TRIALS OF SOLUBLE SALT REMOVAL FROM POROUS MATERIALS BY MEANS OF EXTRACTION POULTICES

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Abstract

Two masonry surfaces, one of brick and another of brick wall covered with venetian "Marmorino" plaster render on the first floor of Palazzo Minotto in Venice, were chosen to assess the extraction capabilities of soluble salts by the "*Westox Cocoon*" poultice produced by Westlegate Pty. Revesby, Australia, in comparison to the standard system used in current practice composed of a mixture of *Arbocel + Sepiolite*.

The performance of the poultices was evaluated by determining the salt content in the poultice materials (direct extractive capacity) and in the treated wall surfaces (indirect extractive capacity) by comparison before and after two poulticing applications. The salt content of the experimental areas was measured in samples taken at various depths with a drill.

The results have shown, in samples taken at various depths after the second application, a very similar residual presence of salts both in the brick and in the Marmorino for the two treatments.
Instead, the situation after the first application shows a different behaviour depending on the type of poultice used. The walls treated with Westox Cocoon show a decrease in the saline content in the most superficial layers while those treated with Arbocel + Sepiolite show an increase in saline content in depth as if this poultice summoned the salts from within the wall without being able to absorb them. As regards the extraction capacities, this is significantly more constant for the Westox Cocoon poultice, which shows to be able to extract a good amount of salt after the first poulticing. This amount increases with the second application. The Arbocel + Sepiolite poultice seems, initially after the first application, to summon the salts from within the wall without being able to extract them. For this poultice these last results indicate clearly, more so than for Westox Cocoon, the need for least two applications in sequence.

1 - Introduction

The ICVBC, Institute for Conservation and Improvement of Cultural Heritage of the CNR (Italian National Research Council), together with EdilVenezia Spa has conducted an assessment on site of methods of extracting soluble salts from masonry both by traditional and by innovative poultices. The experimental areas are located in two rooms on the first floor of Palazzo Minotto in Venice. The performances of the poultices in question were evaluated by determining the salt content in both poultices (direct extractive capacity) and in the treated wall surfaces (indirect extractive capacity) by comparing the salt content of samples taken by drilling at various depths in the experimental areas before and after poulticing.

2 – Poultices

The poultices tested were:
1- Westox Cocoon (WeC) - Ready to use paste in 5 litre buckets of 12% aqueous solution (density = 1.15)
2- Arbocel + Sepiolite (ArS) - Prepared just before application by mixing: 12 gr of Sepiolite (Tolsa, S.A), 12 gr of Arbocell Technocel 1000-1 (CFF GmbH & Co. KG) and 350 ml deionised water (density = 1.06) until homogeneous.

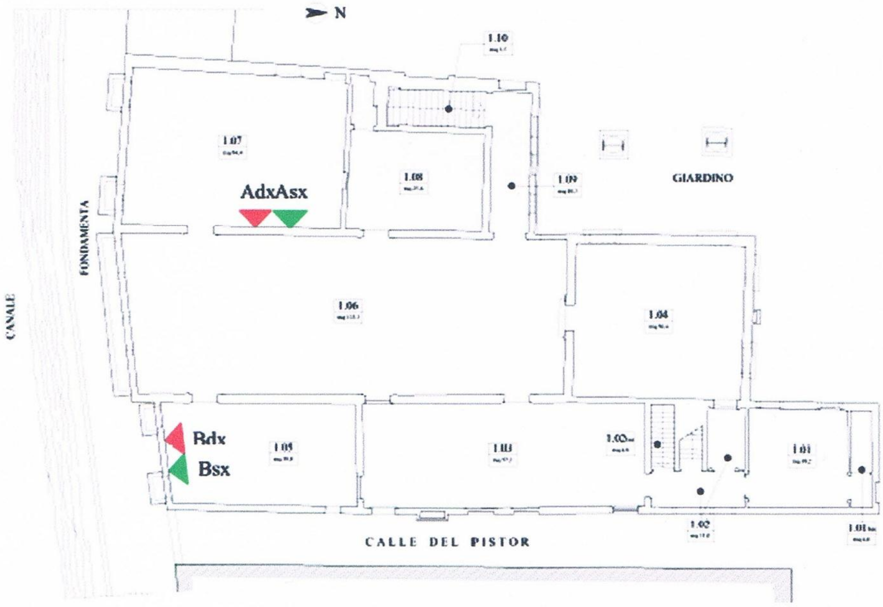
3 - Characteristics of the pilot-areas chosen for testing

The areas selected after preliminary inspection at Palazzo Minotto were two rooms located on the first floor having the following characteristics (Fig. 1 and plan of the first floor of Palazzo Minotto):
- An area of face view brick devoid of plaster in room 1.07;
- An area of brick wall covered with "Marmorino" Venetian plaster, in room 1.05;

Two areas of about ½ square meter for each of the two types (Brick and Marmorino) were chosen, on each was applied the two kinds of poultices to be tested (WeC and ArS). See Fig. 2.

