

Using crushed waste bricks for urban greening with contrasting grassland mixtures: no negative effects of brick-augmented substrates varying in soil type, moisture and acid pre-treatment

Running head: Testing waste bricks as urban substrate component

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Appendix

Table A1

Species pool for designed, regional seed mixtures and the non-regional standard seed mixture, i.e. *Regel-Saatgut-Mischung* RSM 7.1.2 (= landscape lawn with forbs) (DIN 18917, 2018). Percent values indicate the weight ratio of grasses/legumes/forbs in the different seed mixtures (Table 1). Establishment rate is indicated for each Experiment (1/2/3; see Material and Methods). Nomenclature follows ‘World Flora Online’ (www.worldfloraonline.org, last checked: 06.03.2019). All seed mixtures and the associated R script are stored in accessible data files (see data availability).

Species pool for designed seed mixtures					Standard seed mixture		
Species name	Family	Establishment rate			Species names	Family	Est. rate
		1	2	3			1
Grasses	30–60wt% in seed mixture					98.3wt% in seed mixture	
<i>Agrostis capillaris</i>	Poaceae	1	1	0.86	<i>Agrostis capillaris</i>	Poaceae	0.97
<i>Alopecurus pratensis</i>	Poaceae	0.61	0.81	0.58			
<i>Anthoxanthum odoratum</i>	Poaceae	0.35	0.43	0.21			
<i>Briza media</i>	Poaceae	0.43	0.17	0.9			
<i>Bromus erectus</i>	Poaceae	0.4	0.21	0.89			
<i>Bromus hordeaceus</i>	Poaceae	0.85	0.94	1			
<i>Cynosurus cristatus</i>	Poaceae	0.33	0.50	0.89			
<i>Helictotrichon pubescens</i>	Poaceae	0.07	0.06	0.97			
<i>Festuca rubra</i>	Poaceae	0.02	0.10	0.76	<i>Festuca rubra</i>	Poaceae	1
<i>Phleum pratense</i>	Poaceae	0	0	0.97			
<i>Poa angustifolia</i>	Poaceae	0.78	0.80	0.93			
<i>Trisetum flavescens</i>	Poaceae	0.82	0.87	0.94			
					<i>Festuca trachyphylla</i>	Poaceae	1
					<i>Lolium perenne</i>	Poaceae	0.97
					<i>Poa pratensis</i>	Poaceae	0.97
Legumes	5–15wt% in seed mixture					0.3wt% in seed mixture	
<i>Medicago lupulina</i>	Fabaceae	0.20	0.18	0.95	<i>Medicago lupulina</i>	Fabaceae	0.22
<i>Onobrychis viciifolia</i>	Fabaceae	0.49	0.54	0.52			
<i>Vicia cracca</i>	Fabaceae	0.06	0.16	0.26			
<i>Vicia sepium</i>	Fabaceae	0.08	0.04	0.05			
					<i>Lotus corniculatus</i>	Fabaceae	0.91

