

A PROMISING APPROACH OF INCORPORATING BIOSOLIDS INTO BRICKS

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Research Team



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Overview of Presentation

① Significance of the study

② Some of the results

③ Important Findings

Significance of the Study

- ✓ Possible incorporation of biosolids into fired-clay bricks is a **alternative approach** for a comprehensive utilization of biosolids
- ✓ Reduces the growth of biosolids in stockpiles and the demand for landfill spaces
- ✓ Reduces the usage of natural virgin resource, **Brick soil** in manufacturing fired-clay bricks
- ✓ Important Concept in Sustainable Development

Samples Used in this study



ETP Biosolids

Eastern Treatment Plant



WTP Biosolids

Western Treatment Plant

Some of the results....

Chemical composition

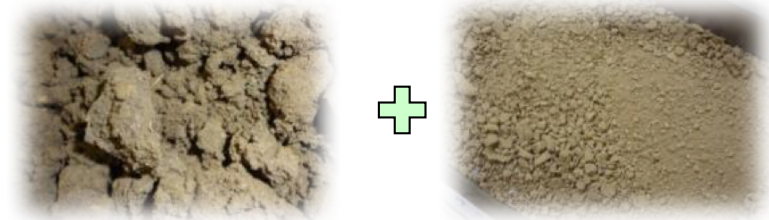
Sample	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	K ₂ O	MgO
ETP1	59.43	17.60	9.58	2.18	0.91	1.59
ETP2	56.06	20.80	11.02	1.97	0.92	1.38
ETP3	51.55	21.90	9.12	2.02	1.00	1.30
WTP	46.91	15.90	8.60	2.15	2.82	1.35
Brick Soil	64.75	19.20	6.60	1.14	4.96	1.73

Some of the results....

Geotechnical Engineering Properties



Particle sizes of biosolids



Biosolids

Soil



Standard compaction test

Some of the results....

Geotechnical Engineering Properties

Property	ETP1	ETP2	ETP3	WTP	Brick Soil
Specific Gravity	2.51	2.46	2.43	2.14	2.69
Liquid limit (%)	46	58	67	53	32
Plastic limit (%)	27	25	41	41	19
Plasticity Index (%)	19	33	26	12	13
Gravel size particles (>2.36mm) (%)	0.4	-	-	13.4	1.2
Sand size particles (0.075 - 2.36 mm) (%)	87.5	84.3	89.2	76.0	74.6
Fine grained size particles (<0.075 mm)	12.1	15.7	10.8	10.6	24.2
Organic content (%)	7.1	9.5	14.4	23.3	1.2