PALAZZO MINOTTO, Venice - POULTICING TEST AREAS - 15/01/2007

- **COCOON (right)** — **A - BRICK**
- **ARBOCEL+SEPIOLITE (left)** — **B - MARMORINO**



FIRST FLOOR - PLAN VIEW

Figure 1 – Palazzo Minotto, Venice: on the left the room with the brick wall (Room 1.07) - on the right the area with brick wall coated with Marmorino plaster (Room 1.05)

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4 - Poulticing and sampling protocols

4a – Sampling of the test areas.

On the selected areas (Fig. 1) sampling was by drilling, with collection of powder, at three different depths (Ist = 0-5 mm; IInd = 5-15mm; IIIrd = 25-50 mm)before application of the poultices(samples before)

The procedure called for the collection of dust samples in the centre of each treated area after two successive applications of the poultices(step 1 and Step 2) of uniform thickness (about 1 cm) left in contact with the surfaces for a period of about 20-30 days (samples after).

4b –Sampling of the poultices

From each poultice, two pieces of equal area were sampled for salt content after extraction in water of the soluble salts and subsequent analysis after the Ist and the IInd applications. The table shows the list of samples taken at the various stages of intervention.

Phases	Sample from	Test area	Poultice type	N.of samples	Analyses per sample	Days of contact	Total
Step1	Brick	A1p	Westox Cocoon1	1 before	3	0	3
A1d	Westox Cocoon1			1 after	3	20-30	3
A2p	Arbocell/sepiolite			1 before	3	0	3
A2d	Arbocell/sepiolite			1 after	3	20-30	3
Poultice	Ia1d		Westox Cocoon1	1 after	1	20-30	1
Ia2d	Arbocell/sepiolite			1 after	1	20-30	1
Step1	Marmorino	B1p	Westox Cocoon1	1 before	3	0	3
B1d	Westox Cocoon1			1 after	3	20-30	3
B2p	Arbocell/sepiolite			1 before	3	0	3
B2d	Arbocell/sepiolite			1 after	3	20-30	3
Poultice	Ib1d		Westox Cocoon1	1 after	1	20-30	1
Ib2d	Arbocell/sepiolite			1 after	1	20-30	1
Total analyses Step 1							**28**
Step2	Brick	A1dd	Westox Cocoon2	1 after	3	20-30	3
A2dd	Arbocell/sepiolite			1 after	3	20-30	3
Poultice	Ia1dd		Westox Cocoon2	1 after	1	20-30	1
Ia2dd	Arbocell/sepiolite			1 after	1	20-30	1
Step2	Marmorino	B1dd	Westox Cocoon2	1 after	3	20-30	3
B2dd	Arbocell/sepiolite			1 after	3	20-30	3
Poultice	Ib1dd		Westox Cocoon2	1 after	1	20-30	1
Ib2dd	Arbocell/sepiolite			1 after	1	20-30	1
Totale analyses Step 2							**16**
General Total of analyses (Step 1+2)							**44**

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4c - Testing procedures

The samples collected were given coded numbers and were subjected to water extraction and analyzed by Ion-Chromatography procedure according to Italian Norm UNI 11087-2003. The salt content was expressed in all cases, as percent by weight of total soluble salts and singly of the following ionic species: Cations: Calcium - Magnesium - Sodium - Potassium; Anions: Nitrates - Sulphates - Chlorides.

The contents of any pre-existing salts in the poultices, expressed as a percentage by weight of the same material as that of the poultices was determined. The values obtained (diatomite of the WeC 0078 =%; sepiolite of ArS = 0319%) were very modest - although more relevant to Sepiolite - and were deemed finally to be irrelevant.

Figure 2 - The poultices on the two types of substrate (bricks at the top - Marmorino below): Westox Cocoon on left and Arbocell + Sepiolite on the right

5 - Results

The following table shows the analytical results expressed as a percentage by weight of anions and cations, determined in dust samples collected in the various media (bricks and marmorino) at 3 different depths both before and after the two successive applications of each type of poultice.