Species pool for designed seed mixtures					Standard seed mixture		
Forbs	35–55wt% in seed mixture					1.4wt% in seed mixture	
<i>Achillea millefolium</i>	Asteraceae	1	1	0.97	<i>Achillea millefolium</i>	Asteraceae	0.94
<i>Campanula glomerata</i>	Campanulaceae	0.96	0.88	0.90			
<i>Campanula patula</i>	Campanulaceae	0.74	0.71	0.82			
<i>Campanula rotundifolia</i>	Campanulaceae	0.69	0.75	0.78			
<i>Cardamine pratensis</i>	Brassicaceae	0.76	0.67	0.85			
<i>Crepis biennis</i>	Asteraceae	0.33	0.42	0.66			
<i>Daucus carota</i>	Apiaceae	0.77	0.72	0.90	<i>Daucus carota</i>	Apiaceae	0.91
<i>Galium album</i>	Rubiaceae	0.83	0.88	0.24			
<i>Geranium pratense</i>	Geraniaceae	0.21	0.44	0.55			
<i>Hypochaeris radicata</i>	Asteraceae	0.54	0.94	0.50			
<i>Leontodon hispidus</i>	Asteraceae	0.49	0.30	0.77	<i>Leontodon hispidus</i>	Asteraceae	0.12
<i>Leucanthemum vulgare</i>	Asteraceae	0.87	0.87	0.89	<i>Leucanthemum vulgare</i>	Asteraceae	1
<i>Luzula campestris</i>	Juncaceae	0	0	0			
<i>Plantago lanceolata</i>	Plantaginaceae	0.75	0.71	0.91	<i>Plantago lanceolata</i>	Plantaginaceae	0.84
<i>Plantago media</i>	Plantaginaceae	0.93	0.75	0.88			
<i>Primula veris</i>	Primulaceae	0	0	0.91			
<i>Prunella vulgaris</i>	Lamiaceae	0.82	0.87	0.52			
<i>Ranunculus acris</i>	Ranunculaceae	na	na	na			
<i>Ranunculus bulbosus</i>	Ranunculaceae	na	na	na			
<i>Saxifraga granulata</i>	Saxifragaceae	0.04	0	0			
<i>Silene dioica</i>	Caryophyllaceae	0.65	0.92	0.88			
<i>Silene flos-cuculi</i>	Caryophyllaceae	1	0.93	0.78			
<i>Thymus pulegioides</i>	Lamiaceae	0.64	0.62	0.88			
<i>Tragopogon pratensis</i>	Asteraceae	0.28	0.40	0.42			
<i>Veronica chamaedrys</i>	Scrophulariaceae	0.73	0.58	0.79			
					<i>Centaurea jacea</i>	Asteraceae	0.78
					<i>Galium verum</i>	Rubiaceae	0.59
					<i>Pimpinella saxifraga</i>	Apiaceae	0.03
					<i>Sanguisorba minor</i>	Rosaceae	0.38

Table A2

Three seed mixtures sold by the company Krimmer. The values are the proportion to the whole seed mass in one mixture. Nomenclature follows ‘World Flora Online’ (www.worldfloraonline.org, last checked: 06.03.2019).

Name	Family	Seed mixture		
		30%/70% (herbs/grasses) [%]	50%/50% (herbs/grasses) [%]	60%/40% (herbs/grasses) [%]
<i>Achillea millefolium</i>	Asteraceae	1.0	1.0	0.7
<i>Agrimonia eupatoria</i>	Rosaceae	0	2.0	0
<i>Agrostis capillaris</i>	Poaceae	0	1.0	0
<i>Alopecurus pratensis</i>	Poaceae	3.0	2.0	0
<i>Anthoxanthum odoratum</i>	Poaceae	3.0	4.0	12.0
<i>Anthriscus sylvestris</i>	Apiaceae	0.5	0	0
<i>Arrhenatherum elatius</i>	Poaceae	2.0	1.0	0
<i>Briza media</i>	Poaceae	0	4.0	4.0
<i>Bromus erectus</i>	Poaceae	0	3.0	3.0
<i>Bromus hordeaceus</i>	Poaceae	3.0	4.0	0
<i>Campanula glomerata</i>	Campanulaceae	0	0	0.2
<i>Campanula patula</i>	Campanulaceae	0.1	0.2	0.5
<i>Campanula rotundifolia</i>	Campanulaceae	0	0.1	0
<i>Carum carvi</i>	Apiaceae	3.0	2.2	2.1
<i>Centaurea jacea</i>	Asteraceae	2.0	2.4	4.0
<i>Centaurea scabiosa</i>	Asteraceae	0	0.6	1.0
<i>Crepis biennis</i>	Asteraceae	0.6	1.0	1.0
<i>Cyanus segetum</i>	Asteraceae	2.5	2.5	2.5
<i>Cynosurus cristatus</i>	Poaceae	9.0	7.0	12.0
<i>Dactylis glomerata</i>	Poaceae	2.0	0	0
<i>Daucus carota</i>	Apiaceae	1.5	1.5	1.0
<i>Dianthus carthusianorum</i>	Caryophyllaceae	0	0	1.0
<i>Festuca ovina</i>	Poaceae	0	4.0	0
<i>Festuca pratensis</i>	Poaceae	11.0	2.0	0
<i>Festuca rubra</i>	Poaceae	17.0	8.0	5.0
<i>Galium album</i>	Rubiaceae	1.5	1.5	0
<i>Galium verum</i>	Rubiaceae	0	0.5	1.0
<i>Geranium pratense</i>	Geraniaceae	0	0	0.5
<i>Glebionis segetum</i>	Asteraceae	0	0	1.5
<i>Helictotrichon pubescens</i>	Poaceae	2.0	1.0	0
<i>Hypochaeris radicata</i>	Asteraceae	0	0.5	0.5
<i>Knautia arvensis</i>	Dipsacaceae	0.8	1.5	3.5
<i>Lathyrus pratensis</i>	Fabaceae	0	0.8	0.5
<i>Leontodon hispidus</i>	Asteraceae	0.3	1.2	1.2
<i>Leucanthemum vulgare</i>	Asteraceae	2.5	3.0	3.0

