https://doi.org/10.33472/AFJBS.6.5.2024.4105-4119

African Journal of Biological Sciences

Biorealm: An Artificial Ecosystem For Sustainable Living

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Article History
Volume 6, Issue 5, May 2024
Received: 01-05-2024
Accepted: 07-05-2024
DOI:10.33472/AFJBS.6.5.2024.4105-4119

Abstract

The change in temperature, climate change, ever so increasing population and over use of the renewable and non-renewable resources are the subjects of significant concern in the modern era, as us humans are the pivot of all these problems which are responsible for this imbalance caused in the nature. Curbing this issue requires swift, efficient measures and advancement in technology. As the days are progressing and we are observing the drastic changes occurring all around us, the need to create an artificial biosphere that could sustain all forms of life is more than ever. Sure, it comes with its own sack of challenges but as the wheels of time are progressing, we definitely can imagine an artificially created ecosystem on earth. A lot of research and experiments have been carried out and some are in progress. Some of the bright experiments include Biosphere 2, bios 3, and many more. They were created to achieve the objective, if humans and plants could survive in an enclosed artificially created biosphere. But unfortunately, we haven't had a successful hand in the experiments but have observed very helpful and astonishing facts. A few flaws had led to the failure of the above systems but biosphere 2 has been the most successful by far. Though, they did run into some major issues, but this is an example that with the help of technology we can achieve lengths of success which can prove to be essential and helpful for our existence on this earth.

Keywords: Biorealm, self-sustenance, sealing the biosphere, mesocosm, exchange of gases, semi-permeable membrane, temperature regulation, phase change materials, coexistence of species, genetically modified crops, bioengineered microorganisms, resource management

Overview

Since the very beginning of life on Earth, humans have been trying to understand everything around them and evolve, not only to fulfill their curiosity, but also to survive. Just like Charles Darwin proposed, "It is not the strongest of the species that survives, not the most intelligent that survives. It is the one that is the most adaptable to change." Not very long ago the idea of 'biospherics' was generated, which helps in the overall study of the Earth. Since then, initiatives have been taken to artificially generate a self sustaining biosphere, one which may even help in survival in the space in the future. Therefore, research has been and is still being conducted in the field, trying to generate an enclosed ecosystem.

This paper, while studying a collection of past projects, provides an analysis on their strengths, the areas of improvement, new ideas for development and the scope of the same in the future. The Earth is a miraculous planet which provides the right conditions for the survival of all, and although every single detail can't be replicated, they can be understood and similar conditions may be provided after a few changes. This artificial ecosystem needs to co-exist various forms of life, and only then it is possible to make it into a whole new realm, a bio realm for the future.

Introduction

Biosphere: Introduction to the designate

Biosphere can be defined as the region of the surface and atmosphere of the earth or another planet occupied by living organisms. The term biosphere is taken from the Greek word "bios "meaning "life" and "sphaira" meaning "sphere" also known as the ecosphere [1], from Greek oikoçoikos meaning "environment" and apaipa, is the worldwide sum of all ecosystems. It can also be termed as the zone of life on Earth.

Earth's Biosphere

The first and foremost evidence of life on Earth was the biogenic graphite which was discovered in 3.7 billion-year-old metasedimentary rocks, along with the microbial mat fossils that were found in 3.48 billion-year-old sandstone . Various life forms are found in every part of the Earth's biosphere, including hot springs, soil, inside rocks at least 12 miles deep underground, and atleast 40 miles high in the atmosphere. Marine life and many forms have been found in the deepest corners of the World Ocean while much of the vast oceans remain to be explored. [2]

Our biosphere has been divided into a variety of biomes, which are inhabited by fairly similar fauna as well as flora. On earth, biomes are primarily separated by latitude. Terrestrial biomes that lie within the Antarctic and Arctic Circles are comparatively barren of animal and plant life, while more populous biomes can be found near the equator. [3]

