Supplementary Information

Title

Rewetting the hyper-arid Atacama Desert soil reactivates a carbon-starved microbial decomposer community and also triggers archaeal metabolism

Authors

Christoph Rosinger[1,2], Johannes Rousk[3], Michael Bonkowski[4], Janet Rethemeyer[5], Andrea Jaeschke[5]

Affiliations

[1]Institute of Soil Research, Department of Forest and Soil Sciences Vienna, University of Natural Resources and Life Sciences, 1190 Vienna, Austria

[2]Institute of Agronomy, Department of Crop Sciences, University of Natural Resources and Life Sciences Vienna, 3430 Tulln an der Donau, Austria

[3]Section of Microbial Ecology, Department of Biology, Lund University, 22362 Lund, Sweden

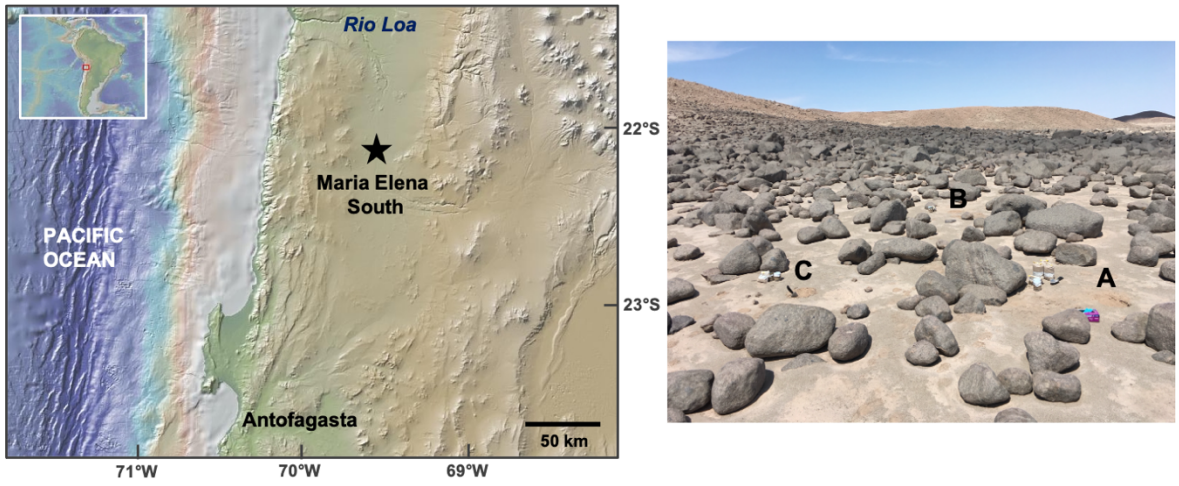
[4]Institute of Zoology, Department of Biology, University of Cologne, 50674 Cologne, Germany

[5]Institute of Geology and Mineralogy, Department of Geosciences, University of Cologne, 50674 Cologne, Germany

Corresponding author

Christoph Rosinger; christoph.rosinger@boku.ac.at

Supplementary Information 1



Supplementary Figure 1. Location of the sampling site

Supplementary Information 2 – Soil physicochemical characterization

Soil pH was measured in soil slurries (1:3 soil/deionized water) with a pH meter (Mettler Toledo) in three-fold technical replication. Electrical conductivity was measured in soil slurries (1:5 soil/deionized water) with a portable multiparameter measuring instrument (Multi 197i, WTW). Elemental composition (CNS) was determined using an elemental analyzer (Vario MICRO cube, Elementar, Germany) before and after decarbonization. Approximately 1 g of ground sample material was treated with 1M HCl to remove inorganic carbon. Samples were then washed with Milli-Q water until the pH was back to neutral and dried in the oven at 60°C.

Supplementary Table 1 Soil pH, electrical conductivity (EC), inorganic and organic carbon, nitrogen and sulfur content in MES surface soils.

Site	pH	EC ($mS\ cm^{-1}$)	TIC (%)	TOC (%)	TN (%)	TS (%)
MES-A	8.08 ± 0.03	2.0 ± 0.07	0.078 ± 0.010	0.026 ± 0.005	0.020 ± 0.001	0.034 ± 0.001
MES-B	8.15 ± 0.04	2.1 ± 0.02	0.089 ± 0.012	0.015 ± 0.010	0.026 ± 0.004	0.037 ± 0.004
MES-C	8.14 ± 0.06	2.6 ± 0.02	0.081 ± 0.024	0.006 ± 0.023	0.023 ± 0.003	0.035 ± 0.005

Supplementary Information 3 – Radiocarbon dating

Preparation of bulk soil samples for radiocarbon analysis (^{14}C) including standard acid extraction was done following the protocol of Rethemeyer et al. (2019). In addition, dry soil from site A was used for total lipid extraction (TLE) according to Wilhelm et al. (2017). The TLE was transferred into tin elemental analyzer (EA) capsules with DCM, and the solvent was slowly removed on a hot plate before wrapping the sample. All samples were measured as CO_2 using an EA system interface coupled to a gas ion source (GIS)-equipped Mini-Carbon Dating System (MICADAS) (McIntyre et al., 2017).

