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CONFORMATION OF AN ASTROBIOLOGY INTERDISCIPLINARY RESEARCH GROUP: ¨TEAM KILLALAB¨ CASE STUDY

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Abstract: The development of new technologies in recent years has highlighted interdisciplinarity as a tool to solve complex problems faced by scientists and engineers in research work. Worldwide, the area of space science and specifically astrobiology has more than 25 missions with high technological development and economic return. However, the success of interdisciplinary teams requires collaboration, responsibility, and leadership on the part of all members, to prioritize the main objectives of the research. Likewise, the formation of interdisciplinary teams can be affected because there is little information about the strategies and tools that recognize the opportunities of the constant interaction of subjects from engineering and sciences. A know methodology based on other recent proposals that include the description of the conformation and behavior of the research team and the analysis of interdisciplinarity through the interrelation and the level of dependence of the existing subject categories in Killalab team. In this research, we present the ensemble interdisciplinary group "Killalab" and its implication in the realization of astrobiological investigations.

Keywords: Astrobiology, interdisciplinarity, subject categories, Killalab.

1. Introduction

With the advance of knowledge and the complexity of the problems, the need arose to involve several disciplines instead of one. In this way, the development of interdisciplinary teams to address contemporary technological and scientific challenges is increasingly recognized [1,2].

The last approaches that investigate interdisciplinarity are based on quantitative methodologies. Many authors use the clustering of citation patterns [3]. Those bibliometric studies of interdisciplinarity are based on machine learning algorithms, in an attempt to understand the fine-grained details of interdisciplinary research with a big data analysis [4]. However, those approaches do not always work in order to study the formation of a research team in a real-life context. It is necessary to know which are the weaknesses and factors that can affect the success of the formation of interdisciplinary teams [5]. From a different point of view, some studies that measured the success of interdisciplinarity, underline that the publications with the greatest impact come from collaborative teams and not from monodisciplinary teams [5].

Research in Astrobiology is a clear example of interdisciplinarity since they require the interaction of various disciplines such as biology, astrophysics, chemistry, geology, aerospace engineering, etc., which are applied to the understanding of the origin, evolution and the detection of life in the Universe [6]. However, although there are many studies to measure the interdisciplinary and curricular proposals to put into practice in student's groups, to date, little research provides information on the development of interdisciplinary research teams [7].

Currently, university students receive specialized training in a particular discipline and rarely interact with students from other disciplines. It is necessary to reinforce a promotion towards interdisciplinary collaboration since it provides the means to think innovatively and solve problems, not only focused on the industrial sector but also on the level of large projects such as what Astrobiology implies. An investigation of the formation of an interdisciplinary team for astrobiology experiments in a real research context will provide the keys for the improvement of the performance of research teams [5].

This article examines the interdisciplinarity inside the team ¨Killalab¨, which develops astrobiology research. The results help to annotate how the interactions have to be emphasized to eliminate barriers and get better results as an interdisciplinary team in other fields of research.

2. The Interdisciplinarity

Interdisciplinarity is the integration of information, data, techniques, tools, perspectives, concepts and/or theories of two or more specialized disciplines to advance in the understanding of complex problems whose solutions are beyond the scope of a single research discipline [8]. The interdisciplinarity arises due to the technological growth that demands solutions that require the linking of different disciplinary fields to answer more complete questions or facilitate the application of knowledge in a specific area [9].

Multidisciplinarity involves several different academic disciplines that investigate a topic or problem but with multiple disciplinary objectives. The research process occurs in parallel to compare results, but without integrating disciplinary knowledge [10]. This last aspect is important because it differentiates the interdisciplinarity of the multidisciplinarity, in the integrating aspect between the disciplines which occurs strongly in the interdisciplinarity as opposed to the multidisciplinarity where the disciplines are only present, and the interaction only occurs within each discipline.

