

## Abstract

The current study aimed to integrate the thermochemical conversion of a bio-solid via steam gasification for the production of a hydrogen-rich syngas, with reduction of carbon dioxide greenhouse emissions through the use of a building waste material, supporting in this way renewable energy initiatives, circular economy and environmental management of wastes. This novel concept was extended to the investigation of the potential of this waste material to be used for amelioration of soils, filling the gap of its current co-application with composts or biomass.

## Experimental Method

The gasification experiments were conducted in a fixed-bed reactor system coupled with a thermogravimetric/differential thermogravimetric-mass spectrometer system, whereas the soil application experiments were carried out by column leaching, simulating field conditions of Mediterranean countries. Outcomes included the composition of the resultant gas, its heating value and the yield of hydrogen, as a function of temperature and amount of carbon dioxide sorbent used from the gasification tests, as well as the leachability of several nutrients and heavy metals through the soil from the leaching tests.

## Results

**Table 1** Proximate, ultimate analyses (% dry) and structural characteristics of materials.

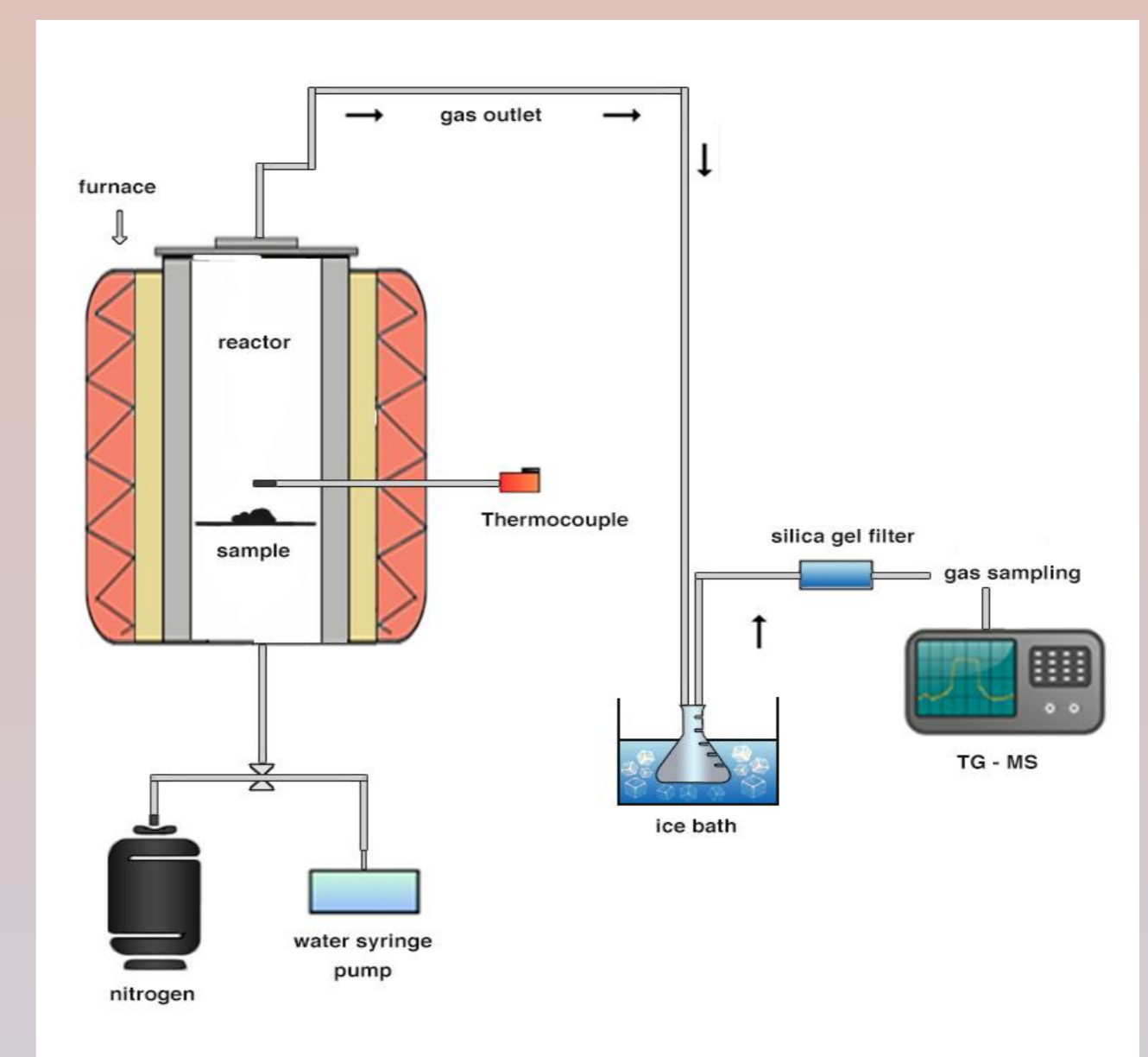
Sample	Volatile Matter	Fixed Carbon	Ash	C	H	N	O	S	Higher Heating Value (MJ/kg)	Specific Surface Area (m <sup>2</sup> /g)
BSL	66.5	16.5	17.0	40.0	6.5	7.0	28.7	0.8	17.1	0.6
BSLB	-	53.1	46.9	43.0	1.3	5.0	3.3	0.5	14.6	3.8