Supplementary Table 2. AMS-^{14}C ages of MES surface soil. $\delta^{13}C$ values are used for correction only

MES site	AMS Lab ID	$F^{14}C$	+/-	Age (year)	+/-	$\delta^{13}C$ (‰)
A	COL7059.1.0.0.1	0.254	0.007	11004	216	-20.5
B	COL7060.1.0.0.1	0.248	0.006	11194	197	-20.0
C	COL7061.1.0.0.1	0.290	0.012	9935	332	-18.4
A-TLE	COL7455	0.515	0.005	5335	77	-28.8

Supplementary Information 4 – PLFA and GDGT composition

Supplementary Table 3. PLFAs detected in MES surface soils after different treatments: extraction without incubation and 5 day-incubation at 25°C with water (+H_2O) and water plus labile C (+H_2O+C). Given is the concentration in ng g^{-1} dry soil. PLFA structural groups are divided in saturated, monounsaturated (MUFA), polyunsaturated (PUFA) and terminally branched (Terbrsat) fatty acids

	Control			+H_2O			+H_2O+C		
PLFA	A	B	C	A	B	C	A	B	C
$C_{12:0}$	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.23	0.04	0.13
$C_{13:0}$	0.02	0.01	n.d.	n.d.	n.d.	0.01	0.31	0.03	0.05
i-$C_{14:0}$	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	50.72	0.31	0.37
$C_{14:0}$	0.49	0.36	0.07	0.12	0.20	0.04	43.75	2.20	2.75
i-$C_{15:0}$	0.04	0.03	0.02	0.02	0.03	0.01	22.97	0.49	0.48
a-$C_{15:0}$	0.09	0.08	0.03	0.05	0.06	0.02	113.78	0.94	8.18
$C_{15:0}$	0.21	0.20	0.08	0.08	0.17	0.07	12.77	2.15	3.04
i-$C_{16:0}$	0.09	0.07	0.04	0.10	0.15	0.08	44.86	1.51	2.35
$C_{16:1\ (\omega9)}$	0.19	0.12	0.03	0.20	0.35	0.24	111.21	68.33	97.81
$C_{16:0}$	7.56	4.89	1.82	3.50	4.10	2.21	357.88	53.55	74.95
i-$C_{17:0}$	0.02	0.02	0.00	0.02	0.02	0.01	6.21	0.53	0.51
$C_{17:0}$	0.11	0.10	0.05	0.08	0.14	0.08	7.84	2.82	3.69
$C_{18:2\ (\omega9,12)}$	0.09	0.07	0.00	0.04	0.11	0.11	9.38	0.19	2.88
$C_{18:1\ cis\ (\omega9)}$	0.68	0.54	0.08	0.47	0.80	0.51	12.18	6.39	7.82
$C_{18:1\ trans\ (\omega9)}$	0.15	0.07	0.01	0.13	0.12	0.13	6.43	3.09	5.28
$C_{18:0}$	5.31	3.21	1.23	2.57	3.10	2.00	12.00	4.67	5.33
$C_{19:0}$	0.02	0.02	0.01	0.01	0.02	0.02	0.08	0.03	0.03
$C_{20:0}$	0.18	0.11	0.03	0.15	0.13	0.09	0.32	0.11	0.17
$C_{22:1}$	5.46	3.47	n.d.	6.42	4.32	2.16	4.94	2.45	5.95
$C_{22:0}$	0.13	0.07	n.d.	0.13	0.09	0.08	0.16	n.d.	0.11
Sum	20.84	13.44	3.51	14.09	13.90	7.87	818.04	149.82	221.87
Saturated	14.03	8.96	3.29	6.63	7.93	4.60	435.35	65.60	90.23
MUFA	6.47	4.20	0.12	7.22	5.59	3.03	134.76	80.26	116.87
PUFA	0.09	0.07	0.00	0.04	0.11	0.11	9.38	0.19	2.88
Terbrsat	0.24	0.20	0.09	0.18	0.26	0.12	238.55	3.77	11.88

