

# Experimental tests for evaluating the effectiveness of essential oil mixtures for the removal of the biological patina at the *Balneum of Villa San Giovanni in Tuscia (Viterbo)*

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# AREAS SELECTED FOR THE EXPERIMENTAL TESTS



**ADAMO**

TECNOLOGIE DI ANALISI, DIAGNOSTICA E  
MONITORAGGIO PER LA CONSERVAZIONE  
E IL RESTAURO DI BENI CULTURALI



FLOOR MOSAIC WITH  
BIOLOGICAL PATINA  
AND IRON  
OXIDATION



FLOOR MOSAIC WITH  
BIOLOGICAL PATINA



PLASTERS WITH TRACES OF  
PAINTINGS AND EVIDENT  
BIOLOGICAL PATINA



UNIVERSITÀ  
DEGLI STUDI DELLA  
**Tuscia**

# AREA 1

## FLOOR MOSAIC WITH BIOLOGICAL PATINA



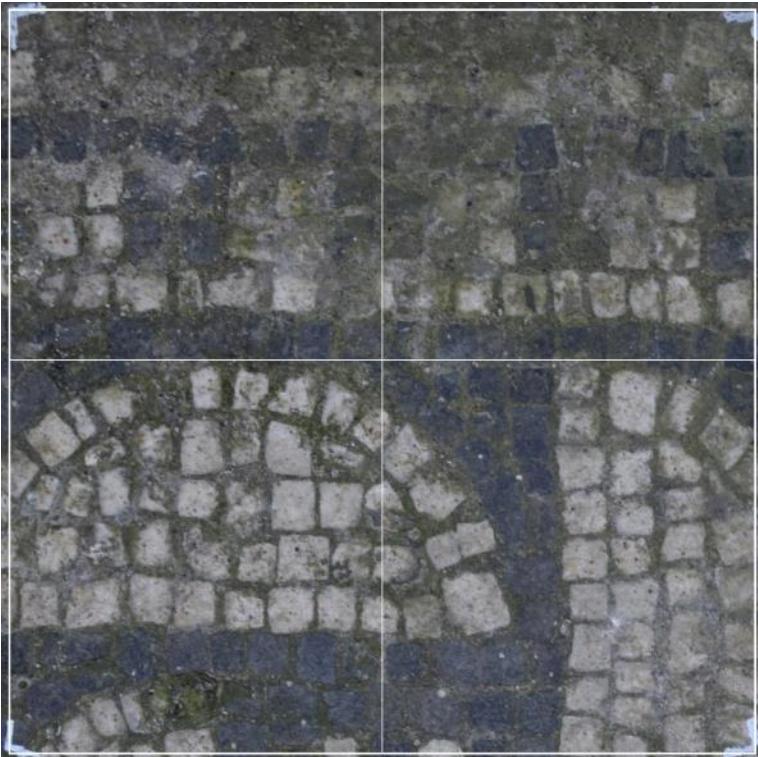