Name	Family	Seed mixture		
		30%/70%	50%/50%	60%/40%
		(herbs/grasses) [%]	(herbs/grasses) [%]	(herbs/grasses) [%]
<i>Lotus corniculatus</i>	Fabaceae	1.2	1.2	0
<i>Medicago lupulina</i>	Fabaceae	0	1.0	0
<i>Onobrychis viciifolia</i>	Fabaceae	0	0	4.0
<i>Papaver rhoeas</i>	Papaveraceae	1.3	2.0	1.5
<i>Pastinaca sativa</i>	Apiaceae	0	0	1.0
<i>Phleum pratense</i>	Poaceae	0	0	0
<i>Pimpinella major</i>	Apiaceae	0.4	0.8	0.8
<i>Pimpinella saxifraga</i>	Apiaceae	0	0	0.8
<i>Plantago lanceolata</i>	Plantaginaceae	2.8	2.5	0.5
<i>Plantago media</i>	Plantaginaceae	0	0.5	0.5
<i>Poa angustifolia</i>	Poaceae	6.0	3.0	0
<i>Poa pratensis</i>	Poaceae	8.0	3.0	0
<i>Primula veris</i>	Primulaceae	0	0.3	0
<i>Prunella grandiflora</i>	Lamiaceae	0	0	1.0
<i>Prunella vulgaris</i>	Lamiaceae	1.0	1.5	2.0
<i>Ranunculus acris</i>	Ranunculaceae	0	0.8	1.0
<i>Ranunculus bulbosus</i>	Ranunculaceae	0	0.5	0
<i>Rhinanthus glacialis/minor</i>	Scrophulariaceae	0	0.8	1.0
<i>Rumex acetosa</i>	Polygonaceae	0.5	0.5	0.5
<i>Salvia pratensis</i>	Lamiaceae	1.0	3.0	6.5
<i>Sanguisorba minor</i>	Rosaceae	1.2	3.2	3.0
<i>Sanguisorba officinalis</i>	Rosaceae	0.3	0.4	0
<i>Scorzoneroide autumnalis</i>	Asteraceae	0.3	0	1.2
<i>Silaum silaus</i>	Apiaceae	0.3	0	0
<i>Silene dioica</i>	Caryophyllaceae	0.6	1.5	2.5
<i>Silene flos-cuculi</i>	Caryophyllaceae	0.4	1.0	0
<i>Silene vulgaris</i>	Caryophyllaceae	0.9	1.9	1.0
<i>Stachys officinalis</i>	Lamiaceae	0	0.4	2.0
<i>Tragopogon pratensis</i>	Asteraceae	1.0	2.0	3.0
<i>Trifolium pratense</i>	Fabaceae	0.5	0	0.5
<i>Trisetum flavescens</i>	Poaceae	4.0	3.0	4.0
<i>Vicia sepium</i>	Fabaceae	0	0.5	0

Table A3

Grain size distribution of the substrates used in the three experiments with brick-augmented substrates. Percent values of sand, fine sand, silt, and clay refer to fine soil.