Brick manufacturing process at laboratory



Soil-Biosolids Compositions



Biosolids



Soil

ETP 1 Biosolids

5% 15% 25% 35% 50%



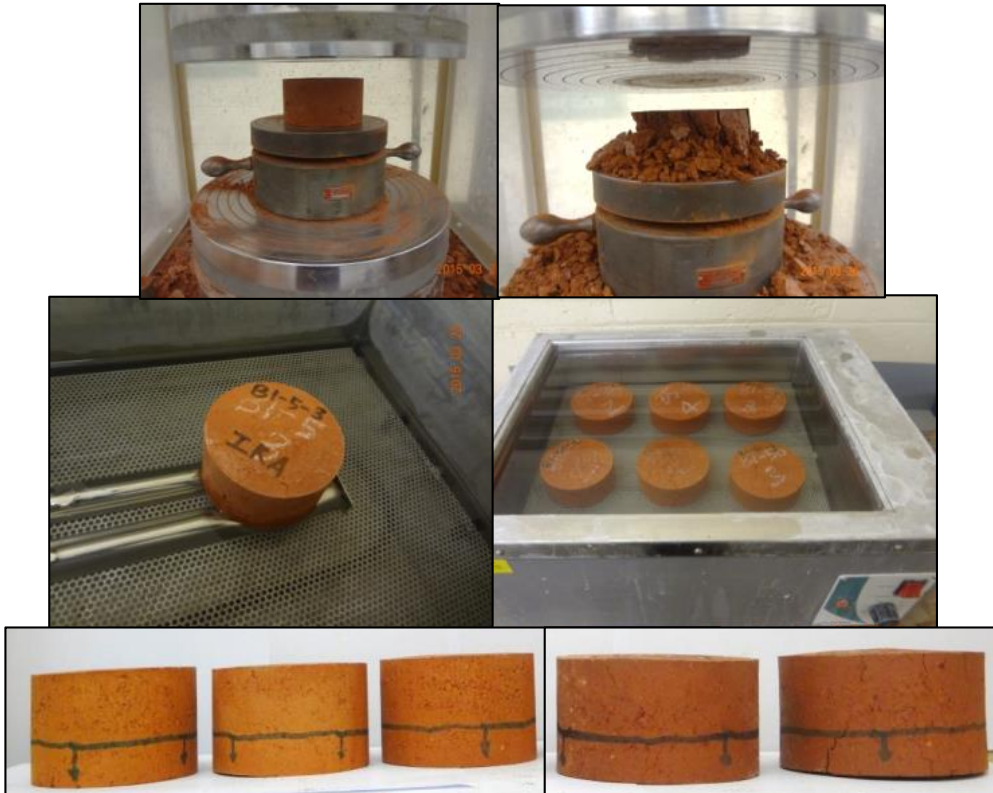
WTP Biosolids

5% 10% 15% 20% 25%



Some of the results....

Properties of biosolids bricks were tested



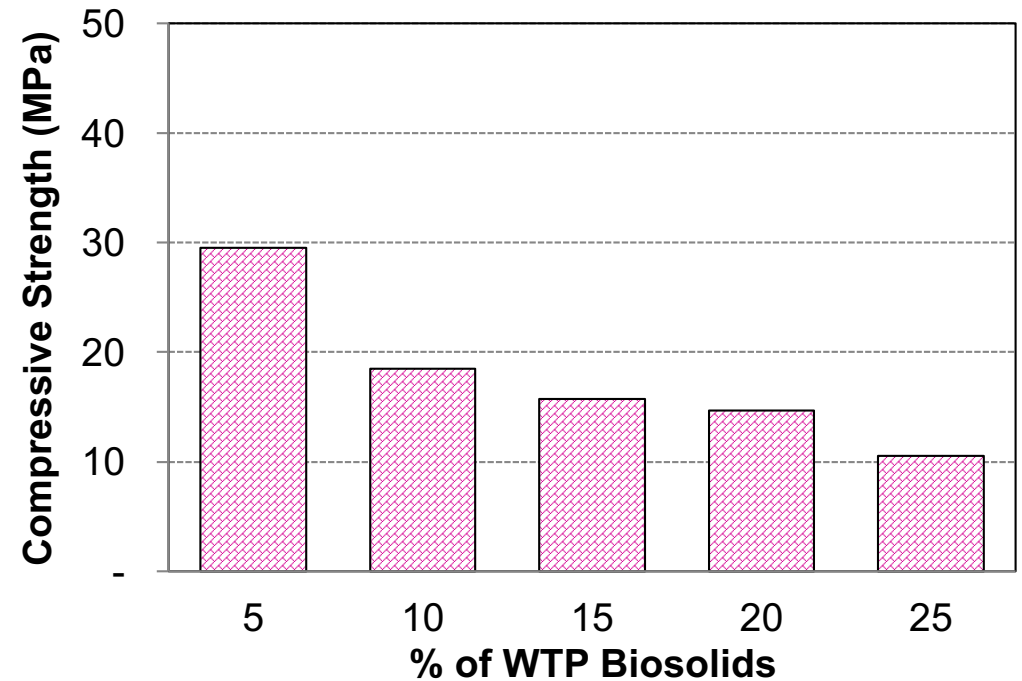
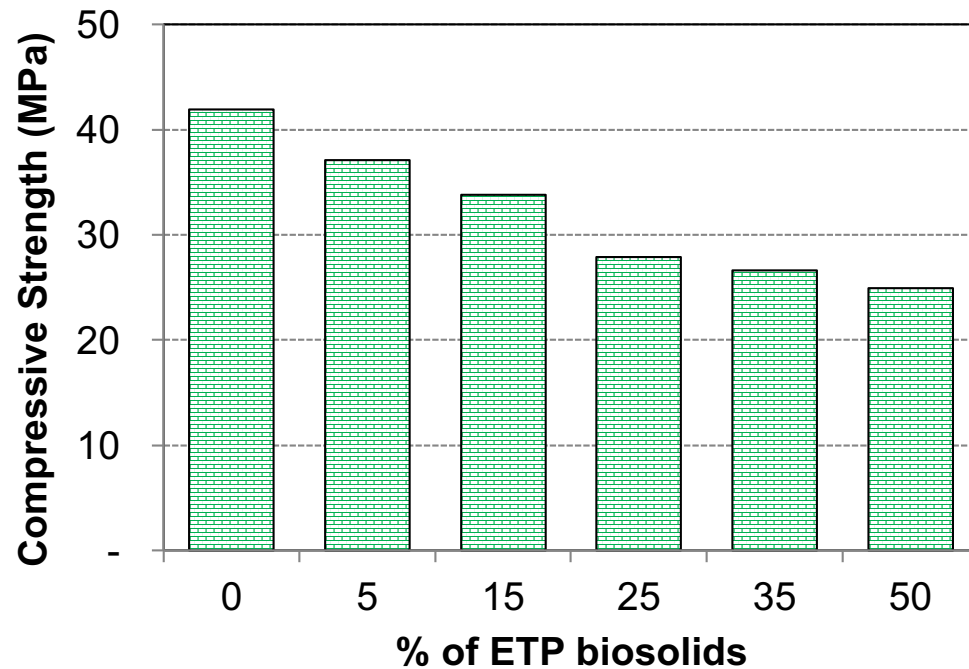
Physical and mechanical properties



