



Ministry of Higher Education,
Research & Innovation

مـوارد
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TRANSFORMING GENETIC RESOURCES INTO VALUE

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Oman will benefit significantly from the existence of a microbial culture collection that preserves and study its microbial biodiversity. Such a culture collection can serve as a core for an ever expanded gene bank which can emerge as a national gene bank for all sorts of microorganisms, including the medicinal and marine ones. The collaboration between Mawarid and the University of Nizwa is also a significant step for the complimentary efforts between different institutes of the country.

Editorial



Dr. Nadiya Al Saady
Mawarid

Welcome to another edition of the newsletter on microbes on behalf of the Oman Animal & Plant Genetic Resources Center (Mawarid) under the Ministry of Higher Education, Research and Innovation. This issue brings you diversified contents of the interesting roles of microbes as genetic resources in discerning their socio-economic value. This issue addresses research and development in the microbial sector and its potential contribution to the country's economy. Among several uses of microorganisms, their role as a bio-fertilizer is significant and valuable in the global market, projected to reach 2,6 billion US \$ by 2023, according to a recent report (Diaz-Rodriguez et al., 2021), while in respect of microorganisms, the mushroom cultivation market was in the tune of USD 16.7 billion in 2020. These examples have been given here to highlight the uniqueness of the role of microbes in research.

This issue of Mawarid's newsletter introduces you to its two ongoing microbes projects. The first project aims to collect, identify, and preserve the macrofungi species, especially mushrooms that grow naturally in different areas and times in the Sultanate, particularly during the Dhofar governorate's monsoon (khareef) season. The second project addresses establishing an ex-situ conservation facility for the culture collections (slants, freeze cells, DNA, encapsulations) for different species of microorganisms

considering specific criteria of their uniqueness in identification and utility.

Mawarid has consistently displayed its ongoing activities with equally enthusiastic staff to show progress in ongoing activities in all its sections, viz. plant, animal, marine and microbes, despite the COVID-19 pandemic conditions in 2020 and 2021. As a result, in this final volume of the year focusing on microbes, we are delighted to present the unique experience of Dr. Mohammed Al-Yahiae, Expert and the team leader of the Microbe Sector, in addressing his past and future research at Mawarid in "Under the Microscope" of the newsletter. However, under the "Oman's Genetic Resources Hero", the Pure Company enumerates the prospects of its technology to clean unclean water of organic waste with foul odor by using the community of microorganisms and biological filters. The company's unique purifying water technology involving microbes is exciting and worth accommodating in the newsletter.

Furthermore, we will also bring you fascinating Mawarid news highlights that include salient information of inter-stakeholder workshop involving Mawarid of the Ministry of Higher Education, Research & Innovation and Directorate General of Agriculture & Livestock Research of the Ministry of Agriculture, Fisheries and Water Resources, for the collaboration in all the common activities

between them.

As ever, we believe that your feedback and comments would add value to improve the quality of our research activities and, in turn, the contents of our newsletter up to your satisfaction in reading.

I hope that you would enjoy reading this edition of the Mawarid newsletter as well.

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"Among several uses of microorganisms, their role as a bio-fertilizer is significant and valuable in the global market, projected to reach 2,6 billion US \$ by 2023, according to a recent report (Diaz-Rodriguez et al., 2021), while in respect of microorganisms, the mushroom cultivation market was in the tune of USD 16.7 billion in 2020."



Collection, Identification & Preservation of Macrofungal Species in the Sultanate of Oman



Themes

Conservation

Description

In 2018, the Oman Animal and Plant Genetic Resources Center (Mawarid), in collaboration with Sultan Qaboos University (SQU), initiated a research project to collect, identify and preserve the local species of mushrooms in the south of Oman. It is a first completed project of its kind in the country. A total of 84 samples were collected and documented with photographs. The molecular identification of all the collected samples was accomplished in SQU's laboratories. Around 48 samples were identified at the species level, and 20 were identified as new genus or species. Some of these could possibly be edible but would require specialists confirmation. Based on the information collected from the local people in Dhofar, it could be inferred that the indigenous edible mushroom king oyster mushroom (Dhofari Mushroom) could be available in local markets during the Khareef season (from June - August). *

Objectives

To collect, identify and preserve macrofungi species, which grow naturally in Oman.

