SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

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STSM title: Smart textiles for fog and dew harvesting
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PURPOSE OF THE STSM

The aim of this STSM was to analyse different types of textiles for fog harvesting, in order to find out which is the correct path to follow in the designing of a new efficient mesh. This evisioning novel smart texile based can be used in building and living applications, in order to make constructions water self-sufficient and achieve Net Zero Energy Buildings.

As means to reach an optimal collection of fog water the development of smart fog collectors is essential, therefore the collecting mesh. The “Raschel” is the textile that has been used in fog collection projects worldwide until now. This is not due to its good performance, instead because it is cheap and easy to find in commerce, it is the mesh most used in agriculture field. Therefore the general purpose of this scientific mission was to test different textiles, coming from various sectors, as naval, construction and agricultural, to understand which are the properties of the more performative meshes, in terms of warp, weft and materials. The hypothesis is that all the mashes tested are more appropriated for fog water collection then the Raschel mesh. The aim was to find the relation between a mesh’s features, as weight, base/height hole’s ratio, shading effect and air permeability between others. Moreover the data collected are useful to replicate the experiment in the lab. Finally the results of these tests can direct the path line for the design of the optimal mesh.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

The first step of the STSM was the design of the Standard Fog Collector, useful to test the selected meshes. It is a bi-dimensional structure composed by a square frame that measures 1m x 1m, supported by two poles of 2m high and two tensors. The high of 2m is useful to intersect a strong wind speed, which is the greater the distance from the ground, and the tensors are useful to resist wind loads. The selected meshes have been applied through strips, to the square frame. After the design, the production phase took place, therefore the author and Ricardo Gil, owner of Nieblagua, went to the smith to coordinate the production of three structures. In the meantime, some permission to occupy public soil were needed from the town council. Therefore the author with the forest rangers and the Arch. Ricardo Gil did an inspection on the selected site, located in Gaitero, at 1690 masl, in a protected area. The location of those fog collectors relates to the context, the presence and disposition of vegetation, the slope and the wind direction. So, in order to have reliable results of fog water collection from the three structures a site visit was essential to understand the right disposition of the installation.

Once the structures where ready, on Monday 19.04.21 they have been installed.

This first test phase had the purpose of determining the efficiency of each mesh compared with the common one (Raschel) and approve the hypothesis that there is much to improve in this aspect of fog harvesting. The Raschel mesh, has been applied to the first structure and it remains there during all the first phase of tests. To the others two structures all the other meshes have been applied in succession, in order to compare them with the standard mesh and then select the more performative for the second phase of tests. For each round of tests the two tested meshes had similar characteristics, in order to have a more accurate comparison.

The second phase of tests consisted in comparing again the meshes that resulted more efficient from the first phase of tests.

The duration period of each test depends on climatic conditions.

During the time of the tests, some climatic analysis have been developed, thanks to the data elaborated by the climatic station of “El Gaitero”. In order to better understand the results of the water collected by each mesh some studies have been carried out taking in account some factors as: precipitation, the percentage of relative humidity, wind speed, and direction. In particular it’s important to get the distinction between the water collected from rain and the one collected from fog. The percentage of relative humidity relates with the timing, in fact fog is formed from 90% RH but it will take more time to collect a litter of water in 95%RH conditions instead of 100%RH. The droplets suspended in the air are deposited on the mesh thanks to the winds that carry them, more speed means more collection but too high speed can push the droplets out of the gutter and make the structure or the mash broke. The impact angle of the droplets determines also the collection. Some climatic graphs have been designed.

Finally the three structures have been dismantled.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

RESULTS (Annex Table of characteristics)

First phase:

In the first phase 5 tests have been carried out. For each mesh the [%] of collection has been identified respect to the Raschel mesh.

1. The experiment took place in 6 days (19.04-24.04), it showed that 2850WO - ROBUXTA LDF GREEN (vertical chains) [+0%] and 2681BL - PRISMA MDF (Raschel mesh) (horizontal chains) got the same result, about 250ml, while 2080VN - ELAION CANDIA (horizontal chains) has collected less water, around 200 ml [-20%].
2. The experiment took place in 2 days (26.04-28.04), it showed that 2240KR - IRIDE MULTI PRO extra (horizontal chains) has collected 1300 ml [+225%], while 2341WO - LIBECCIO 30 (vertical chains) has collected 1000 ml [+150%], and 2681BL - PRISMA MDF (horizontal chains) (Raschel mesh) has collected less water, about 400ml.
3. The experiment took place in 5 days (30.04-04.05), the test showed that: HONEYCOMB mesh overflowed the tank again (>8000 ml) [min +33%], while 2681BL - PRISMA MDF (horizonal chains) (Raschel mesh) collected about 6000 ml and SOLTIS HARMONY 88 collected about 4000 ml [-33%].
4. The experiment took place in 7 days (04.05-10.05), it showed that 2633BL - PRISMA LDF(horizontal chains) has collected 7500 ml [+50%], while 6040BT – ARRICOVER (horizontal

chains) has collected 6000 ml [+20%], and 2681BL - PRISMA MDF (horizontal chains) (Raschel mesh) has collected 5000 ml.