The collaboration of different disciplines has always been a challenge that has involved the creation of scientific culture. The critical factors found for interdisciplinary work have been: The paradigms of the separate scientific disciplines, the capabilities of each team member, the institutional context of research and team management [11]. Integrating the diverse experience of the participants is the key to success, and this is evident in the results of research and collaborative publications [10]. Associated to the success, is the quality of the research being able to be the factors that contribute in this one: the time and the resources that the experiments take, as well as the approval of the conclusions from different monodisciplinary points of view and to arrive at a new holistic understanding of a problem investigated.

Despite the progress of research, interdisciplinarity is not yet applied by students or researchers already trained. Interdisciplinary education programs are required to put this interconnection of knowledge into practice. Many programs handle an approach from multidisciplinarity to interdisciplinarity [12]

3. Astrobiology as an interdisciplinary science

Astrobiology is the study of life in the universe, according to the definition of the National Aeronautics and Space Administration (NASA), which covers from the origin, evolution, distribution to the future of life in the Universe as its Roadmap is exposed [13]. The benefits of astrobiology are several, from its interdisciplinary nature as a new tool for the formation of multiple research teams to the discovery of new habitable scenarios in the Solar-Planetary System neighborhood.

At the beginning of 1988, astrobiology was not considered an interdisciplinary science [10]. With the progress of space missions, the interdisciplinarity of astrobiology has become known as inherent

because it requires at least the conjunction of biologists, chemists, astronomers, and engineers to address experiments that solve questions such as: Can terrestrial microorganisms survive? To the conditions of deep space? (Figure 1).

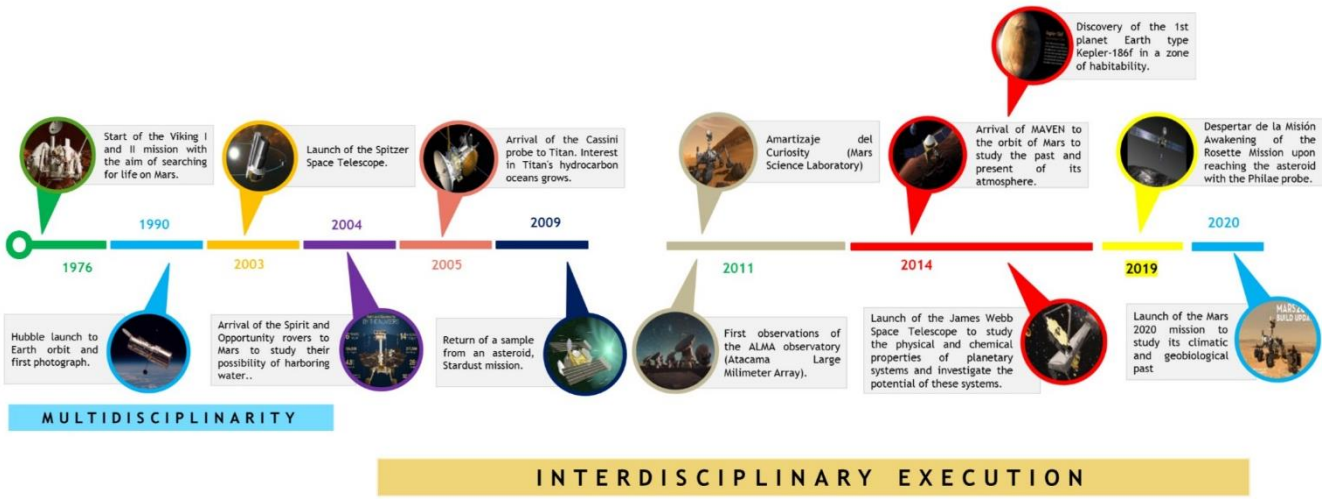

Figure 1. Astrobiology timeline with multi and interdisciplinary approach: Until 2003, astrobiology has been multidisciplinary, and with the advance of space missions, since 2008, it has become a science with interdisciplinary execution. Its success depends critically on the close coordination of various scientific disciplines and programs, including space missions planned for the future.