Specific objectives

1. Establish Oman's first collection and database of macrofungi following standard collection methods.
2. Identify the taxonomically undetermined species of macrofungi using both morphological and molecular methods and characterization.
3. Produce a catalogued and representative collection of properly preserved macrofungi specimens using standard preservation techniques.
4. Share the unique obtained knowledge through publishing scientific papers in international reputable journals.



Establish Oman's first collection and database of macrofungi following standard collection methods.



Key Mawarid Team Members

Researchers:

Moza Al Kharousi
Dr. Shah Hussain
Marwa A. Al Muharabi
Zahra Al Shabibi
Dua'a Al Moqbali
Abdullah Al Balushi
Dr. Mohamed Al Yahyaei
Dr Nadiya Al Saady
Dr. Rethinasamy Velazhahan
Dr. Abdullah M. Al Sadi

Members of Mazoon Hiking Group:

Nabil Al Dhanki
Saif Al Salami
Mohammed Al Jahwari
Ibrahim Al Sabahi



Collaborators (Individual/ Organization)



جامعة السلطان قابوس
Sultan Qaboos University

Volunteer Collectors
(Mazon Hiking Group)

Target Audience

Researchers, Scientists



Achievement/ Impact/ Outcomes

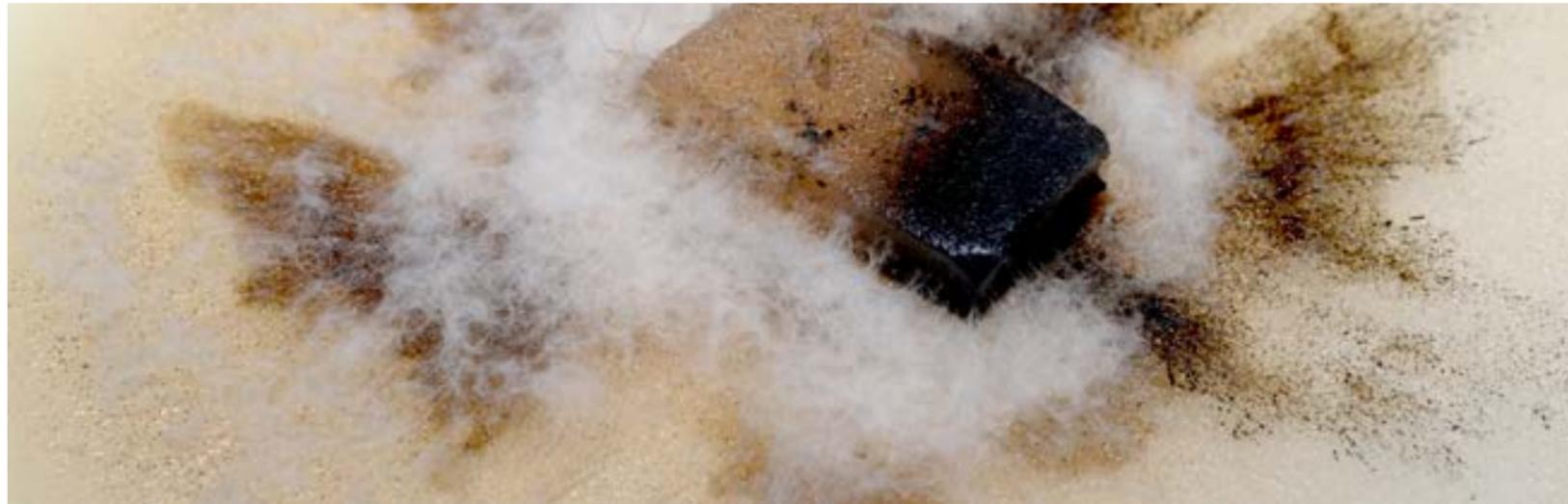
1. The Collection Phase was carried out in the Dhofar region 1-15 September 2018 with the assistance of the Mazon Hiking Group.
2. **84** samples were gathered, photographed and labelled.
3. Molecular analysis of **84** samples showed:
 - a. **48** samples identified at the species level
 - b. **20** samples were identified as potentially new species or genera
4. Webinar workshop was held on "Field collection, identification and preservation protocols of wild mushrooms".