Artificial Biosphere

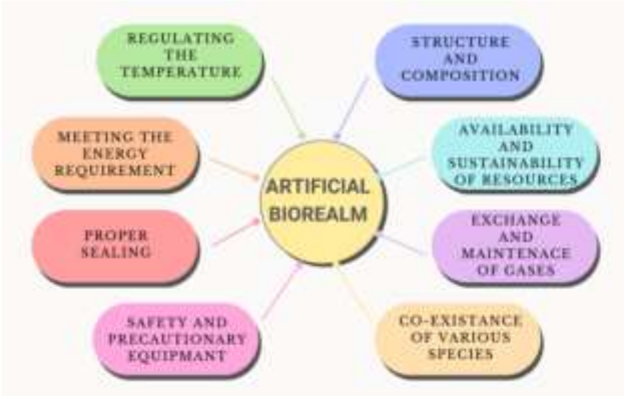
Closed ecological systems, also known as experimental biospheres, have been created to analyze and study the potential for supporting and sustaining life outside the natural ecosystem on the Earth [4]. The objective of creating an artificial biosphere was to create an enclosed system made to imitate the biosphere of the earth where all living as well as non-living forms of life could co-exist. Surely, a big project like making a biosphere similar to that of Earth brings on thousands of challenges and a lot of risks before it is completely functional and operative. Every living organism around us has adapted to survive in the atmosphere and climatic conditions of earth, and manipulating their habitat does pose some threats but with technology, science and resourceful thinking, it is possible. Therefore, there is a need to be very precise in every single detail. [5]

Biosphere : Roots of The term

It is very important to pivot into the very origin of the term "biosphere" and understand what gave rise to the possibility of creating an artificial life sustaining biosphere. This idea was generated when Clair Folsome, at the University of Hawaii, took a sample of the microbial life at the beach of Pacific Ocean and sealed it into many flasks. [6] Many of those microbes are still living today, demonstrating that a closed ecosystem can be artificially created on a vast scale on planet Earth. But, doing so, on a much larger scale and sustaining all kinds of life is completely possible and has been experimented, with few successes in hand.

Methodology

Creating an artificial biosphere involves a series of steps and measures that need to be taken care of so as to have a successful facility. These steps include:-



- Exterior structure and sealing
- Interior structure
- Gaseous exchange
- Temperature regulation
- Energy source
- Sustenance of Resources
- Safety measures

2.1) Exterior Structure and Sealing

The first step towards creating a fully functional biosphere is designing the structure and ensuring that it is properly sealed. The main objective of sealing the biosphere is to control the temperature, pressure, and humidity. [4] Just like a blanket of gases forms an envelope over the Earth's surface, it is required to create a closed atmosphere where the temperature could be regulated. An artificial biosphere is a closed ecosystem capable of sustaining various living forms within. The material of the structure should be selected precisely so that it would be air tight and withstand high pressures. Just as in Biosphere 2, the physical structure was designed to be nearly airtight, facilitate exchange of gases, and withstand atmospheric pressure. The structure was made up of steel tubing and high grade steel and glass frames. [1]

Fig 1.1: [1] Exterior of Biosphere 2

Fig 1.2: [7] Aerial View of Biosphere 2, 1) West Lung, 2) South Lung, 3) Cooling Tower, 4) Energy Center, 5) Intensive Agriculture, 6) Desert, 7) Savannah/marsh, 8) Habitat, and 9) Rainforest

2.2) Interior Structure

While designing the ecosystem, it is necessary to ensure the stability of all the components, both biotic and abiotic. For that, an appropriate structure must be designed, including the habitat of the organisms introduced, a research place at such a position to look over the whole biosphere, appropriate positioning of the chambers, etc. If we break the components of the biosphere, it is like a glasshouse containing various mesocosms, each of which has been properly designed to ensure stability. The Biosphere 2, being the largest artificial biosphere ever created, consisted of 8 mesocosms [7].

Similarly, the biosphere must have a structure suitable for co-existence of various species. A research and management center must be installed at approximately an equal distance from the extremes i.e. it must almost obtain a central position. Moreover, areas which require greater attention should be built in closer proximity to the same, enabling closer monitering. Inspiration can be drawn from existing biospheres to create the desired structure.

Fig 2.1 [8] Biosphere 2 center

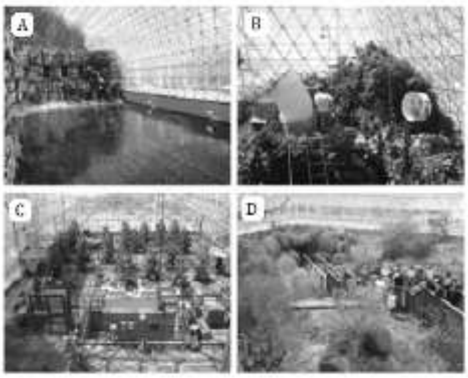


Fig 2.2: [7] Interior of Mesocosms; (A) Ocean. (B) Rainforest. (C) Agriforestry (D) Desert