MARMORINO								
WeC								
	Na	K	Ca	Mg	Cl	NO3	SO4	TOTAL SALTS
I° depth - before	1.688	0.351	2.694	0.327	1.582	0.435	0.192	**7.269**
I° depth - after I application	0.645	0.111	2.030	0.306	0.438	0.418	0.135	**4.082**
I° depth - after II application	0.098	0.145	1.005	0.062	0.568	0.125	0.071	**2.072**
II° depth - before	1.491	0.247	2.833	0.259	0.895	0.327	0.142	**6.194**
II° depth - after I application	0.595	0.098	2.606	0.231	0.108	0.531	0.002	**4.171**
II° depth -after II application	0.112	0.148	0.867	0.083	0.658	0.152	0.176	**2.197**
III° depth - before	1.412	0.173	1.919	0.203	0.437	0.224	0.169	**4.537**
III° depth - after I application	0.759	0.190	2.422	0.308	0.301	0.186	0.078	**4.243**
III° depth - after II application	0.112	0.149	0.808	0.080	0.653	0.159	0.113	**2.074**
Ar+S								
I° depth - before	0.987	0.295	3.202	0.346	1.462	0.293	0.120	**6.705**
I° depth - after I application	0.140	0.149	0.668	0.108	0.793	0.225	0.032	**2.115**
I° depth - after II application	0.068	0.140	0.592	0.131	0.194	0.043	0.015	**1.183**
II° depth - before	0.743	0.171	1.977	0.216	0.401	0.086	0.027	**3.621**
II° depth - after I application	0.596	0.208	2.432	0.265	0.418	0.414	0.129	**4.461**
II° depth -after II application	0.075	0.167	0.566	0.129	0.095	0.015	0.015	**1.062**
III° depth - before	0.653	0.145	1.433	0.156	0.143	0.024	0.026	**2.580**
III° depth - after I application	0.890	0.216	3.914	0.536	0.572	0.368	0.130	**6.627**
III° depth - after II application	0.055	0.186	0.729	0.127	0.051	0.012	0.003	**1.163**

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BRICKS								
				WeC				
	Na	K	Ca	Mg	Cl	NO3	SO4	TOTAL SALTS
I° depth - before	1.186	0.372	0.769	0.135	2.016	0.137	0.026	**4.641**
I° depth - after I application	0.477	0.194	0.430	0.037	0.807	0.052	0.015	**2.012**
I° depth - after II application	0.291	0.201	0.698	0.063	0.693	0.034	0.029	**2.010**
II° depth - before	1.758	0.478	1.219	0.226	3.233	0.187	0.018	**7.120**
II° depth - after I application	1.416	0.366	2.768	0.316	0.041	3.609	0.049	**8.563**
II° depth -after II application	0.098	0.215	0.530	0.130	1.040	0.080	0.037	**2.129**
III° depth - before	1.474	0.694	4.017	0.234	3.071	0.229	0.042	**9.760**
III° depth - after I application	1.343	0.476	2.213	0.327	0.110	4.092	0.172	**8.732**
III° depth - after II application	0.691	0.472	0.714	0.113	0.814	0.141	0.015	**2.959**
				Ar+S				
I° depth - before	1.912	0.616	1.533	0.338	3.436	0.148	0.039	**8.021**
I° depth - after I application	1.925	0.357	2.434	0.237	0.221	3.352	0.095	**8.621**
I° depth - after II application	0.365	0.259	0.864	0.207	0.948	0.065	0.035	**2.741**
II° depth - before	1.598	0.571	1.342	0.374	2.975	0.279	0.050	**7.189**
II° depth - after I application	1.274	0.338	2.406	0.409	0.043	2.931	0.062	**7.463**
II° depth -after II application	0.500	0.365	0.699	0.094	0.993	0.094	0.026	**2.771**
III° depth - before	1.794	0.763	3.416	0.583	3.356	0.379	0.043	**10.334**
III° depth - after I application	0.804	0.500	0.620	0.128	3.323	0.549	0.427	**6.262**
III° depth - after II application	0.519	0.328	0.656	0.131	1.001	0.109	0.022	**2.765**