Follow up/ Actions

1. The project was concluded in December 2021. One manuscript describing unique identified species was submitted for publishing.

Culturing of Ex-stock Microbial Strains in Gene Bank Project



More than **1828**
Fungi strains
collected
(2015-2017)

Themes

Conservation

Description

Identification and preservation of microbial diversity of a country are essential to understand their dynamic role in ecology and the environment. Moreover, many industrial applications are based on the microbial diverse functionality. Application of microbial diversity in the industry is obvious in the fields of medicine, agriculture, food technology, bioremediation and many others. Therefore, it is crucial to maintain and develop a national culture collection that can support the basic research and industrial applications in Oman.

Mawarid in collaboration with the University of Nizwa is hosting the microbial gene pool of the country. These microbes have been isolated from diverse nature of ecosystems of Oman not only to explore their diversity and richness, but also to utilize them for broader biotechnological applications. In this regard, more than 1800 microbial strains are available in the form of live culture (slants), DNA and lyophilized mycelial cells. These live cultures have been replicated and maintained in the first phase of the project (2017-2020). The aim of the second phase is to bring the microbial collection to a new level and expand its diversity and applications.



Objectives

1. To establish an ex situ conservation facility of the culture collection Gene Bank (slants, freeze cells, DNA, encapsulations) for species, considering the following priorities: (a) unique and novel microbes with high secondary metabolites potentials, (b) endemic microflora, (c) hazardous microbes with potential threats to cultivated plants and crops, (d) native species and (e) economically important keystone species of the country
2. To isolate, culture, characterize, conserve, identify and distribute microorganisms from the active and preserved collections in the Gene Bank.



Collaborators (Individual/ Organization)



جامعة السلطان قابوس
Sultan Qaboos University



Key Dates Timeframe

Project phases

Phase I

- Sub-culturing the fungal microbes
- Monitoring growth and morphological assessments
- Coding and re-labelling the new slants as per Mawarid coding method

Phase II

- Glycerol stock preparation for fungal and bacterial cells
- Lyophilization of available of fresh culture with new methods
- Addition of new fungal/bacterial strains to the Gene Bank resources from University of Nizwa



Key Mawarid Team Members

Dua'a Al Moqbali
Moza Al Kharusi
Saif Al-Hosni
Maather Al-Hakmani
Abdullah Al Balushi
Dr. Abdullah Al Hatmi
Dr. Abdullah Al Saadi
Dr. Mohamed Al Yahyaei



Achievement/ Impact/ Outcomes

1. More than **1828** Fungi strains collected (2015-2017)
2. Available in the form of:
 - i. Live culture (slants)
 - ii. DNA
 - iii. Lyophilized mycelial cells
3. Re-cultured around 1366 specimens of fungi preserved in the culture collection.
4. d. Adding new fungi & bacterial strains to the culture collection stock.



Scientific and Innovation Significance

Phase 2 of the project will be launched in the first quarter of 2022. It will bring the current culture collection to a new level. All the strains will be preserved for long term use. The biodiversity of the culture collection and their uses in various experiments will be published in international scientific journals or used in patents. Some of these strains will also be used in experiments for industrial applications.

Benefits to Oman

Oman will benefit significantly from the existence of a microbial culture collection that preserves and study its microbial biodiversity. Such a culture collection can serve as a core for an ever expanded gene bank which can emerge as a national gene bank for all sorts of microorganisms, including the medicinal and marine ones. The collaboration between Mawarid and the University of Nizwa is also a significant step for the complimentary efforts between different institutes of the country.