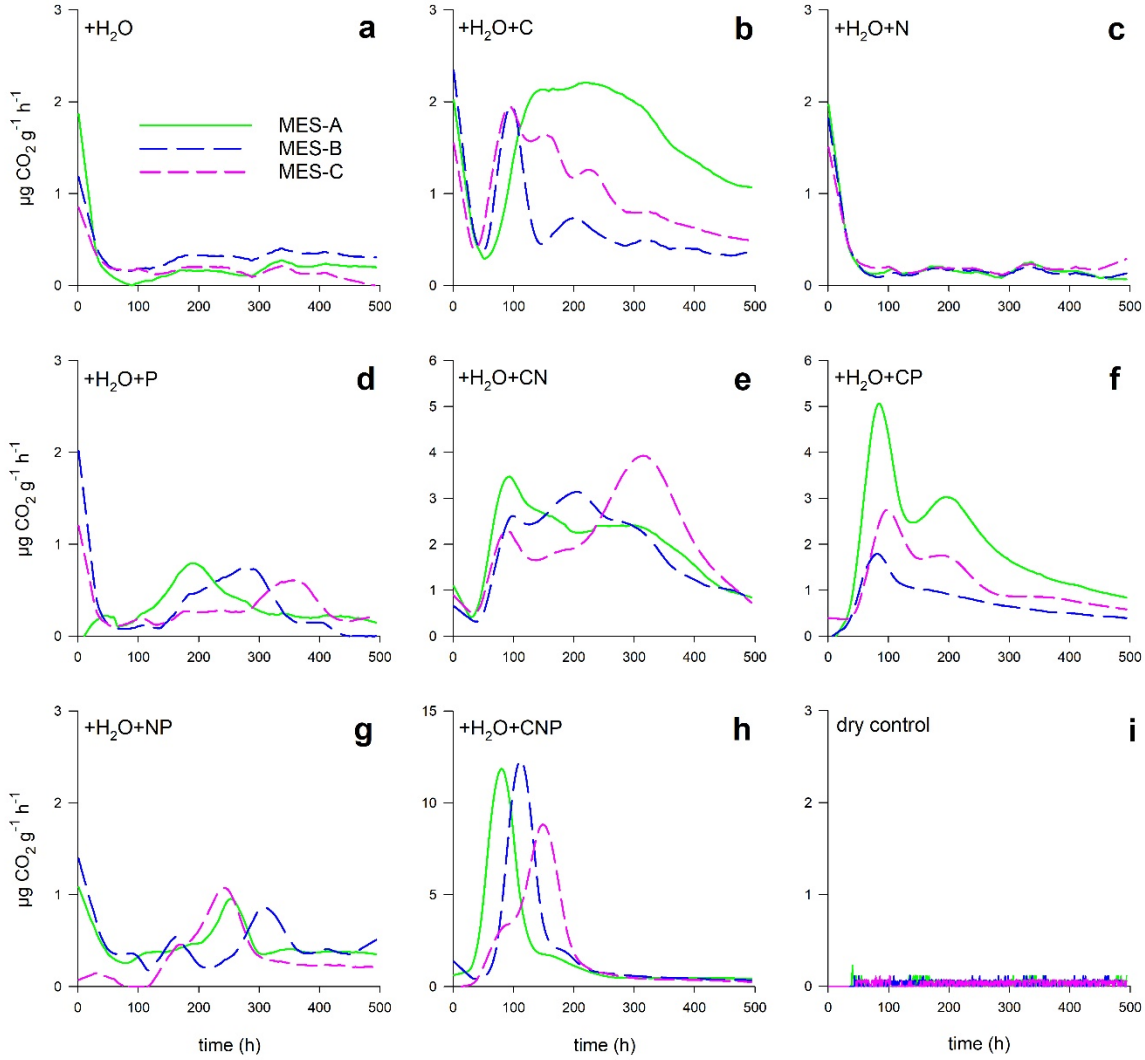
n.d. = not detected

Supplementary Table 4. GDGTs detected in MES surface soils after different treatments: extraction without incubation and 5 day-incubation at 25°C with water (+H_2O) and water plus labile C (+H_2O+C). Given is the concentration in pg g^{-1} dry soil. The TEX_{86} proxy was used to estimate growth temperature using the high temperature calibration by Kim et al. (2010)