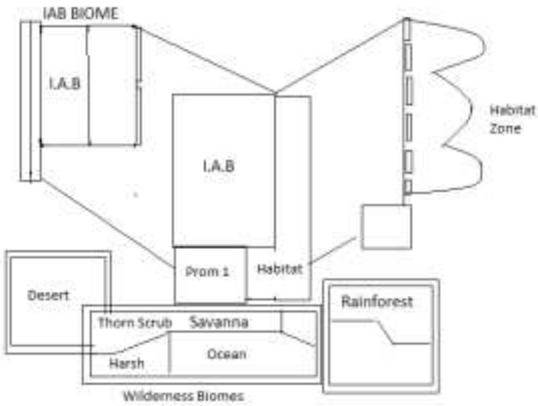


Fig 2.3:Plan of design of Biosphere 2

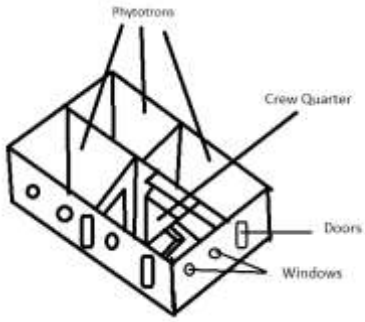


Fig 2.4: Bios 3 structure including 3 phytotrons, .crew quarters, doors and windows

2.3) Gaseous Exchange

The second step is to build a proper mechanism for the regulation and circulation of atmospheric pressure between the atmospheric gases. As in the earth's biosphere the different gases are present in a definite order and composition such as nitrogen 78%, O_2 21%, and 1% other gases. Likewise, proper regulation of gases is imperative, as any imbalance could potentially wreak a great havoc and disrupt life. The various atmospheric gases can be regulated through various means, just as in Biosphere 2 oxygen was maintained through "lungs", which were the large expansion chambers that regulated air pressure inside the facility. In a similar fashion, BIOS-3 maintained the air pressure through cultivated algae that provided enough air-revitalization for 3 persons in the facility.[9]

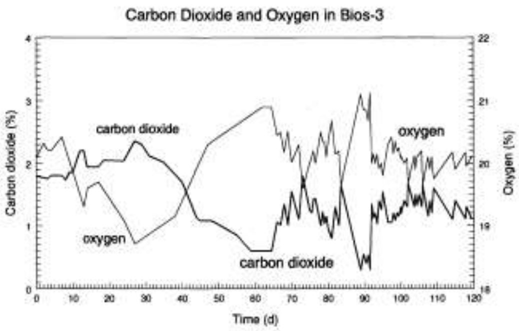


Fig 3.1: [10] O2 and CO2 in Bios 3

One of the reasons for the failure of Biosphere 2 was the miscalculation of the appropriate amount of gases, as it was discovered that the micro-organisms in the soil utilized more oxygen than expected. This caused an imbalance and within weeks, people were suffering from headaches and respiratory problems. As the oxygen level dropped from 20.9% to 14.2%, liquid oxygen was pumped into the facility, yet the original amount couldn't be restored. There was also the risk of Nitrous Oxide poisoning. Hence, the evaluation of requirements of each and every organism is essential, followed by ensuring careful and proper exchange of gases.

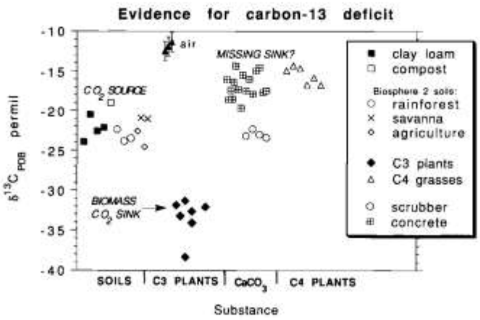


Fig 3.2: [10] Carbon Dioxide usage in Biosphere 2

Just like, fig 3.2 shows the usage of CO2 in various activities. It is noteworthy that the imbalance of oxygen gas started with the imbalance of carbon dioxide itself. This was because of mixing of the same with CaCO3, giving us the hint that the scrubber used was not enough to overcome the given levels. [11]

