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## HUMAN FACTORS AND HABITABILITY IMPACT OF PLANTS ON ISOLATION

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### Abstract

The EDEN ISS project is the first European bio-regenerative system tested in Antarctica. The habitability impact on the crew emerged in term of both psychological and nutritional benefit, making an important contribution to the advancement of international research on bio-regenerative systems both for the exploration of the Universe and for Earth applications. Particularly, during the Crew 2018 and 2019 mission, the psychological and physiological impact of the plants on their well-being was assessed as positive by all crew members as also foreseen by the biophilia concept and presented in this paper. The investigation will be also be proposed at stations like Concordia in order to have a comparison crew without a greenhouse.

**Keywords:** Human Factors · Habitability · Antarctica.

### 1. Introduction

In light of the development of a closed sustainable system to supply edible food in future extreme and isolated environments such as Antarctica or Space, the DLR and its partners decide to develop a greenhouse to be tested at the German Neumayer station III (Fig. 1) in Antarctica: the EDEN ISS project (Fig.2).



Fig.1 Neumayer-Station III. (© Ude Cieluch, Alfred-Wegener-Institut, retrieved on 2010 from [www.daburna.de](http://www.daburna.de)).

The EDEN ISS project is the first European bio-regenerative system tested in Antarctica with the overwinter crew that every year live on the Neumayer III station in complete isolation for all the year long. Every year it produces fresh edible plants for the 10 overwinter

crew members such as Salad, Tomatoes, Cucumbers, etc. for a total of 45 different kinds of Crops (Tab. 1). The production reached on August 2018 26 Kg of biomass and a yearly production of 268 kg (Fig.3, Vrakking et al., 2020).



Fig.2 EDEN ISS. (©DLR)

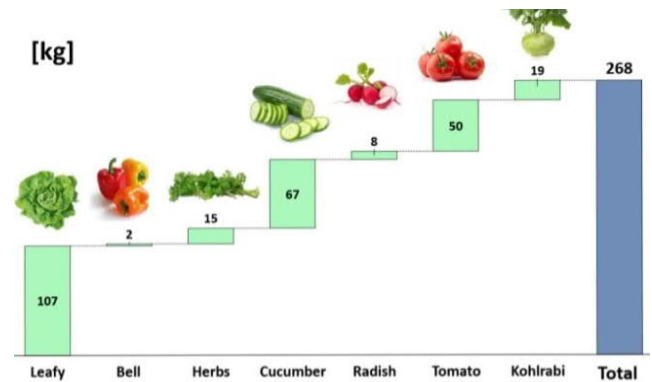


Fig. 3. Crops in 2018 at EDEN ISS (© DLR/ EDEN ISS 2020)

Tab. 1. Crops kind © DLR/ EDEN ISS 2020			
Common Name	Species	ID	
Lettuce	<i>Lactuca sativa</i>	1	Mint
Lettuce, Incised	<i>Lactuca sativa</i>	2	Tomato, dwarf <i>Lycopersicon Esculentum</i>
Lettuce, Batavia	<i>Lactuca sativa</i>	3	Tomato <i>Lycopersicon Esculentum</i>
Lettuce, Babyleaf	<i>Lactuca sativa</i>	4	Cucumber, Mini <i>Cucumis sativus</i>
Lettuce, Leaf	<i>Lactuca sativa</i>	5	Radish <i>Raphanus sativus</i>
Rucola	<i>Rucola selvatica</i>	6	Kohlrabi <i>Brassica oleracea</i>
Mustard		7	Bean <i>Phaseolus vulgaris</i>
Pak Choi	<i>Brassica rapa, chinensis</i>	8	Bean <i>Phaseolus vulgaris</i>
Chard, Swiss	<i>Beta vulgaris</i>	9	Broccoli <i>Brassica oleracea var. italica</i>
Leafy Asian Greens, Hybrid	<i>Brassica rapa var, chinensis</i>	10	Cauliflower <i>Brassica oleracea var. botrytis</i>
Frizzy Lizzy	<i>Brassica juncea</i>	11	Pea <i>Pisum sativum</i>
Leaf mustard, Japanese	<i>Brassica rapa</i>	12	Pepper <i>Capsicum annuum</i>
Mustard	<i>Brassica rapa subsp. narinosa</i>	13	Tomato <i>Solanum lycopersicum</i>
Mustard, Red	<i>Brassica juncea</i>	14	
Kale	<i>Brassica oleracea</i>	15	
Chives	<i>Allium schoenoprasum</i>	16	
Basil, Genovese	<i>Ocimum basilicum</i>	17	
Rosemary	<i>Rosmarinus officinalis</i>	18	
Oregano	<i>Origanum heracleoticum</i>	19	
Thyme	<i>Thymus vulgaris</i>	20	
Parsley	<i>Petroselinum crispum</i>	21	
			22

