Hydrological character of reconstituted and natural soils: comparison of physical analysis and pedotransfer functions (PS3a.41)

Paolo Manfredi[1], Chiara Cassinari[2], Andrea Bosoni[1], Marco Trevisan[2]
1 m.c.m. Ecosistemi s.r.l., Gariga di Podenzano, Piacenza
2 Istituto di Chimica Agraria e Ambientale, Università Cattolica del Sacro Cuore, Piacenza

Reconstituted soil: soil derived from degraded soil to wich was applied a process of reconstitution.
The technology of reconstitution is based on a chemical-mechanical treatment (patented by Ecosistemi s.r.l.) of degraded soil with an initial disgregation of the same one followed by its reconstitution incorporating soil matrices, a subsequent policondensation with humic acids and final restoration.
The reconstitution method improves degraded soils throught a controlled incorporation of organic matter by process that originate neoaggregates of soil with different physico-chemical and microbiological characters from the original one.

The following table compares chemical characters of natural and reconstituted soils.

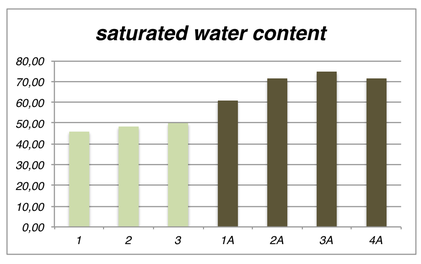
	sample	sand	clay	silt	pH	bulk density	$CaCO_3$	salinity	tot C	org C	O.M.	tot N	tot S	P (Olsen)	P_2O_5
		(g/Kg)	(g/Kg)	(g/Kg)		(g/cm^3)	(g/Kg)	(dS/m)	(%)	(g/kg)	(g/kg)	(g/kg)	(g/kg)	(mg/kg)	(mg/kg)
natural soils	1	403	150	447	8,1	1,86	213,57	0,320	3,80	12,89	22,22	2,30	0,53	67,63	154,97
	2	317	160	523	8,2	1,53	174,52	0,214	3,37	11,80	20,34	1,60	0,32	62,21	142,54
	3	344	130	526	8,0	1,53	218,15	0,239	3,48	11,73	20,22	1,70	0,34	54,44	124,74
	mean	**355**	**147**	**498**	**8,1**	**1,64**	**202,08**	**0,258**	**3,55**	**12,14**	**20,93**	**1,87**	**0,40**	**61,42**	**140,75**
	devst				0,1	0,19	23,98	0,06	0,22	0,65	1,12	0,38	0,12	6,63	15,19
reconstituted soils	1A	203	175	622	7,7	1,15	114,99	0,357	5,80	44,75	77,15	4,50	0,95	83,79	191,99
	2A	395	27	578	8,0	1,11	221,17	0,708	7,84	44,37	76,49	3,50	0,57	68,97	158,05
	3A	374	195	432	7,9	0,99	211,36	0,913	7,32	48,34	83,34	3,90	0,50	67,66	155,04
	4A	348	33	619	8,0	1,08	173,13	1,230	5,87	38,16	65,79	3,80	0,73	75,12	172,15
	mean	**330**	**107**	**563**	**7,9**	**1,08**	**180,16**	**0,802**	**6,71**	**43,90**	**75,69**	**3,93**	**0,69**	**73,89**	**169,31**
	devst				0,1	0,07	48,14	0,37	1,03	4,23	7,29	0,42	0,20	7,36	16,86

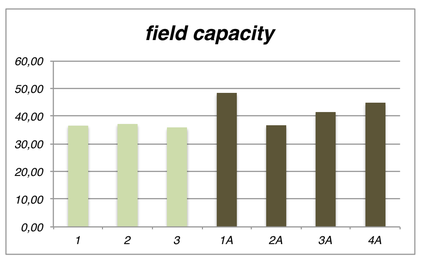
The comparison between natural and reconstituted soils hydrological properties allowed to validate the goodness of reconstitution by improving this soil physical character. The results of the instrumental data confirm this improvement.

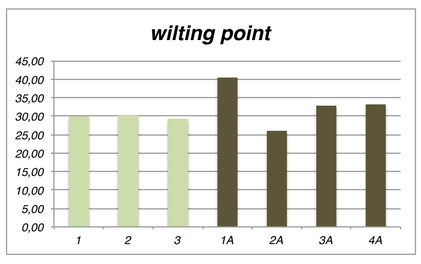
Volumetric water content (θ%) from instrumental analysis at different pressure values.
The analysis was performed through tensiometric cassette and Richard's plates.