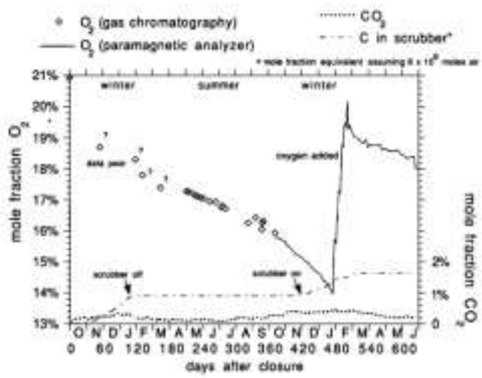


Fig 3.3: [10] Oxygen Levels in Biosphere 2

Although oxygen levels seemed to be appropriate in the beginning, they soon started going down as the activities continued. As a matter of fact, the levels stooped to as low as 14% in 6 months. The biosphere was designed so as to replace each mole of oxygen with carbon dioxide, but due to various factors, the major ones being the degradation of soil and mixing of carbon dioxide with exterior structure to form calcium carbonate, this balance couldn't be maintained.[12]
So, both these problems can be overcome by adding a support to the chambers in the form of an additional membrane of a sieve, which can assist in adsorbing particles, so that only the desired amount would enter. Along with that, this layer must be pressure driven and contain pressure equalizing reservoir, to maintain the pressure fluctuations. [13] The permeability and the selectivity of the membrane could be selected so that it acts both as a scrubber to break Calcium and carbon bonds, along with compressing air. This mechanism would be similar to how oxygen is controlled in oxygen cylinders, because both the biosphere and the cylinders operate on the the same basic principle-they are sealed. [14]

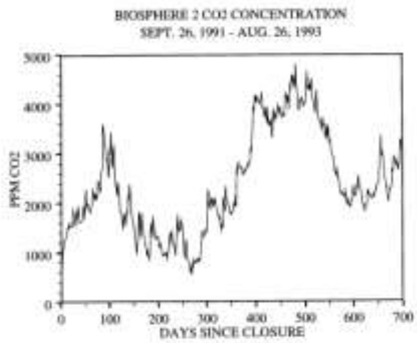


Fig 3.4: [7] Carbon Dioxide levels in Biosphere 2

Therefore, along with a more detailed account of these levels of each and every creature, the expansion chambers must be provided a support in the form of a special membrane to control the oxygen and carbon dioxide.

2.4) Temperature Regulation

The next step is to regulate the temperature, as it is one of the major reasons for creating a biosphere artificially. It has to be ensured that a suitable set of temperature is chosen for the co-existence of various species. Generally, it is chosen between 35-110 degree Fahrenheit, be it for the profuse diversity of plants, animals or any other organisms. [15] An array of various methods is available for the maintenance of the temperature such as thermostats, hot and cold water heating or cooling systems. However, even though it may appear to be simple with the technology available, it still poses many challenges, especially considering the fact that the tropical birds couldn't even survive the first winter season in Biosphere 2.

The instability of temperature gave rise to an ant species, which had no predators and destroyed all other organisms in the soil. Within months, the facility was overrun with new species of cockroaches, katydids and ants. Overall, 19 of the biosphere's 25 animal species planted in the biosphere became extinct. Further, the crops were overrun by weeds, and the people living there were exhausted and narrowly escaped insanity. This highlights how important it is to consider every single detail to achieve this objective.[16]

	Maximum	**Minimum**
Savannah	100°F	55°F
Intensive Agriculture	85°F	55°F
Rainforest	95°F	55°F
Desert	110°F	35°F

Table 1.1: Temperature Ranges (In Fahrenheit) in Biosphere 2

The given table presents the temperature range chosen in Biosphere 2, which despite being quite appropriate, failed due to temperature fluctuations. An addition which could help in the maintenance of temperature is usage of Phase Change Materials i.e. PCM. [17] These substances, while undergoing phase change, can release or absorb significant amount of heat energy, hence helping in persistence of a constant temperature. Using Phase change materials can significantly benefit the temperature management system of the biosphere as they can tone down temperature fluctuations, help in avoiding rapid temperature change by acting as a buffer and even act as a backup in case of failure of primary temperature regulation methods, creating a more stable environment.[18]

2.5) Energy Source

A stable energy source is crucial to supply power to all the machinery and effectively regulate it throughout the facility. If non-renewable sources of energy are used in this process, it would lead to even quicker depletion of resources and undermine the entire purpose of the project. So, we must use sustainable and renewable sources of energy. One of the sources of energy that could be helpful is water. Since we are already using water to regulate the temperature, we could alter the resources and use it for providing energy as well. Along with that, we can establish these facilities in places where there is abundance of sunlight, and then the use of solar energy could prove to be a boon. Light from the Sun is not only an excellent energy source, but also it's of utmost importance for plant growth. [19]

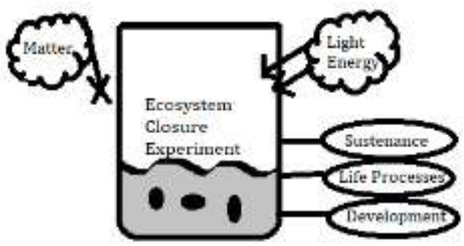


Fig 5.1: Requirements for small scale biosphere

2.6) Sustenance of Resources

Once all the prerequisite necessities are settled, the next requirement is that this system should be able to maintain itself for the settled time duration. The biorealm is incomplete unless and until it is self sustaining, wherein the systems do not require external resources from the atmosphere.