## 2. Plants Interactions

Research on people working in space and Antarctica revealed that they go through different stages of adaptation, showing changes in mood, decrease of performance associated with stress, and changes in interpersonal interactions, causes also from the low habitability these environments offer. But if living in Space and Antarctica could increase stress, plants could reduced it back (Fig 4).

Several studies shows that plants can have psychological and physical benefits:

- Lower blood pressure
- Improve reaction times
- Increase attentiveness
- Raise productivity
- Improve well-being
- Improve perception of space
- Reduce anxiety during recovery from surgery
- Raise job satisfaction

Specifically the improved reaction time and increased attentiveness caused by plants will increase performance, as the person will perform the task faster and more attentively (Kanas and Manzey 2008; Mohanty at al. 2006, Kaplan, 2009).

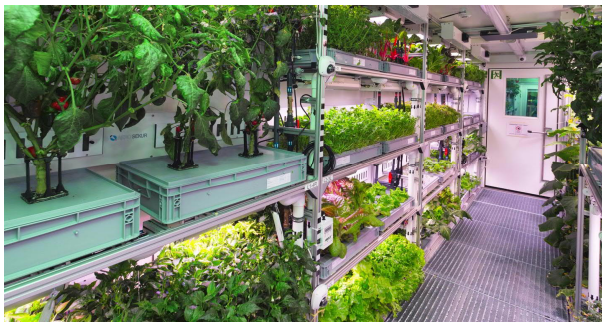


Fig. 4 Inside the EDEN ISS © DLR 2018

## 3. Study on the impact of plants in Isolation

To analyze the impact of plants on performance and well-being, 3 different tools were selected to be used during the year of isolation in conjunction with the use of EDEN-ISS greenhouse:

1. The “Human Factors debriefing” as a guided group discussion about the crew’s human factors interaction with the plants, to collect in an open manner collective ideas/opinions and lessons learned during the mission regarding interaction with the plants from the perspective of the crew.
2. Questionnaires: Dedicated questions on the interaction with the plants developed on the basis of previous investigations to assess the wishes and needs of the participants regarding interaction with plants as well as the frequency, quality, and number of individual activities with the greenhouse and the plants.
3. Final interviews were conducted after the end of the mission on the interaction with Plants and Greenhouse.

The research has been conducted in 2018, 2019 and is now ongoing in 2020 crew. With the questionnaire it has been confirmed in 2018 and 2020 a strong impact of plant interaction on well-being (Fig.5). Moreover an impact also on health was mentioned and implemented on the next investigation (Schlacht et al., 2019).

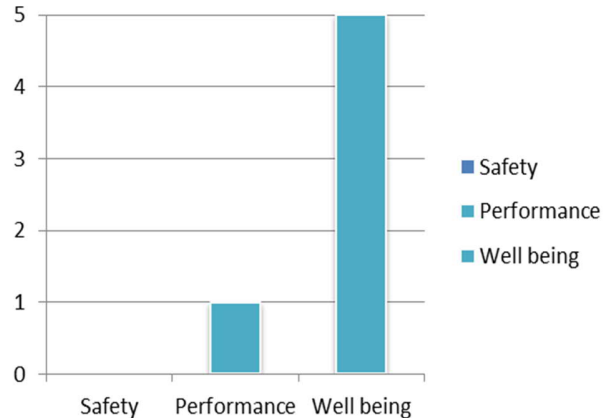


Fig. 5 Graphic on the impact of the plants in isolation. (© Schlacht, 2018)