Substrate	Brick type	Acid treatment	Dry bulk density [g cm ⁻³]	Soil texture	Coarse soil (>2.0 mm) [wt%]	Fine soil (<2.0 mm) [wt%]	Sand (2.0 to 6.3e-2 mm) [wt%]	Fine sand (2.0e-1 to 6.3e-2 mm) [wt%]	Silt (6.3e-2 to 6.3e-4 mm) [wt%]	Clay (<6.3e-4 mm) [wt%]	CaCO ₃ (<2.0 mm) [wt%]
Experiment 1											
Bricks 5% without acid	Clean	No	1.24	Slu	11	89	45	11	40	15	15
Bricks 30% without acid	Clean	No	1.26	Sl4	31	69	48	11	38	15	14
Bricks 5% with acid	Clean	Yes	1.05	Slu	14	86	38	11	46	17	16
Bricks 30% with acid	Clean	Yes	1.03	Slu	32	68	38	10	42	15	18
Experiment 2											
Clean bricks 5%	Clean	Yes	1.05	Slu	14	86	38	11	46	17	16
Clean bricks 30%	Clean	Yes	1.03	Slu	32	68	38	10	42	15	18
Demolition bricks 5%	Demolition	Yes	1.76	Sl4	12	88	80	13	16	4	14
Demolition bricks 30%	Demolition	Yes	1.22	Sl4	37	63	47	13	39	14	13
Experiment 3											
Loamy, 5% bricks	Demolition	Yes	1.03	Sl4	25	75	60	15	26	14	14
Loamy, 30% bricks	Demolition	Yes	1.18	Sl4	40	60	64	15	23	13	12

Medium, 5% bricks	Demolition	Yes	1.23	Sl2	21	79	82	16	12	7	9
Medium, 30% bricks	Demolition	Yes	1.27	Sl2	40	60	77	16	16	8	9
Sandy, 5% bricks	Demolition	Yes	1.40	Ss	17	83	92	17	6	2	5
Sandy, 30% bricks	Demolition	Yes	1.43	Ss	32	68	91	17	7	3	5

Figure A1

Grain size distribution of the substrates used for Experiment 1; all bricks were clean production waste.