Take up the indispensable resource of water as example. It is important to ensure the proper supply of water, which means regulating and recreating the hydrological cycle. The need is to create an atmosphere with appropriate humidity, and a way for evaporated water to get out of the sealed area without causing any disturbance to other systems. In biosphere 2, a striking feature was observed that the water residence in atmosphere was around 5 hours which is about 50-200 times swift than the 9 days in the natural atmosphere of earth. The following table presents the details of the same: [20]

Reservoir	**Acceleration of cycle in comparison to the Earth**	**Residence Time of Earth**	**Residence time of Biosphere 2 (Estimated)**
Atmosphere	50 to 200 times	9 days	~4 hours
Soil water	Almost similar	30 to 60 days	~60 days
Ocean / marsh	About 1000 times	3000 to 3200 years	~1200 days (3.2 years)

Table 2.1 Water fluxes and residence times compared between biosphere 2 and earth's biosphere. [20]

However, the previously suggested installation of a semi permeable membrane would be quite useful to avoid this problem as well, as the membrane can allow the excessive water vapor to escape, preventing excessive condensation while retaining moisture.

In addition to water, for maintaining the food and soil requirements, genetically modified crops can be used in accordance with the Biorealm's needs. [21] The crops with the required characteristics

can be developed, so that they could be utilized properly and cause no imbalance in the need of minerals from soils as well as gases. Since they would be adapted to the biorealm's needs, their sustenance for a longer duration would be much more tranquil.
Along with that, as a measure of overcoming the previous biosphere's soil inaccuracy, bioengineered microorganisms can also be specially adapted for the desired characteristics [22]. Using the same, their genetic make-up would be more precise, and we could generate a whole new community for the biorealm. This field of biotechnology is already rapidly evolving, and although much precision is required, once achieved could prove to be quite convenient.

2.7) Safety Measures

Creating an artificial biosphere is such a long and tedious process that any disturbance could pose as a major threat. Therefore, after all these requirements are fulfilled successfully, we need to ensure the safety of the humans and other organisms in the biosphere. Several test runs must to be made before it is made official, and even after that, safety measures need to be ensured in case anything goes wrong. First of all, it is important to install sensing equipment so that we could be informed in case of any disruption. If there is a failure of any generator, there should be other devices ensuring that nothing goes wrong.[23] In case the energy source fails, supply of fuels like natural gas should be kept in store. Similarly, there should be an alternative and repair parts available for any major device installed. While creating the biosphere, safety has to be our top priority, as one can't risk anyone living there until it is absolutely safe.

3. Literature Review

John Allen [24] studied and conducted research on the whole history in the field of Biospherics, how the idea was generated, what basic requirements were required, what outcome was expected and much more, with a special emphasis on Biosphere 2. When the moon landing of 1969 commenced, an idea of creating ecological projects was generated. This research was looked into and generated a vital element of science- Biospherics. The major objective of biospherics was to master the key to life, both on and off the planet. The team of Space Biospheres Ventures (SBV) used this approach to build a model of Biosphere 2. The major planning concluded with creating a seven biomic area, with volume of 7 million cubic feet, 3.15 acre airtight structure and 12 level hierarchy scheme. To control the biosphere, two forms of intelligence were used, artificial intelligence for activation processes as well as unique computer software for monitoring. Another part of the control system was 'Binocular vision', in which two systems were put into operation- Naturalist as well as artificial observation, so that even if one of them missed any defect in working, the other could identify the same. In 1987, SBV felt the need for more discussions on this newly devised topic. So, in 1987 and 1989, two workshops were held at Royal Society in London and Krasnoyarsk in Siberia respectively for broad scale discussion regarding closed ecosystems, where NASA, the Soviet Space program, ESA, and many leading scientists and ecologists were invited. It was during the second meeting that the term 'Biospherics' was devised. Another major problem they had to overcome was that there were no research facilities near the place where Biosphere 2 was created. So, an entire research facility, BRDC, was build at the project site. Therefore, a lot of obstacles came in the path of creating an enclosed ecosystem, especially because it was a new topic at that time, and the final goal was the settlement on Mars.
John Allen and Mark Nelson [25] took an approach to study the closure experiment "mission 1" at biosphere 2, where each biome had a finite species list and factors such as water quality, current flow, light, temperature, humidity, soil/sediment type were controlled through different control factors. There was a subtropical or tropical biomass with the highest temperature ranging 110

