Suttel fuel cell (Electricity from solar source is preferred). In suggested photo-bioreactor sunlight is directly used in photosynthesis and large amounts of CO_2 from human activities can be bio-mitigation. This causes a gradual decrease in CO_2 concentration while oxygen is being produced. In contrast, there is no CO_2 fixation or production of water via this design. The only thing that happens is conversion of substances to each other and it's not an efficient method for long term missions.

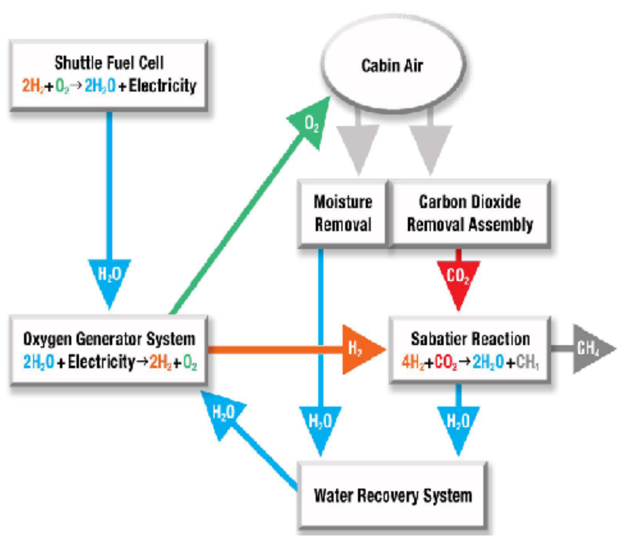

Fig. 3. NASA and ISS station model for produce essential material for astronauts (www.nasa.com).

Through Sabatier system CO_2 is fixed in the form of methane, but as a disadvantage it needs Hydrogen which could be derived from limited amounts of existing H_2O, hydrolysis. The methane gas which is released into space could be used as fuel. It needs oxygen for combustion while produces CO_2. As mentioned before, the created carbon dioxide will be gradually fixed in proposed photo-bioreactor and oxygen will be produced simultaneously. The released methane from Sabatier reaction also could be utilized for heating and energy production. ($2O_2 + CH_4 = 2H_2O + CO_2$). The produced CO_2 will be used in photosynthesis and H_2O yield could enter water recovery system. As a result a photo-bioreactor is necessary along with air and water producing systems.

E. Food preparation in space

The organism and microorganism in this photo-bioreactor in groun are use in superior food. Dunaliella has a remarkable rate of growth. Approximately the population of this microalga doubles in less than 24 hours under appropriate conditions. This means getting more benefits from these unicellular factories in short period of time. Dunaliella Salina contains abundant nutritional substances, such as proteins, inartificial vitamins, mineral substances, unsaturated fatty acids and polysaccharides and so on. Beta-Carotene and polysaccharides and other bioactive substances can be utilized as functional foods in space. The most difficult problem in using Dunaliella as food is the conversion of Dunaliella biomass into products that a spacecraft crew could actually eat over a long period of time. If Dunaliella are to be considered seriously as a primary food source, however, it will be necessary to determine that they can be converted into a wide enough range of palatable forms to make an acceptable complete diet. So, in this photobiorector we can grow up Artemia that can use directly or indirectly in human nutrition.

F. Water Recycling and Waste Management

A glance at the condition of early and present time earth, it's deduced that water has been the most important Issue for establishment of life. There are several organisms can undergo stresses like heat, cold, salinity, heavy metals, excessive light etc. but none of creatures is able to live without water. Then we need water for foundation of life support system in space.

Analogous to hydroponic system cultures, we have to carry a primary source of water for initiation a photo bioreactor. Fortunately, there is a considerable quantity of water in planets like mars which eliminates the need for its transportation. In space stations except for mentioned instances in diagram No.1, potable water is obtained via consuming- recycling chain inside of crew cabin. Reclaiming water is a more complex process than recycling air. Because water on the space shuttle is produced by fuel cells and then stored, water recycling is not an issue. On the ISS, however, there are no fuel cells. Therefore, water must be supplied by either the space shuttle or the Russian Progress vehicle. NASA's life support engineers are working to develop a water recovery system that makes use of the Sabatier Reaction. Doing so would free up volume and weight on board the space shuttle and Progress to allow for transport of other equipment.