**T1 essential oil    T2 BAK**



**T1 essential oil    T2 BAK**



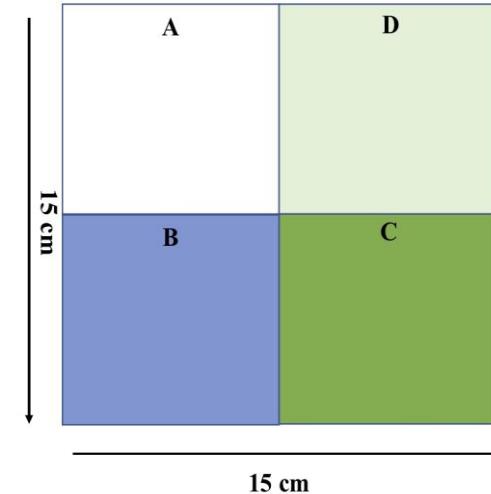
# TEST AREA 1 (T1): Essential oils



**BEFORE TREATMENT**

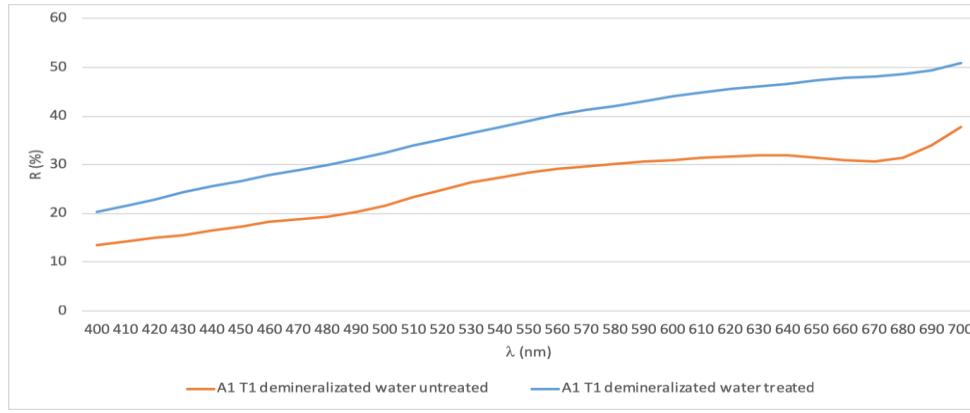


**AFTER TREATMENT**



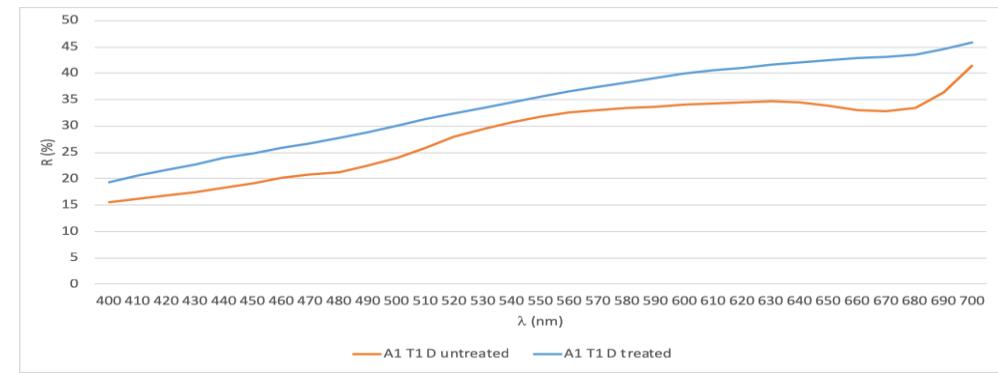
- A: demineralized water, 7 days**
- B: essential oil Mix 10 1.3% in water, 1 day**
- C: essential oil Mix 10 1.3% in water, 3 days**
- D: essential oil Mix 10 1.3% in water, 7 days**

## A: demineralized water, 7 days

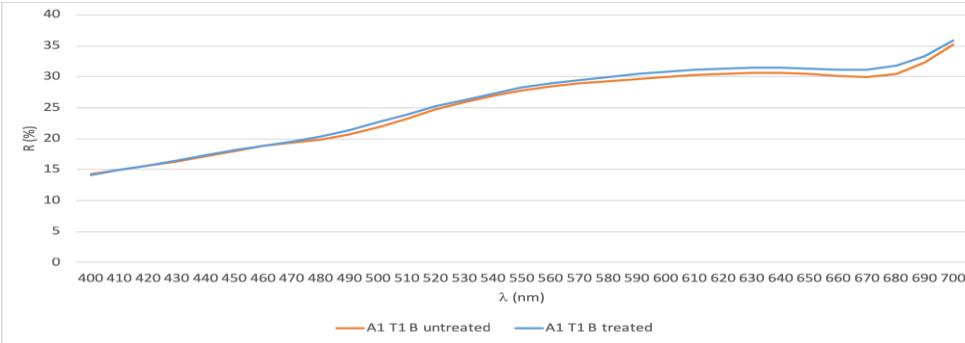


## AREA 1, T1

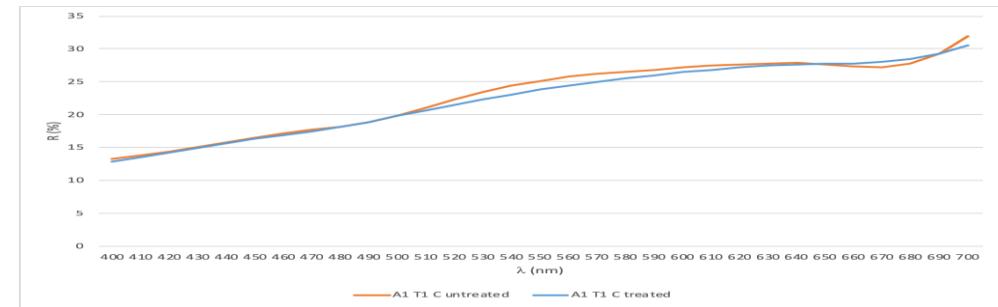
## D: essential oil Mix 10 1.3% in water, 7 days