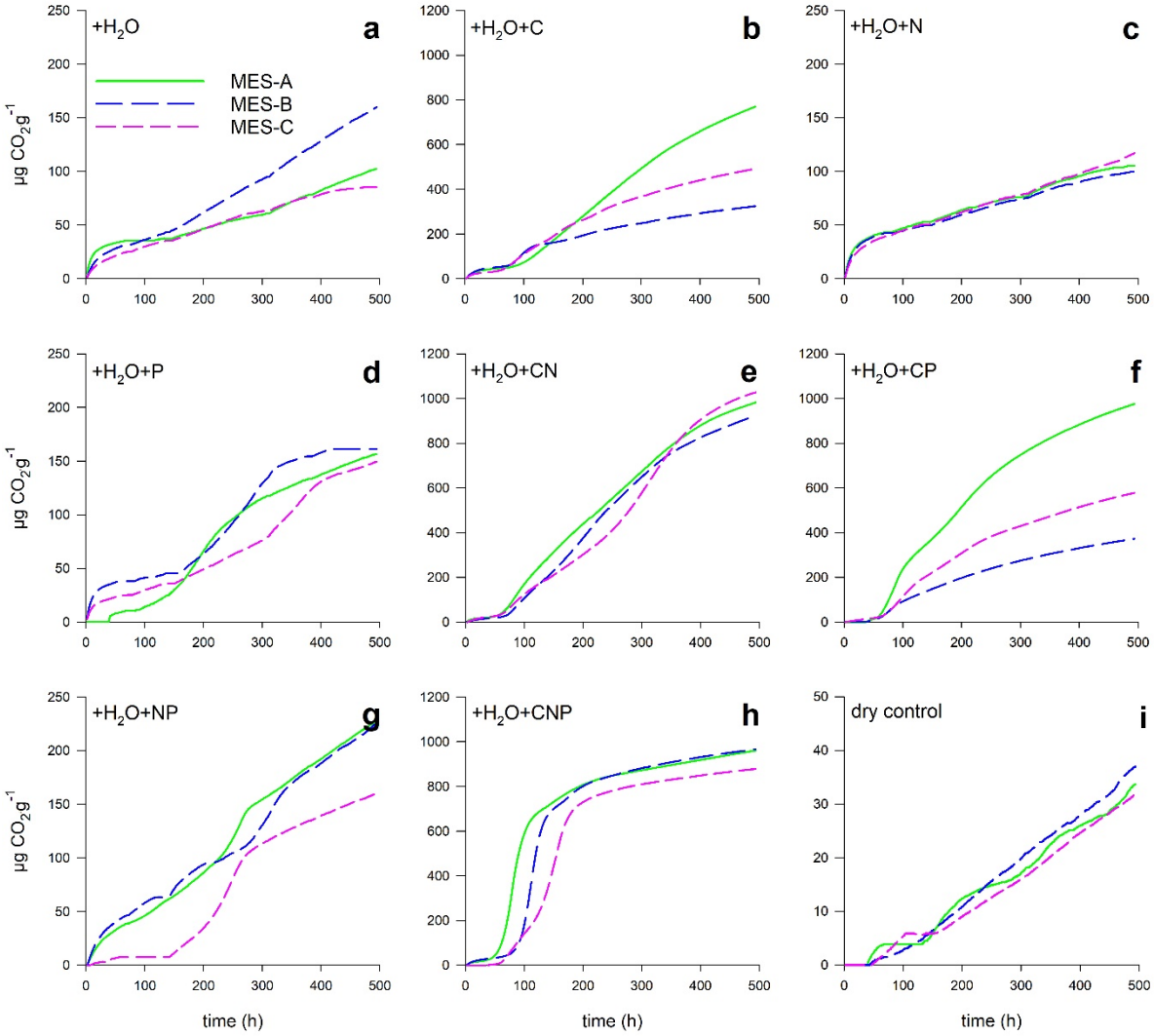
	Control			+H_2O			+H_2O+C		
iso-GDGT	A	B	C	A	B	C	A	B	C
GDGT-0	1.6	1.2	4.5	3.9	n.d.	1.4	24.5	4.8	6.7
GDGT-1	n.d.	n.d.	n.d.	0.9	n.d.	n.d.	17.2	4.7	1.6
GDGT-2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	20.2	5.0	0.4
GDGT-3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	6.5	2.1	0.5
GDGT-4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	92.3	9.7	5.1
Crenarchaeol	9.7	1.6	n.d.	30.7	2.8	1.2	173.8	12.5	12.6
Cren isomer	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7.1	2.0	1.8
Sum	11.3	2.8	4.5	35.4	2.8	2.6	341.7	40.6	28.8
TEX_{86}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.663	0.660	0.634
Temperature	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	26.4	26.3	25.1

n.d. = not detected; n.m. = not measured

Supplementary Information 5



Supplementary Figure 2. Respiration rates of three topsoil samples from the hyper-arid Atacama Desert (Maria Elena South, MES) with H_2O (a) and H_2O plus multifactorial C, N and P addition (b-h) plus a dry control (i) over a time period of 20 days. Note the different scales on the y-axes



Supplementary Figure 3. Cumulative respiration of three topsoil samples from the hyper-arid Atacama Desert (Maria Elena South, MES) with H_2O (a) and H_2O plus multifactorial C, N and P addition (b-h) plus a dry control (i) over a time period of 20 days. Note the different scales on the y-axes

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