degree Fahrenheit. To model earth's atmosphere the temperature was set to 35-110 degree Fahrenheit. Before building biosphere 2 a test module was set to test the basic design and concept module under these light conditions. The aim was to design this prototype to be less than 1% volume of biosphere 2 and 50% bigger than BIOS 3 which had been the largest artificial life facility. Mission 1 was begun on 26 September, 1991for the targeted 2 years. Oxygen levels began to decline rapidly at first in the facility during the two year closure from initial levels of 20.9% to 18% after 5 months of closure. Oxygen levels approached at 14.2% by mid-January 1996. The oxygen that was declined was converted into carbon dioxide in the concrete structures that were left uncovered.There was also a continuous increase in the levels of nitrous oxide. The most important objective of the experiment was to define "Noosphere 1"and the conditions necessary in a biosphere.

John C. Avise [26] Studied the biosphere 2, which was a glass and steel structure, designed to be self- sustaining and contained nearly 4000 introduced species such as tropical rainforest, streams, agricultural area, desert and even a miniature ocean. The source of energy for biosphere 2 was as sunlight and as electricity (which was taken from an adjacent natural-gas power plant). This energy was used to drive "technosphere" which included sensors, air-cooling systems, pumps, scrubbers and other environmental systems. The cost of this man-made technosphere that sustained "eight biospherians" for almost 2 years was about $150 million dollars, approximately $9,000,000 for one person per year. The biosphere 2 didn't tolerate any massive deforestation, forest fires or over exploitation of renewable or non-renewable resources. Yet it appeared that the biosphere 2 had reached its maximum human holding capacity with just 8 people as the food and oxygen supplies were exhausted despite supplemental oxygen and scanty food stores. Even with large supplies of energy from outside it was well beyond its human holding capacity. That led to the indication that the rising population of earth could also reach to its achievable limits, which would lead to starvation,massive hunger, and conflicts over very limited resources worldwide. Therefore, the real message of the biosphere 2 was that we must grow aware of the rising population and as an astronaut's view from space the biosphere 2 gives us a novel perspective and a renewed appreciation for biosphere 1.

Jeffrey P. Severinghaus, Wallace S. Broecker et.al [10] studied the critical situation of Oxygen loss in Biosphere 2. Oxygen is one of the most important requirement whose amount must be maintained while creating an artificial atmosphere. However, this process failed in the two year closure of Biosphere 2, as the oxygen levels had a major decrease from 21% to 14% in the first 16 months, causing a lot of health problems among the people, and the process had to be abandoned. The surprising factor was that a consecutive increase in carbon dioxide wasn't noticed. They came to a conclusion that this oxygen loss was due to the respiration by the microbes, especially the new species which had been created due to the imbalanced atmosphere. It is observed that the experimental soil had excessive amount of organic matter, causing the issue. The photosynthesis process couldn't match the levels of oxygen used. Along with that, the carbon dioxide levels didn't seem to be increasing because they reacted with the structure's concrete to form calcium carbonate. Although it was planned to stop this by using an electric furnace to break the compound, its levels couldn't be maintained.

W F Dempster [27] researched widely on the engineering design of biosphere 2 where he found out that biosphere 2 had an atmospheric system that enabled the low leakage rate of 10% per year^{-1} and had an system for its measurement and detection. The exchange in atmosphere gases was estimated by two independent methods. First, it involved maintaining a positive pressure of about 150 Pascal which forced the outward leakage if there were any existing holes. This forced leakage was directly measured by the rate of deflation and expansion of lungs which was found to be 65% per year. The pressure range was calculated to be 98 pa of zero which was far less than the value computed. The second method was to increase the atmosphere in the facility with inert gases, helium, Sulfur hexafluoride, and krypton, and observe dilution for over a year that confirmed the 10% orless estimate. Energy was transferred as electric power from an external energy plant, using hot and cold water as transferring medium with a sealed piping system. The temperature and humidity conditions were very important to be maintained as the facility was in Arizona, it was estimated that day time temperature could reach 65 degree Celsius fatal to animals and plants. The temperature was thus maintained through fan- forced air circulation heating and cooling were carried out by hot and cool water which was dyed so to detect any leakage if it may. Extra components which weren't being used but were available to be utilized were a very important safety feature of the facility as loss of cold or hot heat exchange of water or the loss of electric power for internal air circulation could lead to drastic change in temperature.