3.1. Development of interdisciplinary teams in Astrobiology

The interdisciplinarity in astrobiology has made possible the development of new technologies that could not have been achieved without the intervention of biology, chemistry, physics, software engineering, mechatronics, and telecommunications [14]. Such is the case of the Mars Science Laboratory (MSL) whose main objective was to reach the surface of Mars, characterize the geology of the landing region, investigate planetary processes that influence habitability, and characterize the broad spectrum of surface radiation [15]. The mission of the MSL was resolved from 2012 to the present day by conducting experiments designed by an interdisciplinary team that included the Curiosity rover, a multi-sensor radioisotope generator, a parachute, an entry, and exit system and a launcher. However, the experiments focused on the operation of the Curiosity (which includes the payload of the mission), and it is precisely the diverse nature of the data required to address the habitability of Mars that led to the realization of a complex charge design useful with an integrated quadrupole mass spectrometer (QMS), gas chromatograph (GC), tunable laser spectrometer (TLS) to analyze the atmosphere and gases developed from rock and soil samples (SAM). For this, interdisciplinary groups of more than 400 international researchers were formed, who worked in groups with their criticism but with open communication to the work capacity of the engineering experts and vice versa that were later gathered in the Project Science Group [16].

In the case of the MSL mission, the Project Science Group (PSG) is a project management tool. Thus, the PSG brings together all specialists to develop an integrated activity plan. In this scenario, the working groups are allowed to meet privately and then interact and participate in the planning [15]. In short, an organization with a high level of systematization and an integrating culture favors the work of an interdisciplinary team.

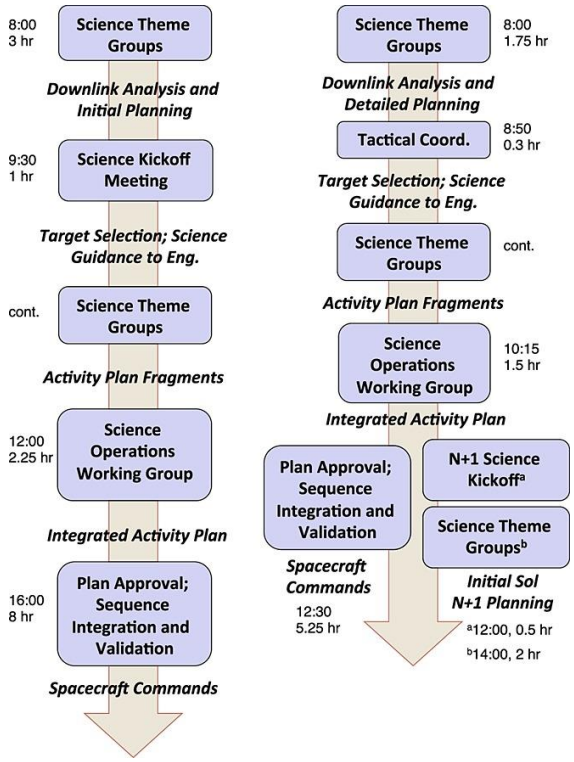

Figure 2. Planning flow when obtaining Curiosity data during the first 180 soles. The planning in meetings was a crucial part of the development of the interdisciplinary groups of Curiosity [16].

4. Methodology

4.1. Case study

Team ¨Killalab¨ (¨Killa¨ means ¨moon¨ in the Quechua language), is a research group of the Scientific Society of Astrobiology of Peru that officially emerged since 2017 after the Lab2Moon Contest organized by the Team Indus Foundation, which was a finalist of Google Lunar XPRIZE. The team received a grant from the National Council of Science and technology in Peru in 2018 to carry out its research. The team started by a small group of scientist, and they led the conformation of the entire team, taking into account the considerations described below. The principal location of the team was Lima, Peru.

This study meets the conditions proposed by Yin, 2003. It means, it contains the nature of researches questions such as how and why, it does not have control of the participants and finally but not less important, this phenomenon develops in a context of real life [17].