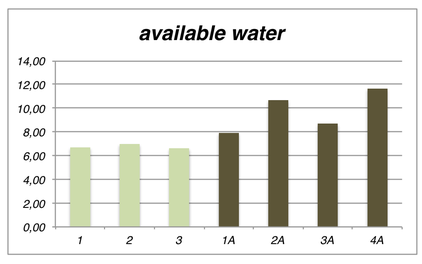
Sample	Pressione (-KPa)									
	0,1	1	3,16	10	31,6	100	316,2	501,2	1000	1496,2
1	46,63	45,18	41,37	40,30	37,53	36,31	35,61	35,11	34,64	32,56
1	42,58	40,43	37,37	36,43	34,64	33,78	32,70	31,99	31,23	30,03
2	49,14	42,91	40,52	38,18	37,16	35,79	34,24	33,09	31,75	29,77
2	47,48	42,99	40,03	38,64	34,72	33,93	33,36	33,14	32,67	30,60
3	50,44	43,36	41,16	39,77	36,36	35,22	34,60	34,18	32,69	31,28
3	49,55	41,03	37,32	35,48	31,77	30,72	30,26	29,96	28,60	27,19
1A	61,95	58,05	55,81	52,45	49,75	48,83	46,22	44,55	44,47	43,12
1A	59,49	53,63	50,68	47,39	43,81	43,02	41,00	40,21	39,96	37,78
2A	75,45	57,06	48,73	41,27	35,15	33,96	31,96	30,62	30,56	27,72
2A	67,39	51,56	43,97	37,78	32,60	31,45	28,93	27,74	27,60	24,29
3A	76,32	60,29	49,89	43,39	40,44	39,37	37,18	35,30	35,30	32,53
3A	73,06	56,03	49,04	43,54	38,58	37,98	36,76	35,84	35,81	33,05
4A	78,09	65,37	53,83	51,30	41,83	40,36	38,97	38,67	37,27	34,55
4A	64,93	60,42	49,96	47,83	38,31	37,10	35,77	35,49	34,55	31,79

Comparison between the water content at different pressure values for all the soils









The instrumental data of the water content at different pressures were compared with data derived by pedotransfer functions (PTFs). PTFs: mathemathical models which correlate the water retention and hydraulic conductivity with some easily-measurable chemical and physical properties of the soil such as texture, density, porosity, and organic carbon content. The PTFs used are based on two models: Mualem van - Genuchten and Brooks- Corey.

The van Genuchten (1980) water retention equation:

$$\frac{\theta-\theta_r}{\theta_s-\theta_r}=\frac{1}{\left[1+(\alpha h)^n\right]^m}$$

The Brooks and Corey (1964) model:

$$\frac{\theta-\theta_r}{\phi-\theta_r}=\left(\frac{h_b}{h}\right)^{\lambda},\ h>h_b;\qquad 1,\ h\le h_b$$

θ = volumetric soil water content (cm^3 cm^{-3});
θ_r= residual soil water content (cm^3 cm^{-3});
θ_s = saturated soil water content, (cm^3 cm^{-3});
φ = soil porosity, (cm^3 cm^{-3});
λ = pore size distribution index (dimensionless);
h = capillary pressure (cm);
h_b = air-entry pressure (cm);
α = parameter of the van Genuchten equation corresponding approximately to the inverse of the air-entry value, (cm^{-1});
m, n = empirical shape-defining parameters in the van Genuchten equation, (dimensionless).