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POULTICES								
WeC								
	Na	K	Ca	Mg	Cl	NO3	SO4	TOTAL SALTS
Mamorino 1 poultice	0.843	0.501	1.152	0.242	2.484	0.544	0.066	**5.831**
Marmorino 2 poultice	0.359	0.399	1.264	0.227	2.039	0.497	0.081	**4.867**
Brick 1 poultice	2.913	0.073	3.403	0.303	5.405	0.725	0.259	**13.081**
Brick 2 poultice	3.532	0.435	4.257	0.489	6.395	0.733	0.150	**15.991**
Ar+S								
Mamorino 1 poultice	2.132	0.293	0.129	0.047	2.476	0.255	0.065	**5.397**
Marmorino 2 poultice	0.346	0.222	1.568	0.666	3.221	0.994	0.107	**7.125**
Brick 1 poultice	1.620	0.203	1.026	0.216	3.363	0.126	0.088	**6.641**
Brick 2 poultice	1.032	0.494	2.229	2.075	3.236	1.013	0.795	**10.793**

SALTS IN THE POULTICE MATERIAL

	Na	K	Ca	Mg	Cl	NO3	SO4	TOTAL SALTS
Sepiolite (Ar+S)	0.037	0.056	0.06	0.044	0.036	0.03	0.056	**0.319**
Diatomite (WeC)	0.011	0.004	0.06	0.007	0.014	0.006	0.006	**0,078**

6 - Indirect extractive Capacity

Table 1 shows the values calculated as the percentage(%) differences between the total saline content in the different substrates poulticed for each pair poultice/material: (before value - after value)x100/(before value). The performance of these percentage differences for the two types of poultice is shown in Figure 3 for Marmorino and in Figure 4 for Brick.

Marmorino	before -> after step1	before -> after step2	before step1 -> after step2
WeC	30.6	64.8	49.3
ArS	-2.3	73.6	74.2
Brick			
WeC	10.3	67.0	63.2
ArS	12.5	67.6	63.0

Table 1 - Differences in percentages by weight of salt in the substrate samples. Before and after the first poulticing; before and after the second poulticing; between first and second poulticing.

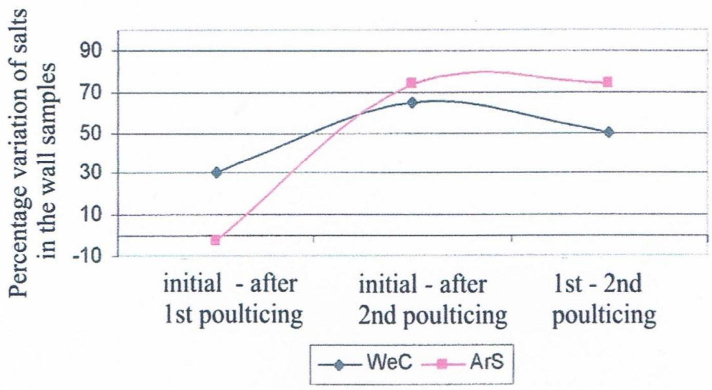

Figure 3 - Percentage variation of salts in the Marmorino samples

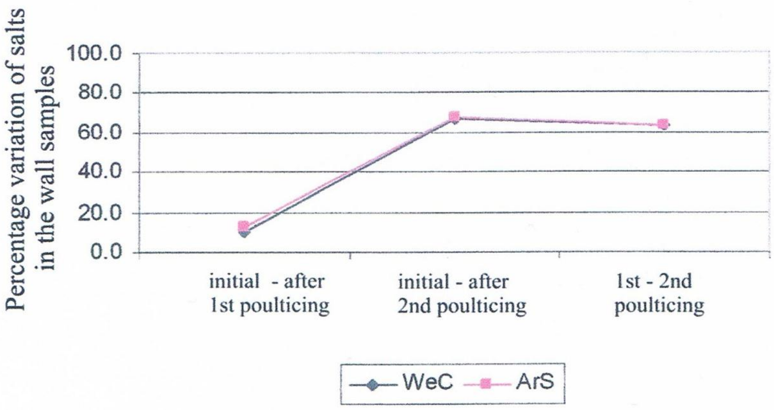

Figure 4 - Percentage variation of salts in the Brick samples

Considering the detail we can observe that after application of two poulticings the amount of salt in samples taken from various depths in *brick* and in *Marmorino* are almost equal. Instead, the first poulticing show a different behaviour depending on the type of poultice used. WeC shows an initial decrease in the most superficial strata while for ArS there is an increase in saline content in depth as if this pack had drawn salts from within without being able to absorb them.

For *brick* substrates, the residue of salts after the two poulticings are again very similar for the two extraction systems. We can, however, observe the same behaviour of the ArS poultice with recalling of salts in surface without absorption, while extraction seems more regular with the WeC poultice.