## B: essential oil Mix 10 1.3% in water, 1 day



## C: essential oil Mix 10 1.3% in water, 3 days



			L*	a*	b*	$\Delta L^*$	$\Delta a^*$	$\Delta b^*$	$\Delta E$
A1 T1 B	MIX 10 1.3%	untreated	57.5	1.21	15.5	0.04	-0.10	0.55	0.56
A1 T1 B	MIX 10 1.3%	treated	57.6	1.11	16.0				

			L*	a*	b*	$\Delta L^*$	$\Delta a^*$	$\Delta b^*$	$\Delta E$
A1 T1 C	MIX 10 1.3%	untreated	55.3	1.34	14.3				
A1 T1 C	MIX 10 1.3%	treated	54.37	1.97	13.12	-0.90	0.63	-1.17	1.60

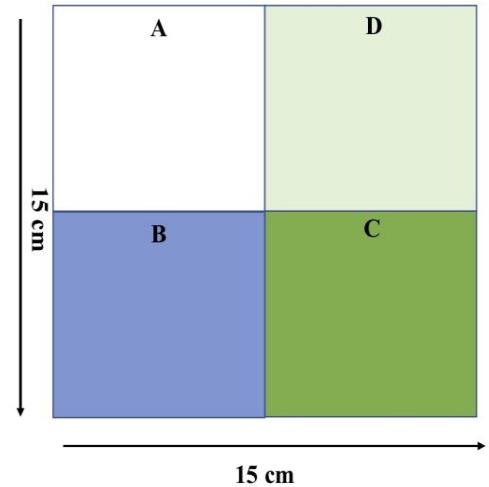
TEST AREA 1 (T 2)  
benzalkonium chloride



BEFORE TREATMENT



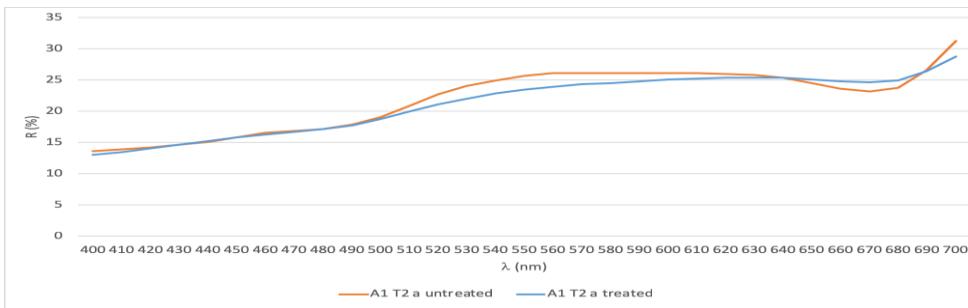
AFTER TREATMENT



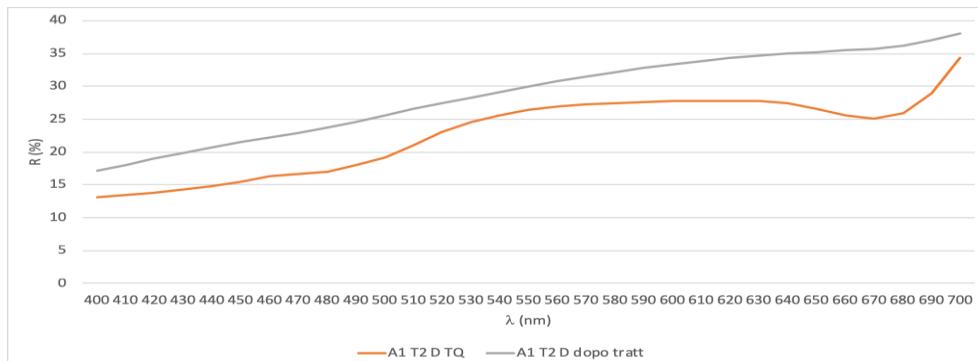
- A: demineralized water, 7 days**
- B: benzalkonium chloride 0.1% in water, 1 day**
- C: benzalkonium chloride 0.1% in water, 3 days**
- D: benzalkonium chloride 0.1% in water, 7 days**