Microbial Database

Establishing the Database of Microbial Genetic Resources



802
Bacteria



64
Macrofungi
(Mushrooms)



1800
Isolates
of Fungi



1200
Historical
Data of
Fungi

Microbial Projects

1. Production of the next generation of agricultural fertilizers using microorganisms
2. Identification and biological activity of novel fungal taxa from Oman
3. Collection, Identification & Preservation of Macrofungal Species in the Sultanate of Oman
4. Culturing of Ex-stock Microbial Strains in Gene Bank Project (Phase II)
5. Cultivation of Omani local species of edible mushroom - To be funded by AFDF





Under The Microscope



Dr. Mohamed Al-Yahya'ei
Supervisor of the Microbiology Research
Team, Mawarid

Can you tell us about your education and career before you joined Mawarid?

Before I joined Mawarid (Aug 2013-Aug 2020) I was working as an Associate professor in College of Food and Agriculture, UAE University. I also had different academic and administrative roles during my career in UAE university such as an Assistant Dean for Student Affairs, Coordinator of MSc Program in Horticulture, Coordinator of BSc Program in Horticulture and a Supervisor of the Aquaculture Research Station of UAE. Before joining UAE University, I worked as a Post-Doctoral Research Associate and lecturer (2008-2013) in the Botanical Institute of the University of Basel in Switzerland. My career actually started as Soil Microbiologist in the Soil and Water Research Center Ministry of Agriculture and Fisheries of Oman.

With regards regards to my Education, I got my BSc and MSc in Soil and Water Sciences from Sultan Qaboos University. After that, I earned two PhD degrees; PhD in Biology and Biotechnology of Fungi from Department of Plant Physiology in the University of Torino, Italy, and PhD in Plant Sciences from the Botanical Institute of the University of Basel in Switzerland. The two doctoral degrees were obtained through a formal agreement between the two universities in the form of a European double-thesis program or "co-tutela". The final examination committee consisted of two professors from the University of Torino and three from the University of Basel, where the examination took place. The program had a full-time duration of 4.5 years (divided equally between the two universities).

What are your research interests and your main findings in the field of soil microbiology?

My research is focused on the isolation and identification of arbuscular mycorrhizal (AM) fungi from desert soils in the Arabian Peninsula. These are beneficial microorganisms that live in association with plant roots. In 2011, I published the first study (to my knowledge) characterizing the AM fungal communities from the southern Arabian Peninsula (Al-Yahya'ei et al., 2011). Using molecular and morphological tools, the study showed the presence of a unique and unexpectedly diverse AM fungal community. The study also showed that introducing agriculture in such a desert habitat can dramatically increase the diversity and abundance of AM fungi. After more than two years of further isolation and investigation using various molecular markers and propagation methods, and together with my research partners at the University of Basel in Switzerland and West Pomeranian University of Technology in Poland, we have revealed and published three new species to the world: *Diversispora omaniana*, *Septoglomus nakheelum* and *Rhizophagus arabicus*. These were the first three new species of AM fungi that were discovered in the Arabian Peninsula. The fact that the three species were found in the same site of approximately 1 hectare confirmed our earlier findings that there is a rich, hidden diversity in the desert soils of the region. In the same year, four other species newly reported in Arabian Peninsula were revealed through molecular and morphological characterizations. They were published in another scientific paper.

In the years 2017 and 2018, we discovered two additional new AM fungi, *Pervetustus simplex* from Oman and *Dominikia emiratia* from the UAE. *D. emiratia* was the first symbiotic fungus discovered in UAE and received widespread media coverage and social interest. In 2018, and after further molecular and morphological analyses, we found that the species we had discovered earlier, *Diversispora omaniana*, does not belong to the genus *Diversispora*, but is unique enough to represent a separate clade at the rank of a new genus, which we named *Desertispora*. Therefore, the name of the fungus is now *Desertispora omaniana*.

These are indeed interesting discoveries. Do they enhance our understanding of the desert ecosystem in any way?