The ISS uses both physical and chemical processes to remove contaminants, as well as filtration and temperature sterilization to ensure the water is safe to drink. Additionally, water is checked often to ensure it meets NASA's water quality requirements and is monitored closely for bacteria, pollutants, and proper pH (6.0-8.5) (Fig. 3). Unlike recycling of breathing moisture that can be easily achieved, the processing of sewage waters is an important problem. Plants are suggested as alternatives in water recycling from urine and solid wastes but there are several difficulties using them for this purpose. In instance plants which are used in hydroponics, are sensitive to pH changes, inorganic toxic elements or those of above threshold. Other methods for water recycling need filtration to remove microbes. NASA's Exploration Life Support (ELS) Lab at Johnson Space Center in Houston, Texas is currently developing a biological treatment system that will purify water on future space missions. The microorganisms used in this process destroy contaminants in the water. Dunaliella has a noticeable ability to eliminate heavy metals and some other toxics. It is also capable of living in extra saline conditions which bacteria could rarely survive it. Then Dunaliella can serve as a filtration and water recovery machine. Furthermore by the time lapse, useful bacteria from intestinal flora will be removed. This illustrates the need for use of suitable Probiotics to recover the loss. Since in the absence of mentioned bacteria, numerous immunologic problems will occur for astronauts, Recovery of them during filtration phase is necessary. These bacteria are known as human Metagenome because of their remarkable role in human health.

G. Energy in space

Biological hydrogen production. Hydrogen gas is seen as a future energy carrier by virtue of the fact that it is renewable, does not evolve the "greenhouse gas" CO2 in combustion, liberates large amounts of energy per unit weight in combustion, and is easily converted to electricity by fuel cells. Biological hydrogen production has several advantages over hydrogen production by photo-electrochemical or thermochemical processes. Biological hydrogen production by microalgae Dunaliella for example, requires the use of a simple solar reactor such as a transparent closed box, with low energy requirements. Electrochemical hydrogen production via solar battery-based water splitting on the hand requires the use of solar batteries with high energy requirements.

Biological hydrogen production is a method of photo-biological water splitting which done in a closed photo-bioreactor based on the production of hydrogen by algae. Biological hydrogen evolution provides a sustainable and environmentally friendly way to produce clean Energy from renewable resources. Cyanobacteria and green microalgae split water into molecular hydrogen and oxygen using sunlight under special conditions. Photosynthesis consists of two processes: light energy conversion to biochemical energy by a photochemical reaction, and CO_2 reduction to organic compounds such as sugar phosphates, through the use of this biochemical energy by Calvin-cycle enzymes.

Under certain conditions, however, instead of reducing CO_2, a few groups of microalgae and Cyanobacteria consume biochemical energy to produce molecular hydrogen. Hydrogenase and nitrogenase enzymes are both capable of hydrogen production.

Electricity generator. Scientists at Stanford have discovered the greenest source of energy yet - direct electricity harvesting from plants! They've successfully collected energy from photosynthetic electrons generated at the cellular level. They employed Chlamydomonas reinhardtii, a close relative of Dunaliella for this purpose. Stanford Scientists Harvest Electricity from Algae Photosynthesis. Through photosynthesis, the chloroplasts of the algal cells split H2O molecules to oxygen, protons and electrons. After this split, light energy from the sun zaps the protons into high gear and the electrons then speed through the cell dolling out their energy to proteins that use it to create sugars. During the Stanford experiment, researchers were able to intercept the electrons before they went on their high speed jaunt. They used a tiny gold electrode placed inside the membrane of an algae cell to collect the electrons. Now that's a sophisticated heist. So far researchers have only had success on the cellular level, and each cell provides a relatively tiny amount of energy. To fill an AA battery you'd need a trillion cells practicing photosynthesis for one hour that's a lot of cells for a little bit of juice. WonHyoung Ryu, the lead author of the research paper, noted that this is just the first step in a long line of experiments in harvesting energy from plants. These scientists were the first to harvest electrons from plant cells.

Future Prospect. The Earth is mankind cradle but any body will not be in cradle all over. Establish new civilization in space and other globs inevitable. So, the reasonable support systems relying on photosynthesis is finally suggested. The establishment of an atmosphere and food continuum like that of the earth will be possible, if we can design a good photo-bioreactor. For this purpose they must fit into pattern of nature which has always been as a source of inspiration for human.

A vast industrial and food Potential of Dunaliella, Spirulina cause that we can grow up many plant and animal beside of them and it is self-evident that future photo-bioreactor must use from this microorganism. In future the produce hydrogen and with improve of other technology we can design very better than defined this paper. But we can declare without Dunaliella and Spirulina cannot establish any new civilization in space.

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