# AREA 1 T2

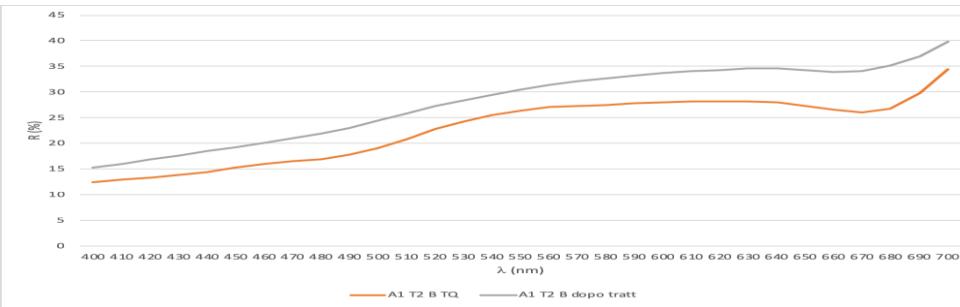
**A: demineralized water, 7 days**



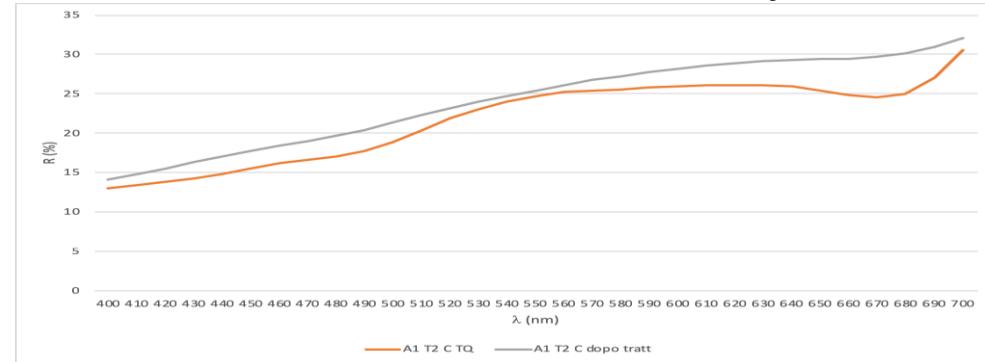
**D: BAK 0.1% in water, 7 days**



**B: BAK 0,1% in water, 1 day**



**C: BAK 0,1% in water, 3 days**



			L*	a*	b*	ΔL*	Δa*	Δb*	ΔE
<b>A1 T2 B</b>	<b>BAK 0.1%</b>	<b>untreated</b>	56.2	0.72	18.3	4.04	0.98	-1.25	4.34
<b>A1 T2 B</b>	<b>BAK 0.1%</b>	<b>treated</b>	60.2	1.70	17.0				

			L*	a*	b*	ΔL*	Δa*	Δb*	ΔE
<b>A1 T2 C</b>	<b>BAK 0.1%</b>	<b>untreated</b>	54.7	0.42	15.2	1.21	1.46	-2.30	2.9
<b>A1 T2 C</b>	<b>BAK 0.1%</b>	<b>treated</b>	55.9	1.88	12.9				8