Of course. The newly discovered AM fungal species represent unique entities that can be used to understand the dynamics and functionality of symbiosis under an experimental setting that imitates the desert's environmental conditions. For example, four of these species (*Diversispora aurantia*, *D. omaniana*, *Septoglomus africanum* and *P. simplex*) were utilized to study the dynamics of the fungal community under different water regimes, mimicking the seasonal availability of water in the desert. Our results showed that under each water regime, the fungal community alters its composition to adapt to the availability of water. It was extremely interesting to find that each fungal species "works better" and dominates the community under certain water availability conditions. The findings demonstrate the importance of the fungal diversity for the desert soil and the plant health that it supports. The experiment also showed that the introduction of an invasive AM fungal species (a strain of AM fungus *Rhizophagus irregularis* that was isolated from Switzerland) can strongly alter the structure of the desert AM fungal native assemblage with a consequent impact on the entire symbiotic mycorrhizal relationship. The message was clear: we need to maintain and protect the native diversity of AM fungi that support native plants and thus the whole desert ecosystem.

"I believe that we are conducting pioneering research in the Arabian Peninsula that covers the full circle from isolation to applications of AM fungi. Our research has an impact on the sustainability of agriculture in this part of the world, where soil limitation and environmental stresses present a real challenge."

The global attitude is moving towards the shift to sustainability, can your field of studies contribute to this shift?

Yes. First of all, agricultural practices are known to affect the diversity and efficiency of AM fungi. While agricultural practices in general have been evaluated for their effects on AM fungal communities in some desert ecosystems, organic farming practices for example have received little attention. In light of this lack of knowledge, we conducted a study to evaluate the abundance, richness and diversity of the AM fungal community under organic farming of a desert ecosystem in the UAE, and to compare it with an adjacent conventional farming system and native vegetation. In total, 12 sites, including 6 plant species, were sampled from both farming systems and the native site. Spore morphotyping revealed 24 AM fungal species, with 21 species in the organic farming system compared to 14 species in the conventional one and none from rhizosphere soil of the native plant (*Tetraena qatarensis*). AM fungal spore abundance, species richness and Shannon-Weaver diversity index were higher under organic farming. Our study demonstrated that organic farming in such a desert ecosystem is an advocate for AM fungal diversity. This might imply that AM fungi play an important role in the sustainable production of food in such a resource-limited desert habitat.

Furthermore, AM fungi are increasingly being used as biofertilizers. We examined the potential of the isolated AM fungi from the Arabian Peninsula as pre-transplant biofertilizers. We established 90 single-spore cultures of AM fungi as reference cultures, 7 of which significantly improved the growth of an important food crop, *Phoenix dactylifera*, and a common native plant *Prosopis cineraria*. The scientific paper that shows this effect has just been published. In this study, we showed the utility of establishing cultures of AM fungi in the laboratory for use in conservation, sustainable agriculture and revegetation programs in arid landscapes. This method can be applied to similar areas with similar environmental stresses.