Leachate Analysis

Some of the results....

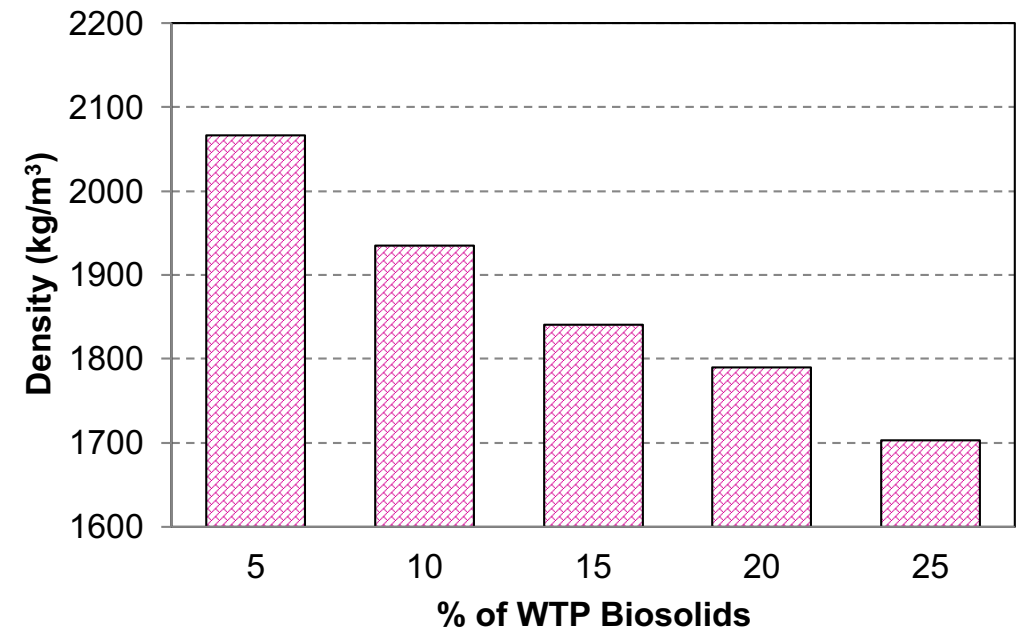
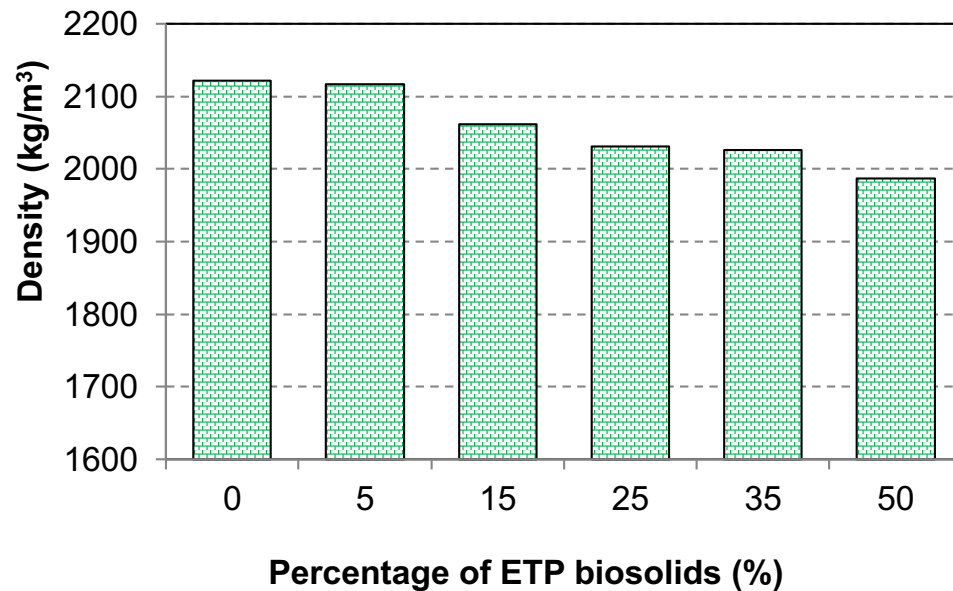
Compressive Strength