**AREA 2**  
**PLASTER WITH TRACES OF PAINTINGS AND EVIDENT  
BIOLOGICAL PATINA**



**T1 essential oil**



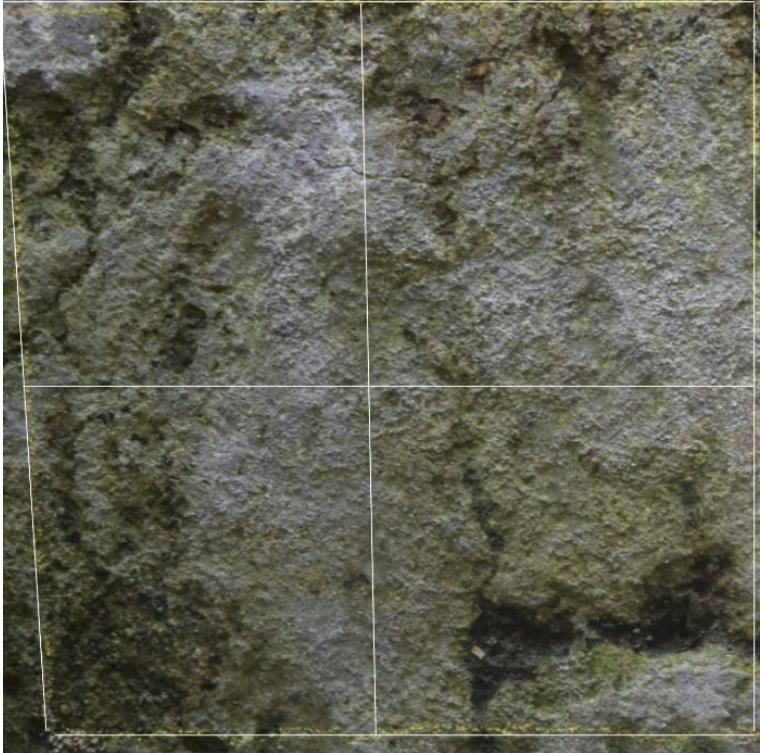
**T2 BAK**

**T1 essential oil      T2 BAK**

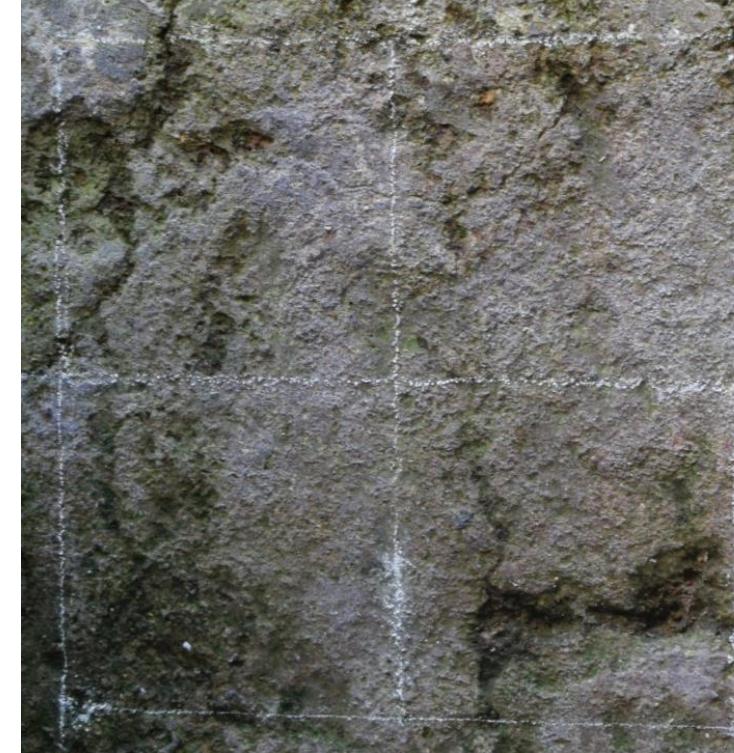


## TEST AREA 2 (T1)

### Essential oils



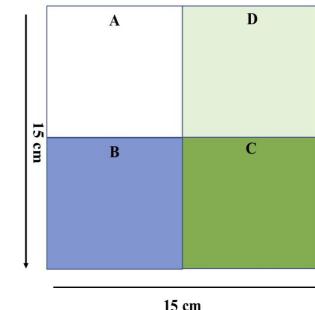
BEFORE TREATMENT



AFTER TREATMENT

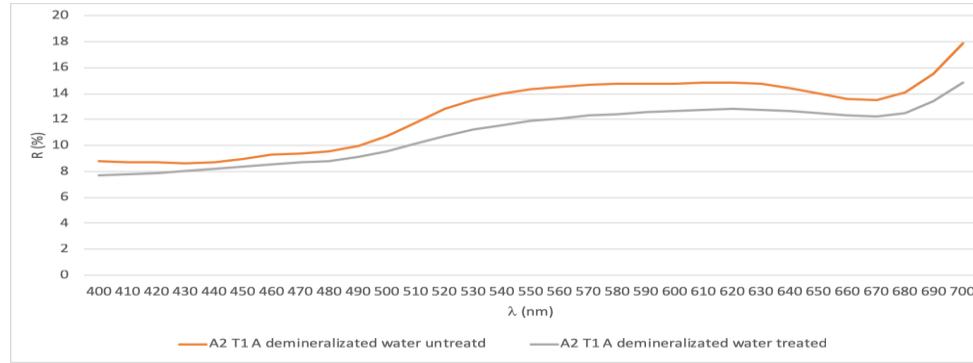


AFTER 13 DAYS OF TREATMENTS



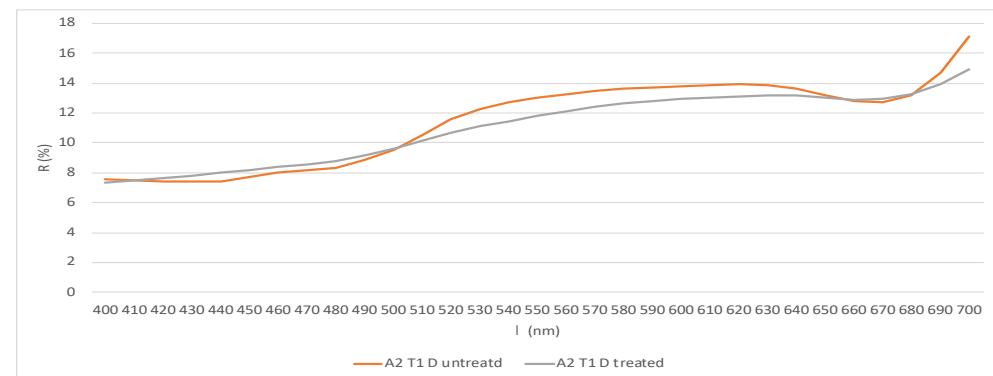
- A:** demineralized water, 7 days
- B:** essential oil Mix 10 1.3% in water, 1 day
- C:** essential oil Mix 10 1.3% in water, 3 days
- D:** essential oil Mix 10 1.3% in water, 7 days