Salisbury, Frank B. et.al [28] studied the experiments taken up by scientists in the BIOS-3 to understand the possibility of human life in a small, enclosed artificially made ecosystem. The idea of developing earth's biosphere laid the foundation of bioregenrative life support. The biosphere 2 was publicized as a prototype for further space exploration but it could have never survived the airless atmosphere of mars or moon. It was just a prototype to study the biomes of earth intricately. On the other hand, bIOS-3 was constructed as a part of soviet space program. When BIOS-1 was constructed it regenerated the atmosphere for 1 person in a sealed $12m^3$ chamber connected with air ducts and an 18 l algal cultivator containing Chlorella vulgaris. The algal system worked by removing carbon dioxide and producing oxygen, accounting for approximately 20% of the quantities of pure food, water and air required by a single human. After some advancements the project was renamed BIOS-2 and air purification now was done by both algae (75%) and higher plants (25%). In 1972, BIOS-3 was constructed at a cost of $1 million dollars and was completely underground. It was made by welding the steel plates and had four compartments which could be sealed independently. A thermocatalytic filter (also called "catalytic converter") helped in the purification of air by heating the air to 600-650 degree Celsius, which worked by oxidizing organic molecules to carbon dioxide and water. Transpired water was also condensed and recycled, mainly as nutrient solutions for the plants. Some of this water was boiled for general cleaning and washing. But water was drinking was purified through ion-exchange filters. The most important observation was that organisms were self-regulating, whereas engineered components have no self-repair capacity and hence are the weakest link of an artificially constructed system.

William Swenson, David Sloan Wilson et.al [29] worked on the approach on selecting the desired characteristics for the creation of an artificially controlled closed ecosystem by the selection method. They decided to use this method for experimenting because they realized that this method is quite simple as well as logistically feasible. Ecosystem selection refers to creating a large number of ecosystems with different characteristics and selecting those which produce the desired result. These ecosystems may be physically small, but they contain a lot of species through which their characteristics may be tested and chosen. Some major traits they focused on were pH and degradation of toxic compounds and above ground plant biomass. Their first experiment was to check soil ecosystem, in which they conducted sterile control treatments and randomly interspersed microcosms within the growth chamber. At generation 15 of the experiment, a fungus appeared which destroyed the plants. This fungus didn't appear in generation 16. Another experiment was for aquatic ecosystem, in which 28ml of pond water and 2ml of sediment was originally added to 72 test tubes. However, this time, the parent ecosystems which were selected were not mixed for creating the offspring ecosystems. They concluded that for ecosystem selection to work, the phenotypic trait of the ecosystem should vary, this variation must be caused due to fundamental properties of the ecosystem and the offspring ecosystems i.e. the newly created ecosystems must resemble their parents in the effects of the original phenotypic traits

Charles S Cockell, Adrian Southern et.al [30] took an approach to research on the effect of altered UV Radiation in an artificially constructed ecosystem. Although UV Radiations are mostly considered as damaging factors, they have their own importance, which was realized by the effects on plants and microbes in Biosphere 2. UVA radiation is used in ultraviolet dependent vision by many insect pollinators and fishes, while UVB radiation is required for induction of flavonoids of plants, which in turn protects it against UVA. UVA radiations help in activating photolyase, which is required not only for photoreaction, but also for repairing thymine dimers, which are present in the DNA due to UVB radiation. So the basic observation was that how UVA and UVB radiations balance each other out in the normal ecosystem, and how it is important to maintain this in Artificial Biosphere. To overcome this situation, we can theoretically develop some calculations and access relationship between wavelengths of different kinds. However, it would require a lot of testing before it can be used practically. This would help a lot for the creation of an artificially created system on Mars or Moon.

Achim Walter and Susanne Carmen Lambrecht [8] took an approach to research upon the biosphere 2 the project's aim was to research in the field of "experimental climate change science". Within the mecosome the climatic conditions were strictly controlled. The research facility enclosed savannah, tropical rain forests, mangrove, marsh and ocean etc. it was designed as to provide a prototype station for future space missions. It was an advancement after the construction of Bios-3, which was a 300 m3 project, designed to be sent in the outer space, in which 2-3 men survived for four months, producing about 50% of their food, that was made to be grown under artificial light, and regenerated about 90% of their air and water. The Biosphere 2 on the other hand, was a prototype designed along the same principles but exceeded its volumetric mark by about 50% and proved the working of the technical features on a very large scale. After the end of the mission one, the project was terminated after 6 months as to fix some major faults. Major being the high concentration of nitrous oxide and due to very high soil respiration rates the oxygen levels also dropped dramatically. Further the water quality was degraded and large piles of calcium carbonate from the scrubbing of excess CO_2[10] began piling on the basement of building. Organically rich soils were imported into the facility that would produce high agricultural produce, but it turned out to be a major flaw that couldn't be fixed. The composition of soli varied from biome to biome. The topsoil of the agricultural system consisted of 70% clay loam, 15% commercial peat and 15% commercial compost, whereas the rainforest topsoil was mixed from 50% loam, 25% coarse organic material and 25% gravelly sand. The high proportion of organic material presentin all topsoils provided optimum conditions for soil microorganisms, which resulted in the release of large amounts of carbon dioxide and consumed equivalent values of oxygen. But, still the CO_2 levels did not reach life threatening levels of around 4000pm due to uncured concrete within the facility that made it to react and form calcium carbonate. The oxygen level was also kept above 14% by pumping liquid oxygen.