Results were **higher** than the minimum value given in the Australian Standards (**5MPa**)

Some of the results....

Density



Biosolids-bricks were **lighter** than conventional bricks

Some of the results....

Leachate Analysis

Two methods were used;

US EPA method – TCLP method 1311

Australian Bottle Leaching Procedure (ABLP)



TCLP method

ABLP method

Particle size < 9.5 mm

Particle size < 2.4 mm



Some of the results....

ABLP results

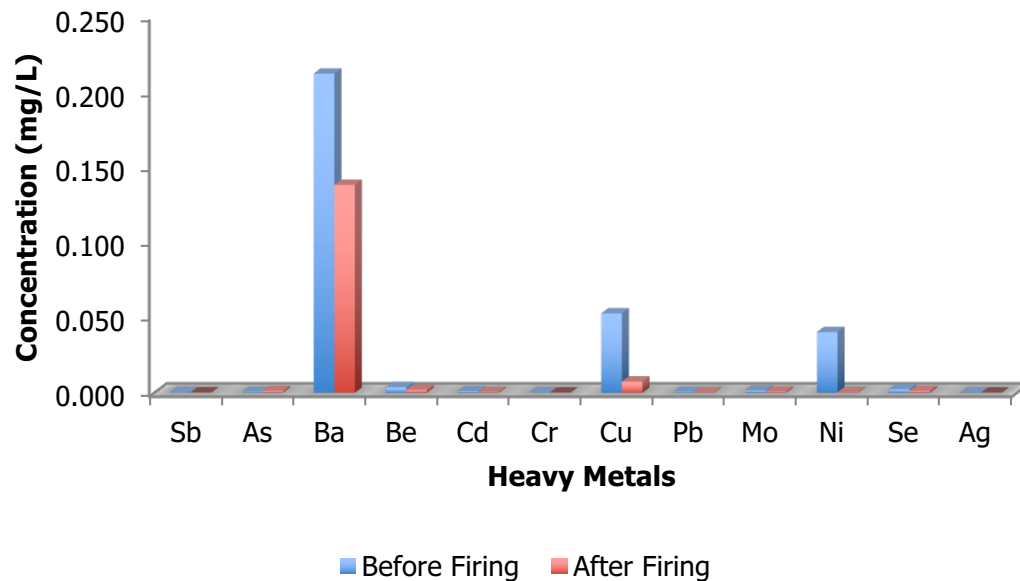
Heavy Metal	Concentration Limits (mg/L)	Concentrations (mg/L)		
		Control Bricks	Bricks with 25% of ETP biosolids	Bricks with 50% of ETP biosolids
Sb	2.0	0.0001	0.0001	0.0100
As	0.7	0.0002	0.0002	0.0500
Ba	70.0	0.1282	0.1422	0.4900
Be	1.0	0.0018	0.0018	0.0100
Cd	0.2	0.0004	0.0004	0.0020
Cr	5.0	0.0001	0.0001	0.0100
Cu	200.0	0.0250	0.0271	0.0300
Pb	1.0	0.0002	0.0002	0.0100
Mo	5.0	0.0006	0.0006	0.0100
Ni	2.0	0.0003	0.0003	0.0100
Se	1.0	0.0011	0.0011	0.0100
Ag	10.0	0.00008	0.00008	0.0100
Zn	300.0	0.11590	0.0743	0.0200