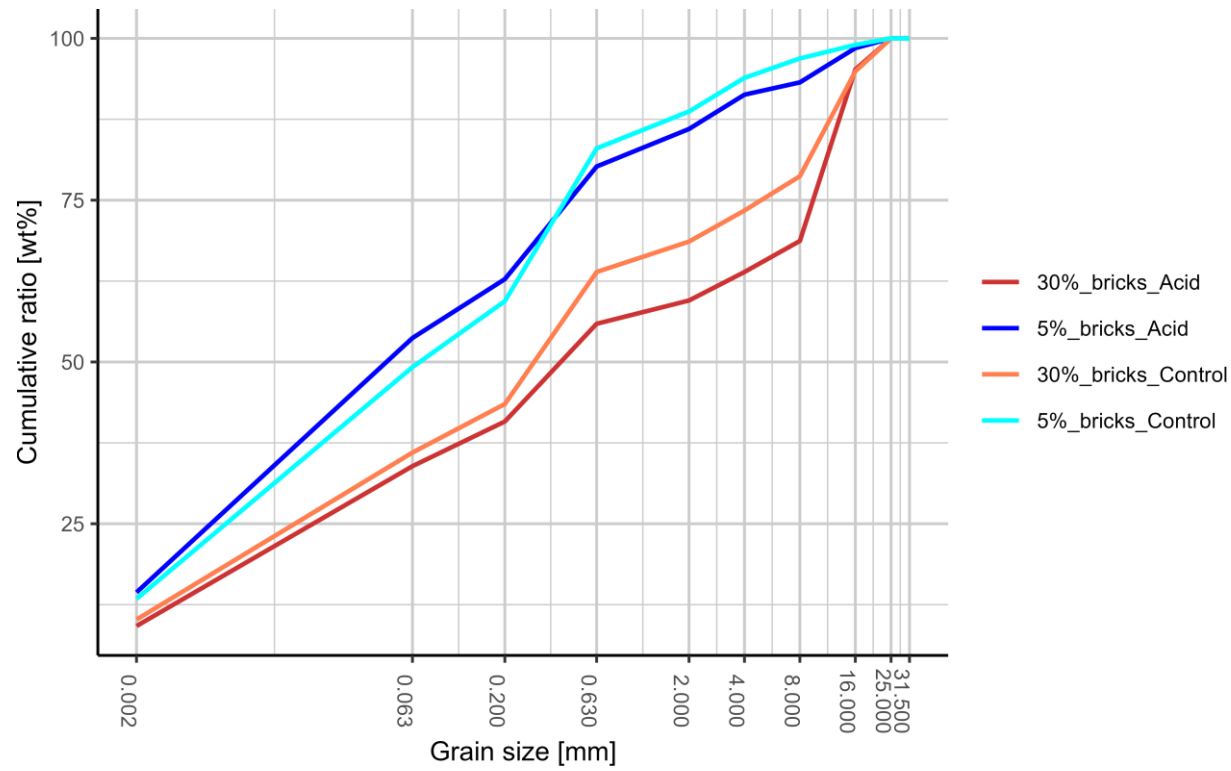


Figure A2

Grain size distribution of the substrates used for Experiment 2; all bricks are treated with phosphorous acid.