## A: demineralized water, 7 days



## AREA 2 T1

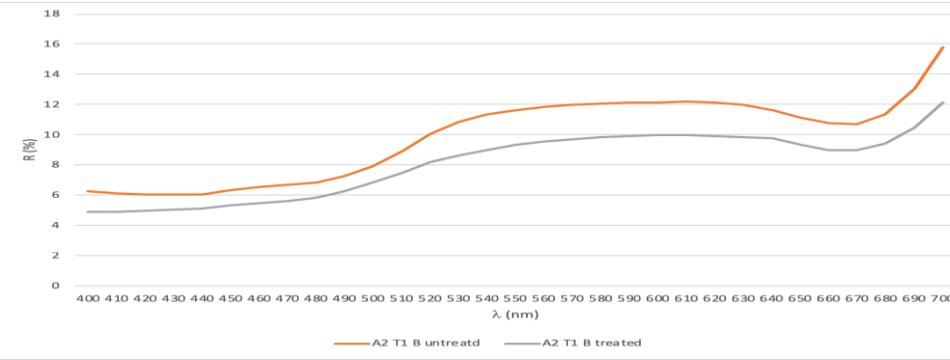
## D: essential oil Mix 10 1.3% in water, 7 days



			L*	a*	b*	ΔL*	Δa*	Δb*	ΔE
A1 T2 A	demineralized water	untreated	55.7	-0.52	15.7	-1.93	1.53	-2.50	3.51
A1 T2 A	demineralized water	treated	53.8	1.01	13.2				

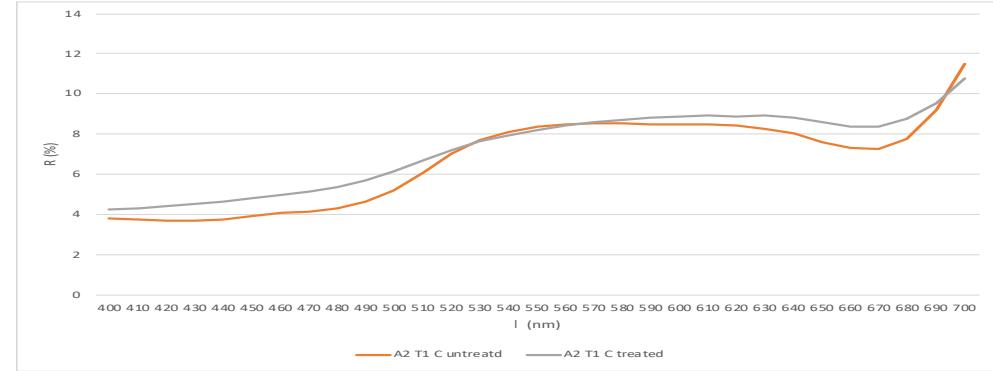
			L*	a*	b*	ΔL*	Δa*	Δb*	ΔE
A1 T2 D	BAK 0.1%	untreated	56.5	0.46	17.3				
A1 T2 D	BAK 0.1%	Treated	59.0	2.26	12.6	2.51	1.80	-4.74	5.65

## B: essential oil Mix 10 1.3% in water, 1 day



			L*	a*	b*	ΔL*	Δa*	Δb*	ΔE
A1 T2 B	BAK 0,1%	untreated	56.2	0.72	18.3	4.04	0.98	-1.25	4.34
A1 T2 B	BAK 0,1%	treated	60.2	1.70	17.0				

## C: essential oil Mix 10 1.3% in water, 3 days



			L*	a*	b*	ΔL*	Δa*	Δb*	ΔE
A1 T2 C	BAK 0.1%	untreated	54.7	0,42	15.2				
A1 T2 C	BAK 0.1%	treated	55.9	1.88	12.9	1.21	1.46	-2.30	2.98