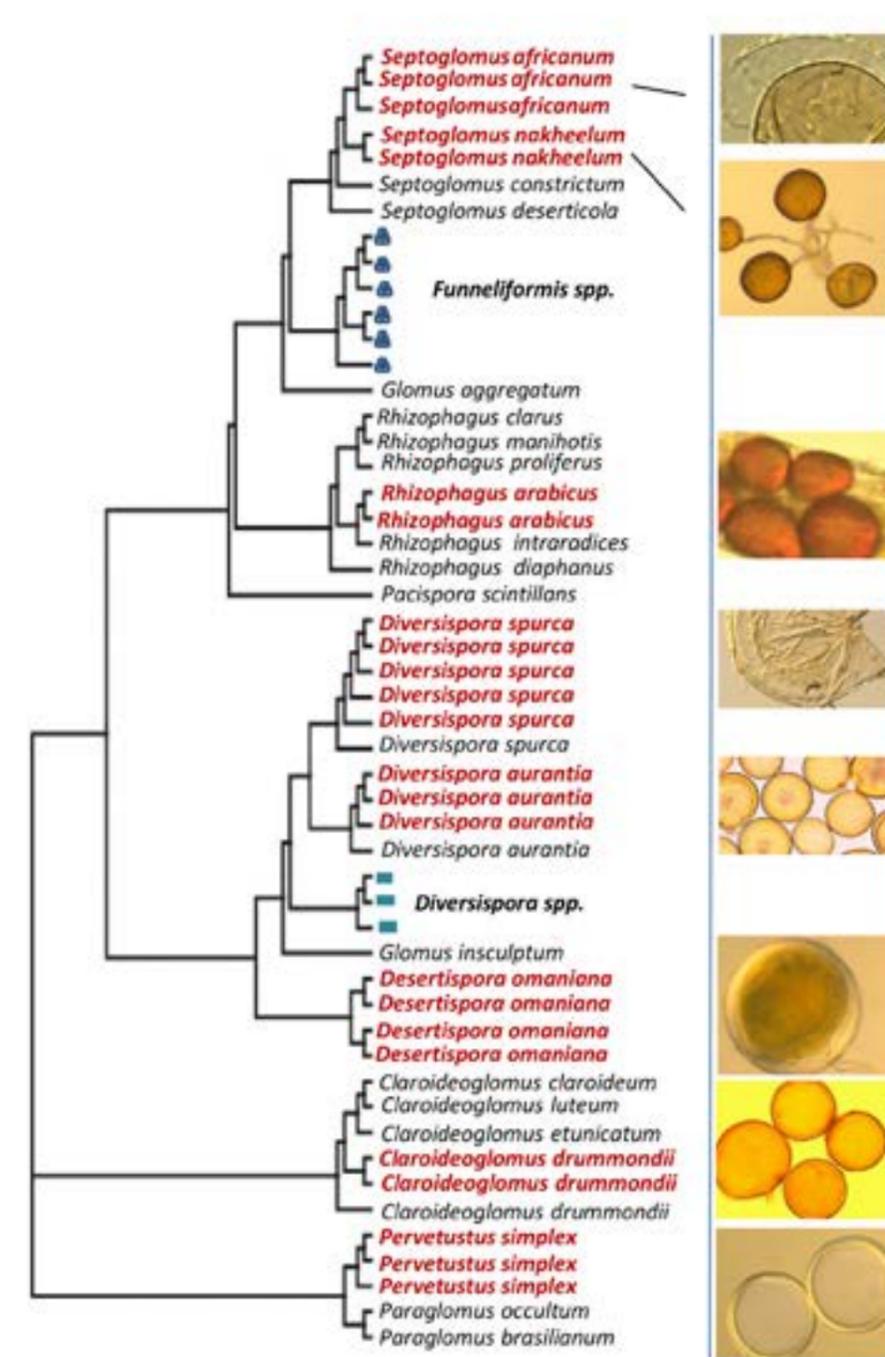
I believe that we are conducting pioneering research in the Arabian Peninsula that covers

the full circle from isolation to applications of AM fungi. Our research has an impact on the sustainability of agriculture in this part of the world, where soil limitation and environmental stresses present a real challenge.

What are your current projects in Mawarid?

At the moment, I am either managing or supervising different projects in the field of the microbiology. One project is focusing on the conservation and culturing of ex-stock microbial strains in Gene Bank. This is aiming to establish an *ex situ* conservation facility of Gene Bank (slants, freeze cells, DNA, encapsulations) for species, considering the following priorities: (a) unique and novel microbes with high secondary metabolites potentials, (b) endemic microflora, (c) hazardous microbes with potential threats to cultivated plants and crops, (d) native species and (e) economically important keystone species of the country. The project is running in collaboration with the University of Nizwa.

Another project is in the field of sustainable agriculture. We are isolating the soil microorganisms that can enhance the growth of plants and to evaluate their efficiency. This is a project in collaboration with Sultan Qaboos University and the private sector. Another project have just started and it is in collaboration with Sultan Qaboos university to identify the biological activities in some of fungal taxa from Oman. We also have a project that will start very soon in the field of food industry and it aims to cultivate Oman local species of edible mushroom.