4.2. Research settings

The Team Killalab, which develops a project in astrobiology, had to use techniques and processes from different disciplines to address the following goal: ¨To study the effects of radiation from the outer space environment on cyanobacterial biofilms isolated from the Peruvian high Andean ecosystems using an autonomous aerospace minilaboratory¨. The conformation process of the team had the following considerations:

- A careful and strategic selection was made of the necessary disciplines and individual participants capable of occupying those positions [18]. These team members had to possess characteristics of vision, dedication, reliability, ability to take responsibility for their limitations or errors, and to solve problems [19]. Thus, the members of the interdisciplinary team were expected to cooperate, share leadership, and demonstrate responsibility.

- The team members shared the commitment to complete their tasks required to meet the principal goal.
- The establishment of specific objectives for each scientific discipline was made after the complete conformation of the members of the team and after determined the principal goal in order to keep the team focused on the tasks that seek to solve a single problem as other authors suggest [20].

4.3. Data collection

To examine the effect of the interdisciplinarity within the research group, the present qualitative study used the observation and the description of the conformation of the members (stakeholders), the specific objectives of each discipline, the subject categories involved and the relationship between them. Those are considered scientific disciplines boundaries used in other studies as a measure of the degree of interdisciplinarity [4].

5. Results and discussions

5.1. Team Killalab disciplines conformation

The research team has been composed mainly by Masters and Ph.D. researchers and young graduates whom some of them did their thesis with specific objectives from the general proposal. The disciplines present in the research group were chemistry, biology, physics, electronic engineering, mechanical engineering, and computer science. The team was constituted with 13 members.

In the project, there was a principal investigator (PI), whose function is to direct the team members to establish common specific objectives to the research by disciplines. The PI for interdisciplinary research can come from any discipline as long as it possesses the required experience relevant to the research objectives and can bring together the unique and diverse perspectives that are fundamental to achieving these objectives [21]. In Killalab team, the PI came from science.

Team meetings were an essential tool for communication and knowledge exchange. The maintenance of the approach and the execution of the study were complemented with the establishment of deadlines for the research milestones.

5.1. Specific objectives and interaction of tasks

For the realization of the astrobiological research, specific objectives were proposed by disciplines as a strategy to maintain the team focus on one goal (Table 1).

Each discipline also had their tasks to meet the specific goals of the total research. The manufacture of the payload mini-laboratory), which will experiment with space, was considered a milestone of that. We use the tasks of this great stage to show the dependence and communication that existed between disciplines. Those are represented in Figure 4, as mechanical tasks (M-1,2,3,4,5 and 6), electronic tasks (E-1,2,3,4,5,6,7 and 8), science tasks (S-1,2,3,4,5 and 6) and computer science tasks (P-1,2 and 3). Within the scientific tasks were considered those of the disciplines of chemistry, biology, and physics. This table also represents the communication strategy between scientific disciplines in order to carry out their corresponding tasks. After a consensus, the next task was continued.

The tasks interactions that had the most significant impact on the realization of this stage were science-mechanics and mechanics-electronics, followed by electronic-computer science. Likewise, it is important to mention that identifying all the areas of study and the related sciences and engineering allowed the focus on the main objective of the team and the experiment.

Table 1. Specific goals from each discipline involved in the team Killalab.

Discipline	Specific Goals
Biology	Study of the survival of cyanobacteria to the extreme conditions of space
Chemistry	Study of the chemical modification of the protective pigments of cyanobacteria
Physics	Evaluate physical conditions of the payload that can resist the total components
Electronic engineering	Design of the electronics of the payload (minilaboratory)
Mechanical engineering	Design the mechanics of the payload (minilaboratory).
Computer science	Get data from simulations and real ultraviolet radiation exposure in outer space.

5.1. Interdisciplinary interaction of team Killalab:

Interdisciplinarity was represented within Team Killalab as a result of the interactions of the disciplines of biology, chemistry, physics, mechanical engineering, electronic engineering, and computer science. In this representation (Figure 3), the disciplines are denoted with yellow circles and black letters. Astrobiology was included as one more because some of the team members already had a background in astrobiology research. The subject categories are in pink and represent the integration between the disciplines. These subject categories are biochemistry, microbiology, material science, robotics, programming, microelectronics, biophysics, and astrophysics. The subject categories in light blue resulted from a more profound exchange of knowledge, and that had an immediate application in the specific objectives.