## TEST AREA 2 (T 2) benzalkonium chloride



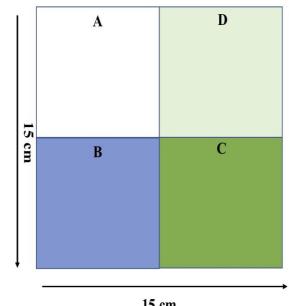
**BEFORE TREATMENT**



**AFTER TREATMENT**

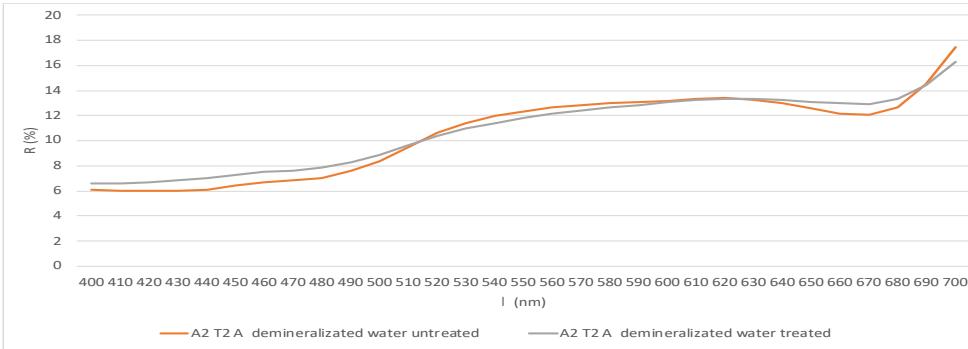


**AFTER 13 DAYS OF TREATMENT**



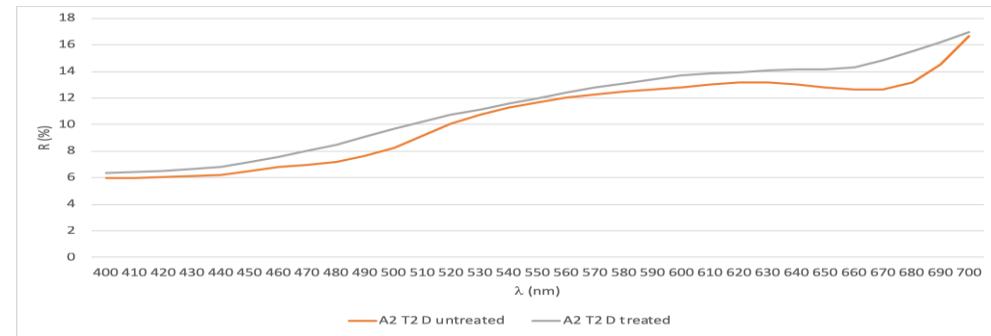
# AREA 2 T2

**A: demineralized water, 7 days**



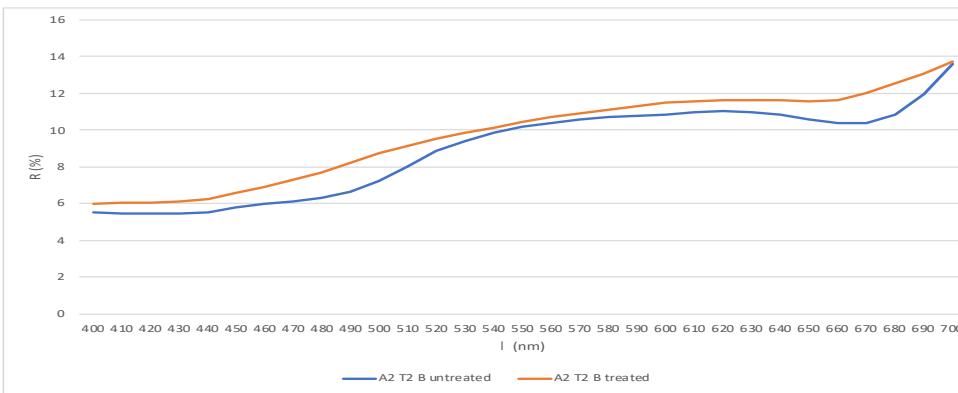
		L*	a*	b*	ΔL*	Δa*	Δb*	ΔE	
A1 T2 A	demineralized water	untreated	55.7	-0.52	15.7	-1.93	1.53	-2.50	3.51
A1 T2 A	demineralized water	treated	53.8	1.01	13.2				