5. The experiment took place in 4 days (10.05-14.05), it showed that 2352WO - LIBECCIO 50 (horizontal chains) has collected about 1000ml [+43%], while 2681BL - PRISMA MDF (horizontal chains) (Raschel mesh) has collected about 700ml and 3150BT - FRUCTUS 5/4 (horizontal chains) has collected about 300ml [-57%].

Second phase:

In the second phase 2 tests have been carried out.

1. The experiment took place in 10 days (14.05-24.05), the MALLA MOSQUITERA collected about 4000ml as the HONEYCOMB, while the 2240KR - IRIDE MULTI PRO extra (horizontal chains) has collected about 3900ml [-2,5%]
2. The experiment took place in 4 days (24.05-28.05), the 2341WO - LIBECCIO 30 (vertical chains) has collected 1500ml as also 2352WO - LIBECCIO 50 (vertical chains), while the 2633BL - PRISMA LDF (vertical chains) has collected a bit less, around 1400ml [-6,6%].

DISCUSSION

From the tests developed emerged that over 11 tested meshes, 6 resulted to be more efficient and 1 equal to the Raschel mesh, this means that actual fog harvesting technology can be much improved.

Regarding the shape of the hole, the rectangular one, in order to be efficient it should have a proportion of 1:4 and a prevalent chain direction, that resulted to be more efficient if positioned in the horizontal direction.

This category includes: 2341WO - LIBECCIO 30 [+150%] and 2240KR - IRIDE MULTI PRO extra [+225%]. Moving from this proportion, reducing it to 1:1, we can understand that at least one side of the square hole should be of 1,3 mm, as noticed by the previously mentioned meshes and MALLA MOSQUITERA [+227,5%]. This last mentioned mesh is the one Nieblagua uses in its projects, this is because it is much more resistant to high wind speeds then the Raschel mesh, but thanks to those tests we discovered that is not just more resistant but it is more efficient in water collection. In fact, it resulted having appropriate features, while 3150BT - FRUCTUS 5/4 [-57%] didn't, it is also characterized by square holes, but bigger. Moreover, the 3D pattern, main characteristic of HONEYCOMB [+227,5%], seemed an optimal added aspect to enhance the efficiency, because it avoid the deposited droplets to flow away. In addition this 3D shape is useful to maintain the shape of the filaments, that can be deformed due to wind pressure, as can happen in MALLA MOSQUITERA because it doesn't have any chain neither. The efficiency of HONEYCOMB resulted with the second phase test. Probably, if it had bigger holes and therefore more air permeability it would be even more efficient.

Instead, the typical triangular form of the Raschel mesh didn't have much success in fog water collection.

Moreover we can notice that the second worst mesh, SOLTIS HARMONY 88 [-33%], is different from the others in many aspects. In fact, it is the heaviest, it has the greatest shade factor and, most importantly, it doesn't have warps and wefts. Those characteristics must be taken into account in the new mesh design.

Another important aspect concerns the filaments, the most efficient meshes resulted to be the ones made by circular filaments, of around 0,28 mm of diameter, contrasting the rectangular ones, 1mm wide, of Raschel mesh.

In addition, we can deduce that the orientation of the mesh covers an important role, in fact 2240KR - IRIDE MULTI PRO extra and 2341WO - LIBECCIO 30 has almost the same characteristics, but the first one resulted more efficient because it was oriented with horizontal chains, instead the second one was oriented with vertical chains.

Finally it is important to underline that all those tests should be repeated many times, in order to have an average of the results, and so a more reliable data.

FUTURE COLLABORATIONS (if applicable)

The future steps of this research can be divided in three aspects, thanks to the creation of an international networking, those are: Replicability of measures, Validation of data in lab and on others sites and finally smart mesh design and its validation.

First, it would interesting to test simultaneously the final meshes (MALLA MOSQUITERA, HONEYCOMB, 2341WO - LIBECCIO 30 and 2352WO - LIBECCIO 50) several times, to verify the efficiency with different climatical conditions, as a means to compare them through more reliable results. Moreover a second phase of tests should be carried out analysing the meshes with a different pattern's orientation.