EPA Victoria regulatory limits

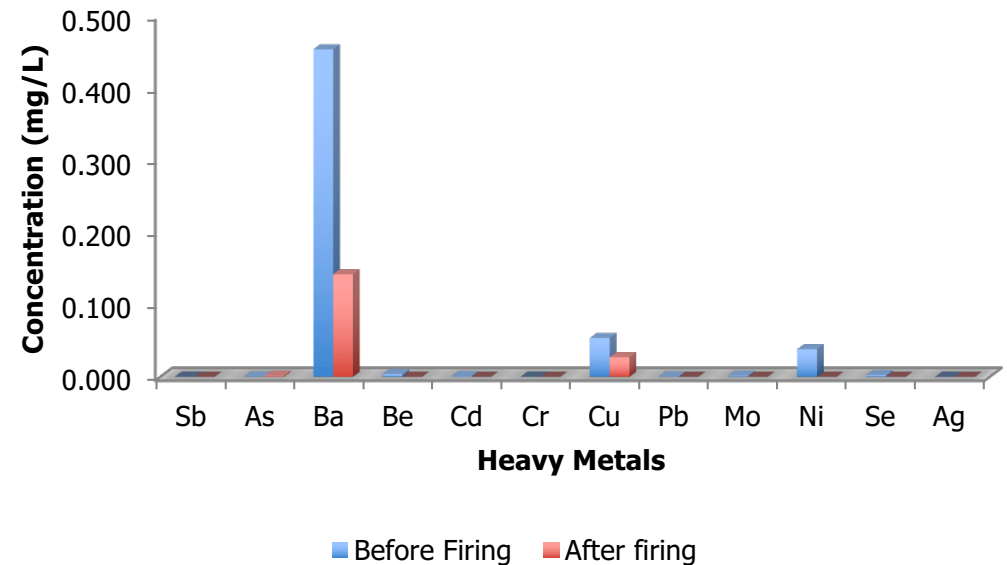
Some of the results....

Leaching concentration between green and fired bricks

ETP1-25 Bricks – **TCLP Concentrations**



ETP1-25 Bricks - **ABL** concentrations



Firing process of bricks minimize the leaching capability of heavy metals from ceramic body

Some of the results....

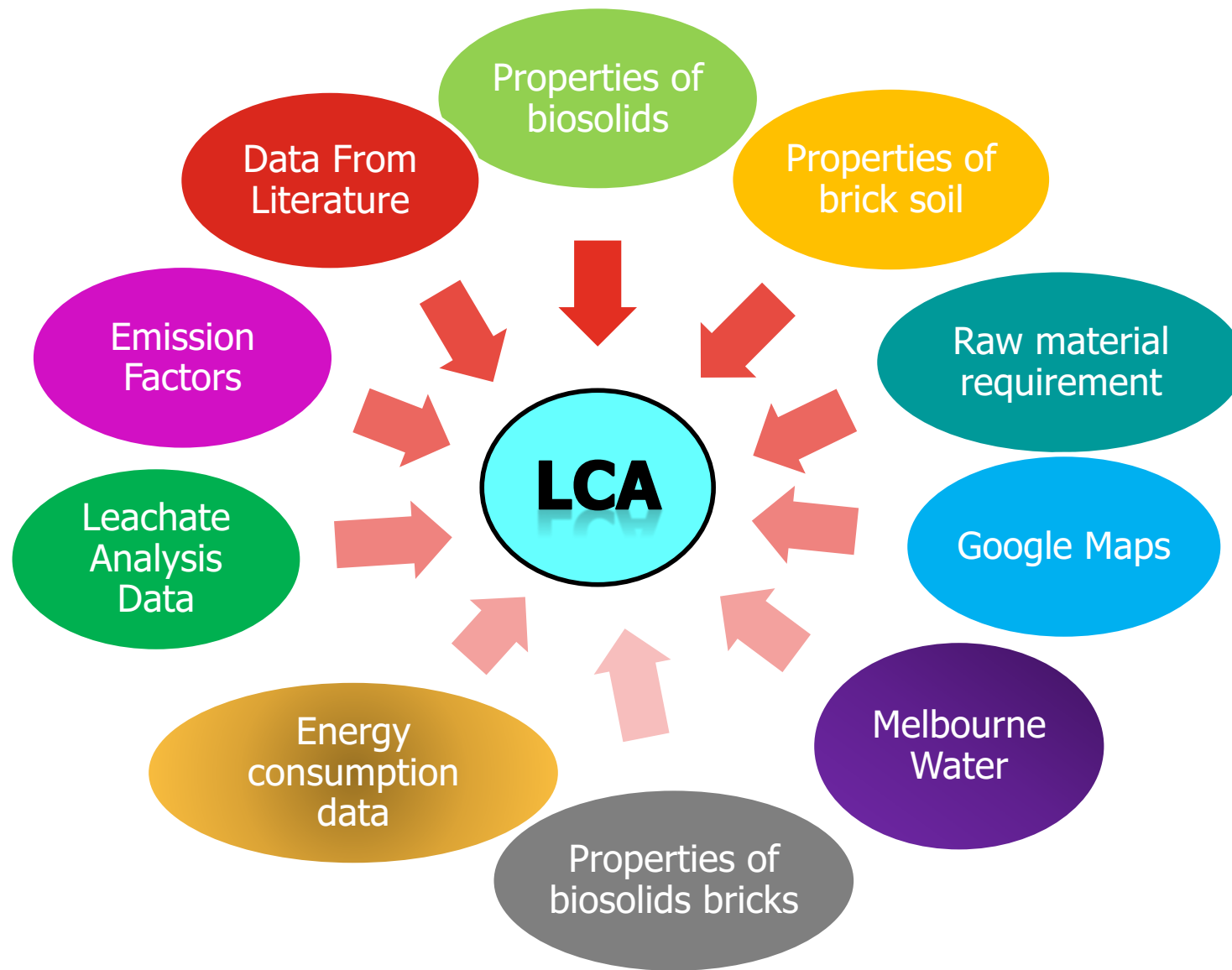
Gas Emissions were measured and emission factors were developed