**D: BAK 0.1% in water, 7 days**



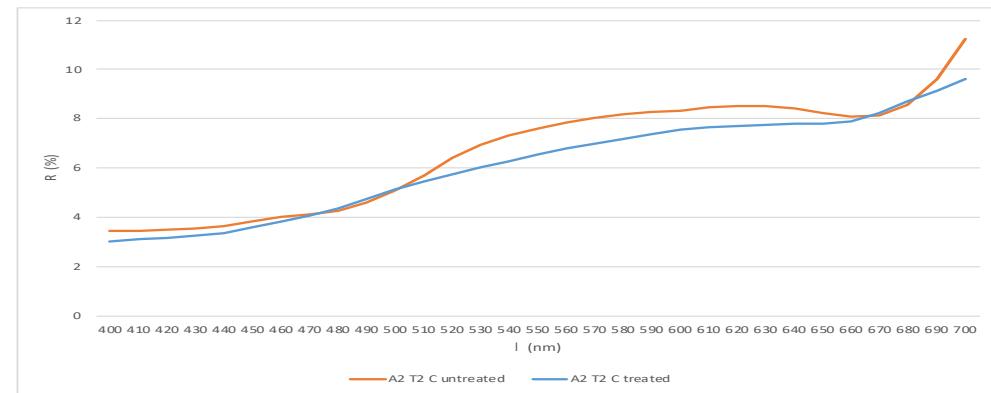
		L*	a*	b*	ΔL*	Δa*	Δb*	ΔE
A2 T2 D	BAK 0.1%	untreated	38.4	1.59	15.18			
A2 T2 D	BAK 0.1%	treated	39.5	1.83	14.01	1.04	0.24	-1.17 1.58

**B: BAK 0,1% in water, 1 day**



		L*	a*	b*	ΔL*	Δa*	Δb*	ΔE	
A2 T2 B	BAK 0,1%	untreated	36.7	0.89	13.9	1.11	-0.32	-1.81	2.14
A2 T2 B	BAK 0,1%	treated	37.8	0.57	12.2				

**C: BAK 0.1% in water, 3 days**



		L*	a*	b*	ΔL*	Δa*	Δb*	ΔE
A2 T2 C	BAK 0.1%	untreated	30.5	1.31	1522			
A2 T2 C	BAK 0.1%	treated	29.1	1.37	13.4	-1.39	0.06	-1.81 2.28

**Table 1: summary of the spectrophotometric analysis performed on the floor mosaic (test area A) and plaster (test area B).**

TEST AREA	PRODUCT	INCUBATION TIME	Chlorophyll flex (640-680 nm)		$\Delta L^*$	$\Delta a^*$	$\Delta b^*$	$\Delta E$
			UNTREATED	TREATED				
A	Mix 10 1.3% in H <sub>2</sub> O	1 day	+++	+++	0.04	-0.100	0.55	0.56
A	BAK 0.1% in H <sub>2</sub> O	1 day	+++	+++	4.04	0.98	-1.25	4.34
B	Mix 10 1.3% in H <sub>2</sub> O	1 day	+++	+++	-3.47	0.03	-1.72	3.88
B	BAK 0.1% in H <sub>2</sub> O	1 day	+++	++	1.11	-0.32	-1.81	2.14
A	Mix 10 1.3% in H <sub>2</sub> O	3 days	+++	+	-0.90	0.63	-1.17	1.60
A	BAK 0.1% in H <sub>2</sub> O	3 days	+++	+	1.21	1.46	-2.30	2.98
B	Mix 10 1.3% in H <sub>2</sub> O	3 days	+++	+++	1.30	1.01	-3.19	3.59
B	BAK 0.1% in H <sub>2</sub> O	3 days	+++	+	-1.39	0.06	-1.81	2.28
A	Mix 10 1.3% in H <sub>2</sub> O	7 days	+++		3.99	1.52	-3.21	5.34
A	BAK 0.1% in H <sub>2</sub> O	7 days	+++		2.51	1.80	-4.74	5.65
B	Mix 10 1.3% in H <sub>2</sub> O	7 days	+++	+	-1.08	0.51	-3.33	3.54
B	BAK 0.1% in H <sub>2</sub> O	7 days	+++	+	1.04	0.24	-1.17	1.58
A	H <sub>2</sub> O	7 days	+++	+	9.57	1.48	-1.34	9.78
A	H <sub>2</sub> O	7 days	+++	++	-1.93	1.53	-2.50	3.51
B	H <sub>2</sub> O	7 days	+++	+++	-2.53	0.85	-3.15	4.13
B	H <sub>2</sub> O	7 days	+++	+++	-1.93	1.53	-2.50	3.51

The inflection between 640 and 680 nm is an indication of the vital activity of the pathogen and identifies the chlorophyll. +++ is used when the inflection is clearly evident (active vegetative form), ++ when the inflection is of medium intensity (average active vegetative form), and + when it is scarcely identifiable (scarcely active vegetative form)



## ACKNOWLEDGMENTS

This work is still in progress and is developed within the practical activities of the course LMR/02: Conservation and Restoration of Cultural Heritage of University of Tuscia, in collaboration with the restorers Livia Alberti and Maria Cristina Tomassetti and the students of PFP1.