2.8 In general, do you think that interacting with plants in isolation could improve your overall						
• well-being	0 Not At All	1 A Little	2 Moderately	3 Quite a lot	4 Extremely	5 Extremely
• motivation	0 Not At All	1 A Little	2 Moderately	3 Quite a lot	4 Extremely	5 Extremely
• social-relation	0 Not At All	1 A Little	2 Moderately	3 Quite a lot	4 Extremely	5 Extremely
• performance	0 Not At All	1 A Little	2 Moderately	3 Quite a lot	4 Extremely	5 Extremely
• health	0 Not At All	1 A Little	2 Moderately	3 Quite a lot	4 Extremely	5 Extremely
• safety	0 Not At All	1 A Little	2 Moderately	3 Quite a lot	4 Extremely	5 Extremely
• other: .....	0 Not At All	1 A Little	2 Moderately	3 Quite a lot	4 Extremely	5 Extremely

Fig. 6 Questionnaire on the impact of the plants in isolation. (© Schlacht, 2018)

The investigation in 2020 is ongoing, from the first results it has found out again that the interaction with the plants positively impact the well-being, and in particular that the green house seems to extremely improve also the health conditions (Fig.6).

The results of the post mission debriefing in 2018 (Tab.2) confirmed again a strong impact on well-being and a positive impact on psychological factors while some operational factors needed to be improved\*.

The result of this research also foresees topics worth further investigation in the field of sensory stimulus against isolation. Examples are: use of edible roots in the meal; analysis of the plants organoleptic stimuli; impact of the variety of the colors of the plants (Fig.7). In particular the variety of crops colors used in 2020 was composed by different varieties of green leaves, red and orange from tomatoes, and by a multitude colored flowers of different species. Cucumbers flowers and others flowers were also considered as one of the highlight during the dark and long overwinter isolation on Neumayer III.

\*In 2020, post-mission debriefing of the 2019’s crew was not conducted because of Covid-19 restrictions, but it will be performed again with the 2020’s and 2021’s crews)

Tab.2 Debriefing on Plants Impact in Isolation in 2018 (Schlacht, 2018)

Factor	Strength Weakness	Vote	Description of most voted matters	Impact
Psychological	+	9/9	Fresh vegetables to eat	Well-being
Psychological	+	8/9	Natural colors	Well-being
Psychological	+	8/9	Observing, living, growing	Well-being
Physiological	+	9/9	Fresh vegetables, valuable nutrition	Well-being
Operational	-	8/9	Frequent system malfunctions	Performance
Operational	-	8/9	Alarm sounds at NMIII too frequent and annoying	Well-being
Operational	-	6/9	Cameras make the greenhouse less comfortable to relax in	Well-being
Operational	-	6/9	Too much lettuce/leafy greens	Performance
Socio-Cultural	-	7/9	Interaction with plants limited to only a few people (except consumption)	Well-being



Fig. 7 Lettuce in the EDEN ISS, 2018 (© DLR / EDEN ISS, 2018).

Since 2018 it has been reported also a problem on this investigation. The crew had some difficulties in filling in the questionnaire because they do not feel it to be anonymous. In specific there are only 10 people that are there for 1 year in Neumayer III. So if you ask for any personal data (e.g. age) then you can easily identify the person. In order to increase the confidentiality it has been added in 2020:

1. Personal meeting with the crew before the mission to increase trust on the research and to personally explain that sensitive data are not reported or published anywhere.

2. A question inside the questionnaire that request if the crew member understood that sensitive data are used only on the analysis and not presented (Fig.8).

However this approach seems to do not have any impact and new strategies are now being investigated.

Fig. 8 Questionnaire: Personal Data (Schlacht, 2020)

### Conclusion

The habitability impact on the crew emerged in term of both psychological and nutritional benefit, making an important contribution to the advancement of international research on bio-regenerative systems both for the exploration of the Universe and for Earth applications. Particularly the psychological and physiological impact of the plants on the crew's well-being in isolation was assessed as positive as also foreseen by previous studies.

A future research goal is to propose the investigation at stations like Concordia in order to have a comparison crew without a greenhouse.

### Thanks

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