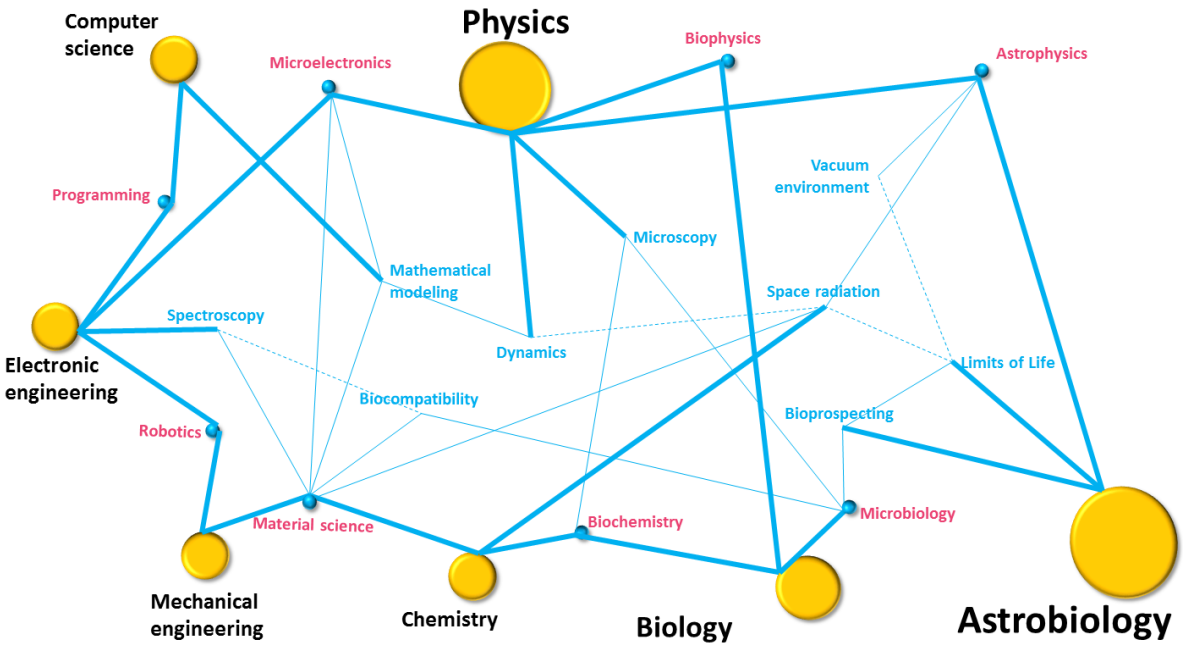

Figure 3. Team Killalab interdisciplinarity representation using subject categories as a result of interactions.

An explanation for obtaining interdisciplinarity within the team is to possess an astrobiology research objective, which needs several disciplines to direct the tasks towards a common goal. However, also it was needed the orchestrated combination of interpersonal relationships and the participation of a PI to facilitate the communication between members.