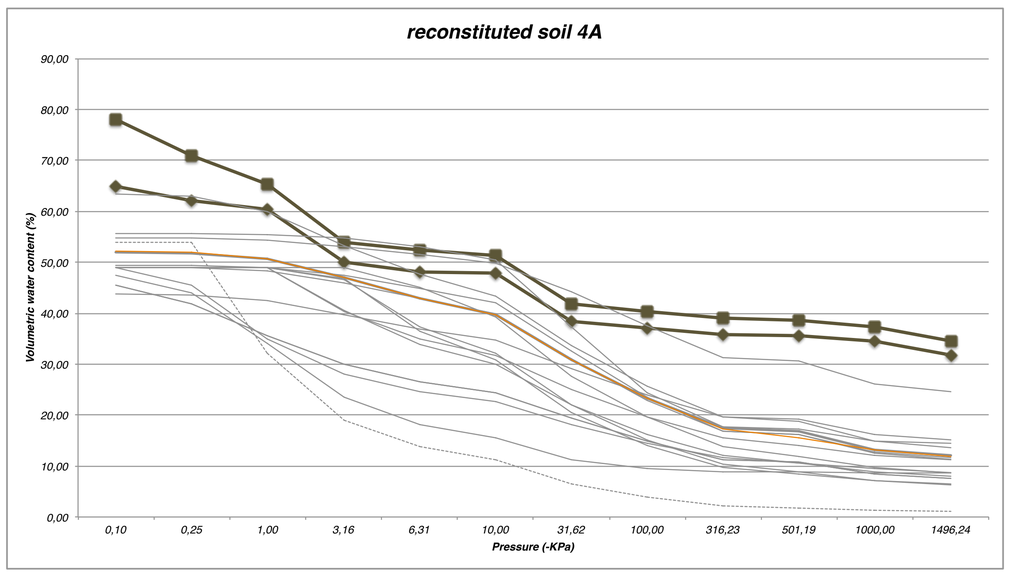
PTF	region	model
HYPRES	Europe	VG
Saxton et al., 1986	USA, nationwide	BC
Campbell and Shiosawa, 1992	No particular	BC
Rawls and Brakensiek, 1985	USA, nationwide	BC
Williams et al., 1992	Australia	BC
Williams et al., 1992	Australia	BC
Oosterveld and Chang, 1980	Canada, Alberta	BC
Mayr and Jarvice, 1999	UK	BC
Wösten et al., 1999	Europe	VG
Varallyay et al., 1982	Hungary	VG
Vereecken et al., 1989	Belgium	VG
Wösten et al., 1999	Europe	VG
Tomasella and Hodnett, 1998	Brazil	VG
Rawls et al. 1982b*	USA, nationwide	VG
Gupta and Larson, 1979	Central USA	VG
Rajkai and Varallyay, 1992	Hungary	VG
Rawls et al. 1983*	USA, nationwide	VG

** = corrected for OM according to Nemes et al., 2009*

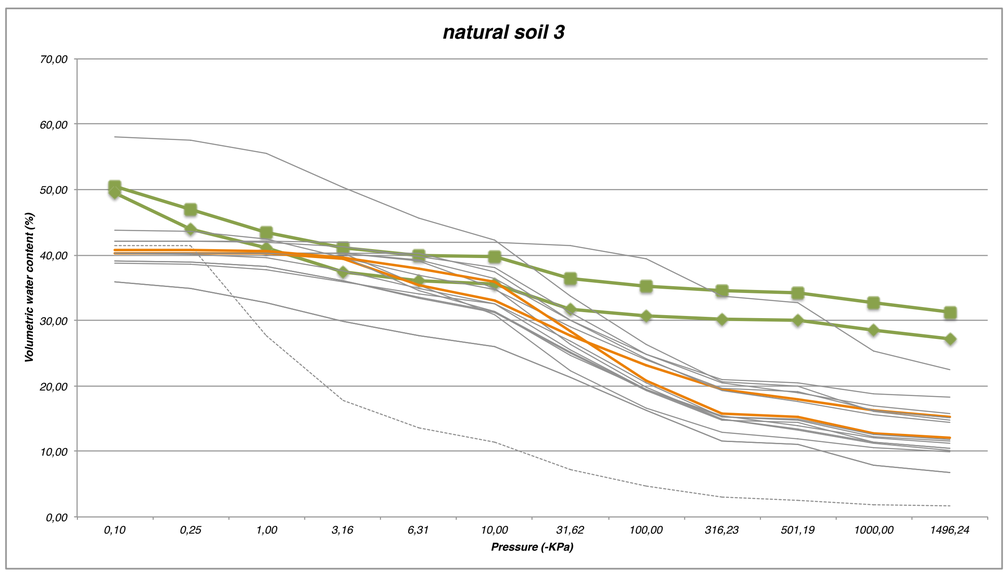
Through the calculation of RMSE were identified the best and worst PTF in representing the instrumental data.

$$\mathrm{RMSE}=\sqrt{\frac{1}{N}\sum_{i=1}^{N}(\theta_i-\theta_i^{*})^2}$$

N = number of measurements;
θ_i and θ_i^* = real and estimated volumetric water content(θ%).



real (green) and estimated (gray) water retention curves



The trend of corn, followed for two years, either on natural and reconstituted soil, validated the hypothesis of best hydrological characters of the reconstituted soil; corn on reconstituted soil had best productions using 50% less water irrigation (PS3a.42: COMPARISON BETWEEN PRODUCTION DATA OF CORN GROWN IN NATURAL AND RECOSTITUTED SOILS, P. Manfredi et al.).
The difference in available water content that can be seen analyzing the performance of corn is not found, so evident, by instrumental data.
This led us to repeat the analysis.
The results of the analysis are now not available for the necessary long residence time of soils in Richards plates.
The reconstituted soils, at different pressure values, to lose their water content need much time than natural soils; that means that reconstituted soils in addition to have a higher available water, maintain this for longer time, favoring crop and allowing water savings.

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