"Group of beneficial microorganisms that have been discovered in Oman soils. Some of them are new to the world (e.g. *Desertispora omaniana*, *Pervetustus simplex*, *Rhizophagus arabicus* and *Septoglomus nakheelum*) (Source: Mohamed Al-Yahya, et al., 2021 <https://link.springer.com/article/10.1007/s-00824-021-13199x>)"



Omani Genetic Resources Hero



It is very interesting to know that the PURE COMPANY has a technology to clean dirty water of organic waste with bad odor by using the community of microorganisms and biological filters. Can you tell us exactly, which of your earlier knowledge urged you to come out with such an environmentally friendly technique?

In fact, I was very discouraged about wasting water, especially in homes, while showering, washing clothes and cooking, considering the economy of its production in Oman. This prompted me to think seriously about the existence of an easy way to purify sewage water in homes. Many scientific papers in purification and some comprehensive ideas of the topic were referred before we began preparing to implement the idea/s, and we made sure of its success through practical experiments.

You have a unique technique to ensure the reuse of unclean water by cleaning it make it suitable for irrigation with no adverse effect of environment. In this respect, which types of unclean water does your technique target?

We are currently targeting black water in homes, and in the future, we will expand to filtering car wash water and slaughterhouse water.

Can you describe your technique of purifying water?

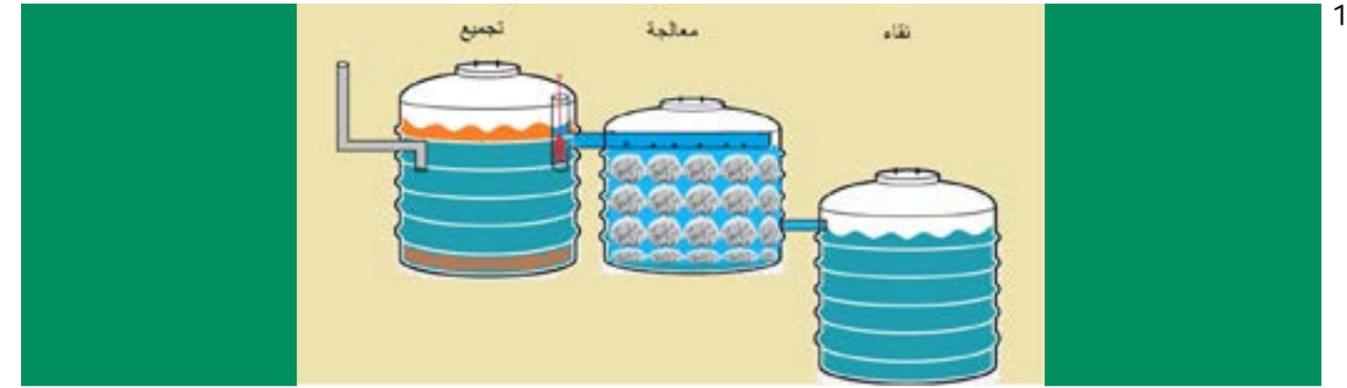
The purification technique is based on the principle of growing an immobile microbial community through the use of natural filters. Microbes can degrade pollutants and organic compounds and rid the water of harmful elements. In this way, water turns into pure water that can be used for irrigation and agriculture purposes.

How safe is your technique for the Omani environment?

Our technique relies on a natural microbial community that is not harmful to the environment. To avoid these microbes' harmful effects, we sterilize the produced pure water with ozone gas that kills the microbes.

Sultanate of Oman has a significant amount of produced water during extracting petroleum products. Can PURE COMPANY purify such produced water to make it available for irrigation? If yes, how can it achieve? If not, what factors hinder in purifying such water?

Scientifically yes, but it needs growing special microorganisms that degrade oil derivatives.



Your purifying technique appears to be very interesting considering its application for irrigation in landscaping, gardens, etc. Can you brief me about the economic feasibility of your technique?

The use of this technique provides two economic benefits: i- Indirect benefit: It helps reduce the depletion of water resources in the country.

ii- Direct benefit: It helps reduce the cost of the water bill and reduce the cost of cultivation of agriculture crops.