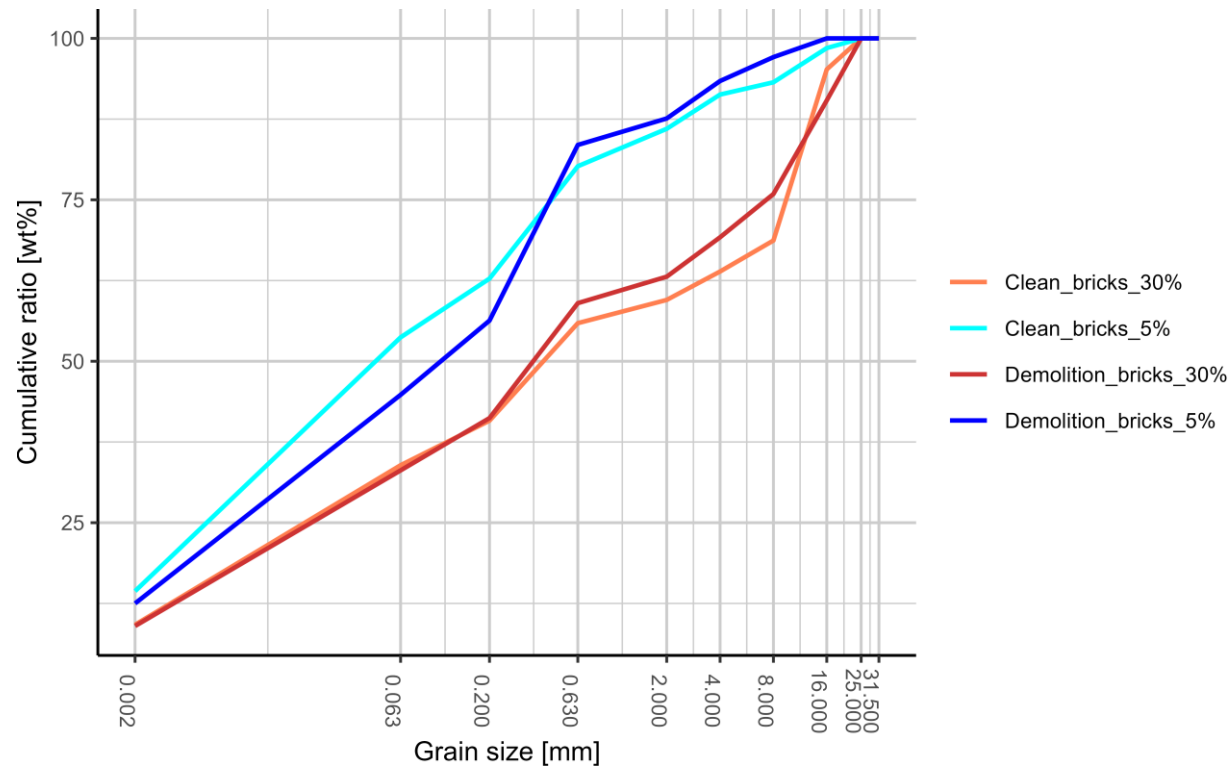


Figure A3

Grain size distribution of the substrates used for Experiment 3; all bricks were acid-treated demolition bricks.

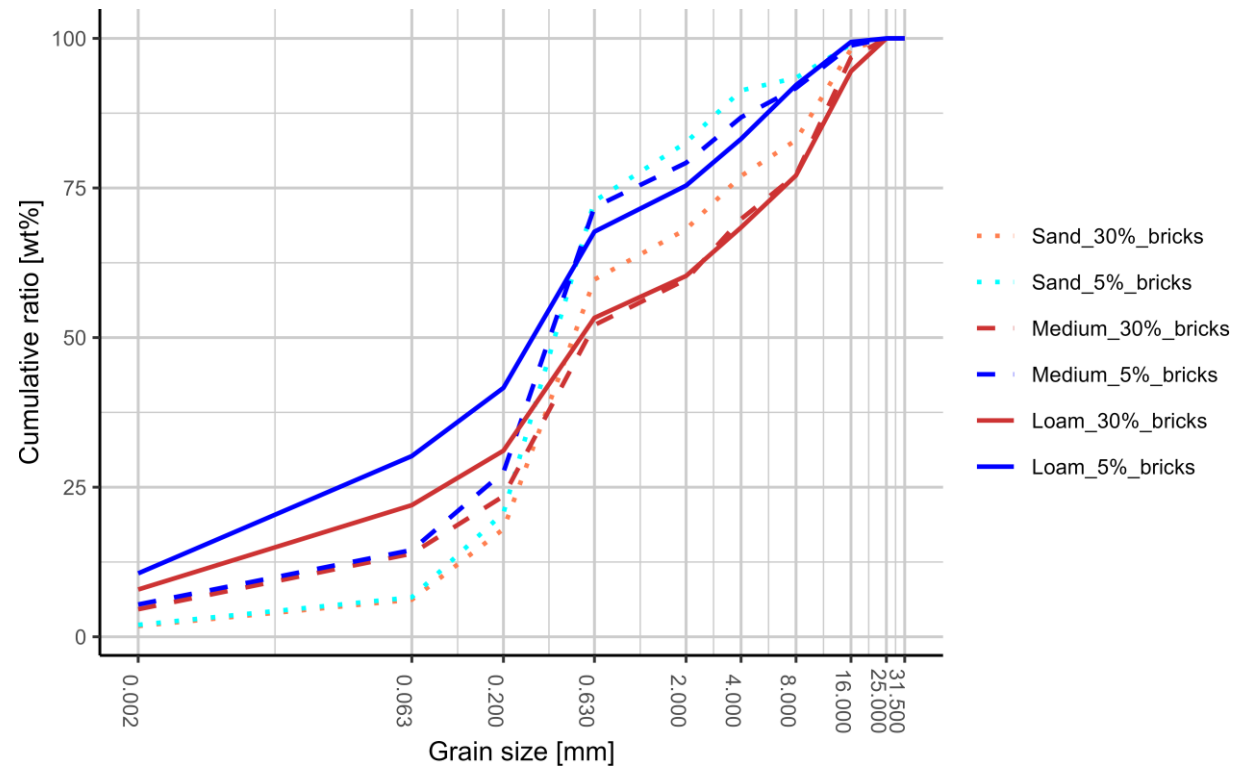


Figure A4

Set up of the Experiments 1, 2 (a) and 3 (b). The trays of Experiments 1 and 2 were randomly mixed within the tables.