In addition, thanks to the results obtained during this period of experiments, and the following ones in the lab, using climatic chamber and wind tunnel, the most efficient mesh will be determined. A future step is the test of these nets in another context, as Italy and Portugal. The resulting mesh can differ, or not, from the one determined as the most efficient in lab or in Canary Islands.

Once these analyses have been completed, the aim is to design a new mesh, with the optimal fog water collection, with the help of some Textile engineers from the University of Minho – Textile engineer department (Portugal) and Ricardo Gil from the company Nieblagua. Then we have to produce a prototype, or even more, with different patterns and verify their efficiency.

Therefore the purpose is to come back to Canary Island and test the quantity that these meshes can actually collect, in a longer period of atmospheric exposure, of at least two months. This new experiment will be held with the support of Nieblagua enterprise and its patented structure upon which the selected textile will be applied. Moreover it would be interesting to test the same prototypes also in Portugal and Italy, or even in other study sites, to compare them with the previous ones.

NAME	PRODUCER	MATERIAL	WEIGHT (g/m²)	CHAINS PER INCH	HOLE DIMENSIONS (mm)	LONGITUDINAL TENSILE STRENGHT (N/m)	LONGITUDINAL ENLONGATION (%)	TRANSVERSAL TENSILE STRENGHT (N/m)	TRANSVERSAL ENLONGATION (%)	SHADE FACTOR (%)	UV STABILITY (kLy)	PERMEABILITY TO AIR	USE
39MVN - ELAKIN EXTRA	ARRIGONI	100% ARLENE® HT high tenacity polyethilene UV stabilized	64	4,5	4,3 x 7,3	7500	56	3100	58	25	300		Triple thread, square mesh. Net for harvesting olives
20MVN - ELAKIN CANDIA		100% ARLENE® HT high tenacity polyethilene UV stabilized	94	6	3,9 X 1,6	7750	41%	8491	35%	10	350		Strong protective olives net, high run resistant
22HDO - OVER MULTI PRO extra		100% ARLENE® HT high tenacity polyethilene UV stabilized	95	3	7,1x1,7	7550	41	5420	43	8	600		
29HDWO - UBOCCO 90		100% ARLENE® HT high tenacity polyethilene UV stabilized	90	3	7,1 x 1,3	5100	40	4000	44	29	500		Light wind barrier, with PES eyelets along the selvages
29DWO - UBOCCO 50		100% ARLENE® HT high tenacity polyethilene UV stabilized	105	6	3,9 X 1,6	10200	30	8000	58	50	500		Medium wind barrier, with PES eyelets every 1 m
36XBL - PRISMA LDF		100% PE HD stabilizzato U.V. / 100% HDPE U.V. stabilized	45	3	3x6	3600	97%	2500	94%	30	500	44	Light density thermo reflective screen made of HDPE flat filament. High light diffusion
26XBL - PRISMA MDF		100% PE HD stabilizzato U.V. / 100% HDPE U.V. stabilized	78	3	3x4	5600	44%	6500	51%	40	500	17	Medium-high density thermo reflective screen made of HDPE flat filament. High light diffusion
38S0WO - ROBUSTA LDF GREEN		100% PE HD stabilizzato U.V. / 100% HDPE U.V. stabilized	96	6	3x1	10500	40	5000	80	51	500	41	Low Density Factor shading screen. Chains and weft in monofilament, second weft in flat filament.
10SBRT - FRUCTUS 3/4		100% ARLENE® HT high tenacity polyethilene UV stabilized	88	WRAPS x cm: 5, WEFTS x cm: 3,6	5,8 x 7,3, Diameter filament: 0,20	13200	23	10102	18	6	700		Anti-hail, Anti-insect and anti-frost knit-weaving net
40ABRT - ARRICOVER		100% PE HD stabilizzato U.V. / 100% HDPE U.V. stabilized	78	3	4,0x1,5x1,1	5230	28	3516	38	15	400		Net for protection against insects and frost
HONEYCOMB	TEXSTORE	Polypropylene monofilament, 3D pattern	155	THREADS/inch: 41	0,4x0,4	1370 N/5cm	11,68	1168 N/5cm	11,43			Delta P (Pa) 10: 1530 l/(dm2/min)	
Soltis Harmony 88	FERRARI	High tenacity polyester micro-yarn base cloth, coating and dirt resistant surface treatment	300	8	1x1	140 N/5cm		140 N/5cm		82			
MALLA MOSQUITERA		[illegible]	[illegible] g/m2	wires: 80 x 10cm, diameter wire: 0,28	1,30x1,39	6799	27,87	8840	21,2	64	600		agriculture