Brick Label	Energy based emission factor (g/MJ)			
	SO ₂	NO	CO	CO ₂
Control Bricks	6.22E-08	0.00008	0.00017	0.0050
ETP1-25	1.35E-07	0.00014	0.00047	0.0151
WTP-25	1.83E-07	0.00010	0.00091	0.0255

Brick Label	Production Based emission factor (g/kg)			
	SO ₂	NO	CO	CO ₂
Control Bricks	2.19E-06	0.0028	0.006	0.177
ETP1-25	4.20E-06	0.0042	0.015	0.470
WTP10-25	3.59E-06	0.0020	0.018	0.501

Calculated emission factors were used in Life cycle assessment of bricks

Comparative Life cycle assessment (LCA) was conducted based on the results of this study.



Important findings

- ✓ **Organic content** present in biosolids has significant effect on the properties of bricks
- ✓ Compressive strength (mechanical properties) and density of bricks **reduce** with the addition of biosolids
- ✓ Loss on ignition, IRA, water absorption, and initial shrinkage **increase** with the addition of biosolids
- ✓ Addition of biosolids contributed to **reduce the energy requirement** during the firing process of bricks
- ✓ SEM results revealed that the addition of biosolids make the brick more porous, thus, improved the **thermal insulation** properties
- ✓ Biosolids amended bricks are **safe in terms of heavy metal leaching**
- ✓ Comparative LCA results showed that biosolids-bricks are environmentally friendly **except** water depletion and ozone depletion impacts

More details about this study....

Journal Publications

1. Ukwatta, A. & Mohajerani, A. **2017**. “Leachate analysis of green and fired-clay bricks incorporated with biosolids”. **Waste Management**, 66, 134-144
2. Ukwatta, A. & Mohajerani, A. **2017**. “Characterisation of fired-clay bricks incorporating biosolids and the effect of heating rate on properties of bricks”. **Construction and Building Materials**, 142, 11-22
3. Ukwatta, A. & Mohajerani, A. **2017**. “Effect of organic content in biosolids on the properties of fired-clay bricks incorporated with biosolids”, **ASCE Journal of Materials in Civil Engineering**, 29 (7)
4. Ukwatta, A. & Mohajerani, A. **2016**. “Geotechnical and chemical characteristics of ETP and WTP biosolids”. **Australian Geomechanics Journal**, 51, 79-86.
5. Ukwatta, A., Mohajerani, A., Eshtiaghi, N. & Setunge, S. **2016**. “Variation in physical and mechanical properties of fired-clay bricks incorporating ETP biosolids”. **Journal of Cleaner Production**, 119, 76-85.
6. Ukwatta, A., Mohajerani, A., Setunge, S. & Eshtiaghi, N. **2015**. “Possible use of biosolids in fired-clay bricks”. **Construction and Building Materials**, 91, 86-93.

Acknowledgements

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Thank you