Considering the trends of Figures 3-4 we can see how the two poultices are equivalent in their ability to draw the salts from the two types of substrate, especially from the brick wall. In the case of Marmorino there are differences, especially after the first poulticing, where ArS has attracted less salt than the WeC, but it seems more active after the second application.

7 - Direct extractive capacity (EC).

In order to evaluate the direct extractive capacities (EC) of the two types of poultices, calculated per unit of poultice volume, the percentage by weight figures shown in Table 2 were subsequently developed (see Table 3) considering the different densities of the two poultices (1.15 and 1.06 for WeC for ArS). The EC value is expressed per unit volume as the exact volumes of the poultice samples containing the salts were not certain.

WeC		
	MARMORINO	BRICK
Appl I	5.831	13.081
Appl II	4.867	15.991
ArS		
	MARMORINO	BRICK
Appl I	5.397	6.641
Appl II	7.125	10.793

Table 2 – Percentage by weight of total salts in the samples of the two types of poultice.

	A poultice + salts		**B** % salts in the poultice		**C** total salts extracted		**D** poultice Vol. (1cc)		**EC**	
Substrato	WeC	ArS	WeC	ArS	WeC	ArS	WeC	ArS	**WeC**	**ArS**
BRICK 1	0.28	0.64	13.08	6.64	0.04	0.04	0.21	0.60	**17.31**	**6.64**
BRICK 2	0.37	0.47	15.99	10.79	0.06	0.05	0.27	0.42	**21.89**	**11.83**
MARMORINO 1	1.05	1.07	5.83	5.40	0.06	0.06	0.86	1.01	**7.12**	**5.92**
MARMORINO 2	1.06	1.03	4.87	7.13	0.05	0.07	0.88	0.96	**5.88**	**7.26**

Table 3 – Development of original figures for the calculation of the extractive capacities of the poultices

$$\textbf{C = extracted salts} = \frac{weightA \times weightB}{100}$$

$$\textbf{D = poultice volume WeC} = \frac{weightA - weightC}{1.15}$$

$$\textbf{D = poultice volume ArS} = \frac{weightA - weightC}{1.06}$$

$$\textbf{EC = extractive capacity x 100} = \frac{weightC \times 100}{D}$$

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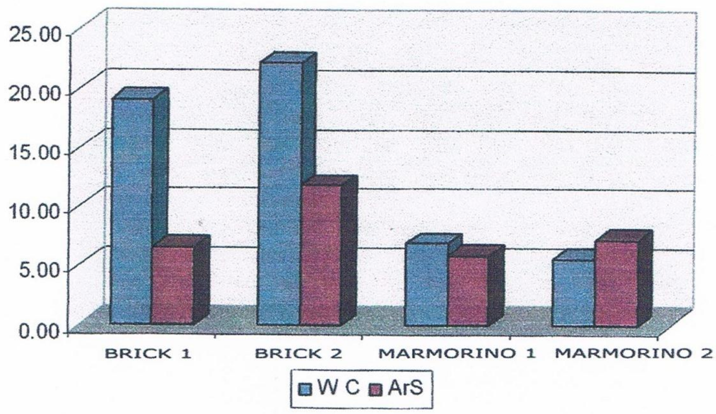

Figure 5 - Comparison of the direct extractive capacities of the two poultices upon the substrate materials

Figure 5 shows how on brick substrate the WeC system has a greater direct extractive capacity with respect to the ArS system, while on Marmorino substrate the extractive capacities of the two systems appear to be more or less equivalent. On Marmorino substrate the second ArS application always shows more extraction with respect to the first, while for WeS this occurs only on brick.

8 - Conclusions

On the basis of the data compiled and of the graphs it can be observed that both extraction systems are effective in the removal of salts after two rounds of poulticing, more or less in the same degree in the two types of substrate.

With regard to the extractive capacity, expressed as the weight of salts extracted per unit of volume of the poultices, this is significantly more constant for the WeC, which shows a good removal of salt after the first poulticing, increased by the second poulticing.
The ArS poultice seems, initially after 1 poulticing, to recall salts from within without extracting them. This clearly indicates the need, more so than for WeC, for at least two poulticing cycles.

The conclusions we can draw confirm the effectiveness of both extraction poultices, as well as the need to effect, particularly for ArS, always at least two applications. Moreover, it highlights a more constant extraction capacity for the WeC poultice, even if the results after the second poulticing are fairly similar for both types. Thus the choice of the use of either type should be based first of all upon actual site requirements, also in relation to a costs-benefits analysis, as the WeS product ready-to-use costs more but can be applied by spraying.

Thanks

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