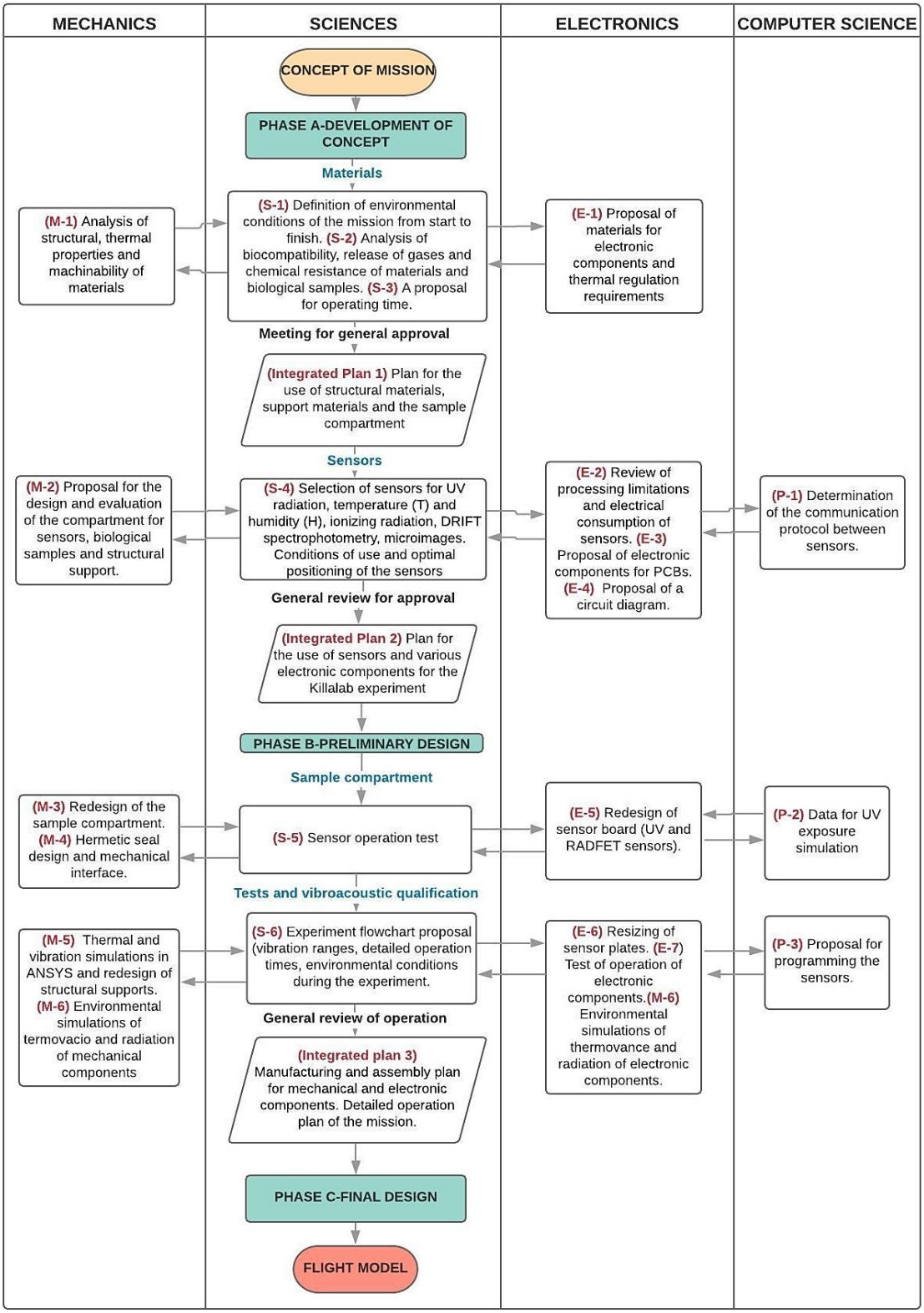

Figure 4. Tasks of team killalab members from the development of concept to the final design of the payload (mini-laboratory).

5. Conclusion

Astrobiology, which by its nature needs several disciplines, facilitated the formation of the Killalab interdisciplinary team that focused on solving how biofilms of microorganisms were affected after space conditions.

The use of subject categories as a boundary discipline helped to identify the communication and interaction between the disciplines of team members in the framework of this qualitative research.

The conformation characteristics of the team, such as communication through meetings to resolve knowledge gaps between disciplines, the respect between them and the order to establish the specific objectives and tasks of each discipline can help improve the implementation and effectiveness of interdisciplinary research or educational programs.

4. Patents

Some authors of the present study have a patent application in the National Institute for the Defense of Competition and Protection of Property in Peru, whose title is ¨Minilaboratory to assess microbial survival¨ and file number is: 002091-2017 / DIN.

Author Contributions: Writing-Original Draft Preparation, R.Q.; Writing-Review & Editing, H.P.; Resources, R.C.; Data curation, V.V, C.L.; Resources, S.R., J.G.; Supervision, J.V, H.P.

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