Matthias C.Rilliga and Janis Antonovics [31] studied the working and requirements of closed ecosystems, with special focus on the creation of closed ecosystem for microorganisms, since they are the most tractable. Overall- one thing was definitely clear, to generate a closed ecosystem, we mustn't allow any material exchange, light can be the only form of energy used and only heat dissipation is allowed. This was a common features of all experimental ecosystems, be it the aquarium of Warrington, World in a jar experiment (by Liebigsche Welt) or the legendary Biosphere 2. Even if one manages to create a closed ecosystem, persistence, evolution and biogeochemical cycles have to be ensured to ensure the sustainability of the same. A question arises- can we make a closed ecosystem for a single organism? We surely can, as long as we are able to ensure stability in the ecosystem- the resources aren't depleting, the organism is taking care of the decomposition process and it's genetic reproduction is controlled. In olden times, the creation of most closed ecosystems have resulted in 'failure' due to one or the other reason, but failure doesn't mean that they were able to do nothing, they just failed to reach their final objective. Today, it is very much possible to create a mecocosm because of the same. Along with that, their studies have left a lot of information, and new methods of sensor technology, robotics and high throughput sensing now increase the possibility of being able to create an artificial biosphere. Such an approach may help us in understanding persistence and stability of Earth's ecosystem, and might help in designing self-sustaining ecosystems for life on other planets.

4. Inferences

Quite a lot of progress can be identified in the field of creating an artificially enclosed ecosystem, ever since the first mention of the idea in 1969. Although it just started as a research to understand the natural biosphere of Earth, the various experiments have resulted in technological advancements and recognition of major challenges and problems, which actually make it possible for creating a whole new biorealm. Over time, various people have studied and recorded their observations, each proving to be an important part of the next one. Starting off with small experiments such as the aquarium of Warrington, world in the jar experiment, the first big project was Russia's BIOS, which included Bios 1,2 and 3, followed by the largest experimental set up so far of Biosphere 2. While Bios 1 provided atmosphere for only 1 person, Bios 3 could ensure the survival of 2-3 people and Biosphere 2 took it to 8 people. The given table can compare the major characteristics of these previously created biospheres: -

Feature	BIOS 3	Biosphere 2
Capacity of people	3 people	8 people
Duration	4 months	2 years
Cost	1 million dollars	150 million dollars
Area	315 m3	3.14 acre
Place	Institute of Biophysics Krasnoyarsk, Russia	Oracle, Arizona
Completion	1972	1991
Initial Owner	Institute of Biophysics, Siberian Branch of the Russian Academy of Sciences	University of Arizona
Structure Type	Underground Steel Structure	Glass and steel structure

Table 3.1: Comparison of Bios 3 and Biosphere 2 project

Various methods were used to create the required amenities in these experimental projects. The aim of creating an artificial ecosystem is to support self sustaining life in an enclosed Biosphere. While Biosphere 2 faced the difficulty of too much organic matter in soil, leading to an overall imbalance, BIOS 3 was only able to sustain itself for a maximum duration of 180 days. However, the basic needs remain the same, including regulation of temperature, maintaining adequate balance of gases, selecting adequate traits to ensure the sustenance of different life forms, and above all, ensuring that it is self sustaining for as long as required, so that it can meet the demands if actually built in space.

5. Conclusion

In the present scenario where degradation of earth is relentless and severe, environmental crisis are arising at every corner of the world. Habitats are being destroyed and many animal and plant species are endangered, many of them already extinct. If the paradigm continues human existence could be put into question. Therefore, creation of successful artificial biospheres could be of utmost significance. Establishing a successful artificial biosphere could also prove beneficial and imperative for the research, development and sustainability of the natural resources and life on earth. Also providing a narrative, of how life could be managed on foreign planets which could play a crucial role in space exploration. However, the engineered enclosure must be created so to replicate the closure and reliability provided by earth's natural atmosphere for it to sustain and protect life.

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