If someone uses PURE COMPANY water, how is it helping the environment?

Each can fix our system in thier house easily and benefit from pure water for irrigating indoor or out-door plants. Even for house purposes, it can be used for cleaning after its chlorination that kills microorganisms.

What is your impression of Mawarid's Manafa'a program bringing scope to your technique?

Mawarid's Manafa'a helped us a lot in marketing and advertising and increased our self-confidence in front of experts and specialists on the technical aspects of purifying water.

What is your plan to upgrade water purification techniques by using microbes and biological filters? In other words, we believe that this technique can proceed further in a larger scale for commercial application. Do you agree?

Of course, the main goal of our technique is to market it as a commercial project, to begin with at the individual level, as an alternative method to using traditional sewage water for irrigating plants at the home's level. We expand to popularize its use in hotels, apartments, government and private institutions.

Who could be PURE COMPANY customers?

We primarily target homeowners, owners of residential complexes, hotels, hospitals and government and private institutions.

Will people be surprised when you tell them how the PURE COMPANY water is produced?

Indeed, some individuals are even willing to try our technology in their homes. Many wonder how microorganisms can do the task of purification so easily and quickly without leaving unpleasant odors and harmful organic compounds.

Do you have any new techniques comming in the in the future?

Yes, we have three creative techniques:

1. Converting steam to pure water without consuming any energy
2. Converting hydrogen sulfide to fertilizers in fish factories.
3. Converting food waste to fertilizers.

"The purification technique is based on the principle of growing an immobile microbial community through the use of natural filters. Microbes can degrade pollutants and organic compounds and rid the water of harmful elements. In this way, water turns into pure water that can be used for irrigation and agriculture purposes."



Mawarid News

The first workshop: Activating joint research activities in the field of animal and plant genetic resources



On 7/12/2021, The Oman Animal & Plant Genetic Resources Center (Mawarid) held a workshop with the Directorate General of Agricultural and Animal Research in the Social Center in Innovation Park to find common aspects of cooperation. The main objectives of the workshop are:

1. Find out the results of previous and current joint projects in the field of animal and plant genetic resources.
2. Reviewing the implemented projects in the field of animal and plant genetic resources in each authority.
3. Discussing and defining future projects in the field of animal and plant genetic resources.
4. Reviewing the possibility of participation of parties of common interest in joint projects in the field of animal and plant genetic resources.

The two parties came out with recommendations in both the plant and animal sectors, and the most important recommendations in the plant sector are:

1. To prepare a research project proposal to explore neglected wild plants and crops.
2. To prepare a project proposal for the initiative of local crop seed production.
3. To prepare a project proposal for the exploitation of medicinal and aromatic plants.
4. To prepare a project proposal for the propagation and characterization of local vegetable crops.

Furthermore, the recommendations in the animal sector are:

1. To prepare a project proposal for collecting, preserving and freezing semen from local goats and sheep.
2. To prepare a project proposal to study the genetic, phenotypic and environmental trends of the productive traits of local animal breeds.
3. To prepare a project proposal for freezing semen from purebred Arabian horses in Oman.
4. To prepare a project proposal for the national initiative to number local animal breeds.
5. To prepare a project proposal for the use of molecular genetics for genetic improvement of the productive traits of goat breeds.
6. To prepare a proposal for a project to standardize the genetic resources of domesticated animals in the Mawarid database (OBIP).



Preparing a project
proposal for freezing
semen from purebred
Arabian horses in Oman.



Preparing a project
proposal for the
exploitation of medicinal
and aromatic plants.



We are now accepting articles on any topic related to genetic resources - ranging from business, fashion, innovation, environment, lifestyle, culture, heritage, food and farming. Any article submitted to us must be original and exclusive to Mawarid's quarterly Newsletter.

Articles submitted shall have the following:

Minimum of 500 words

Photos accompanying text should be in high resolution

Please forward material to: zahra.alabri@oapgrc.gov.om

To see previous Mawarid e-Newsletters, please click here:
<https://oapgrc.gov.om/Pages/E-Newsletter.aspx>

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