**Table 2** Gasification performance of the fuel at 750°C as a function of molar Ca/C.

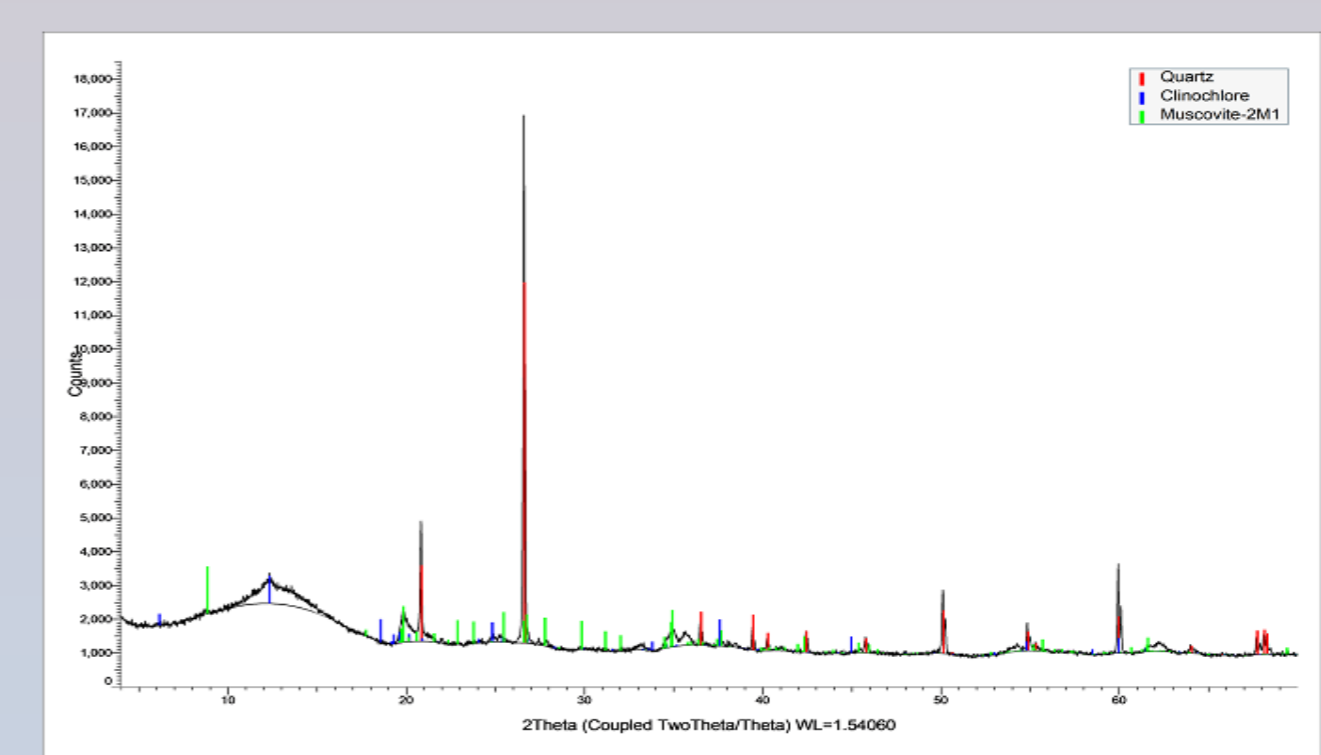
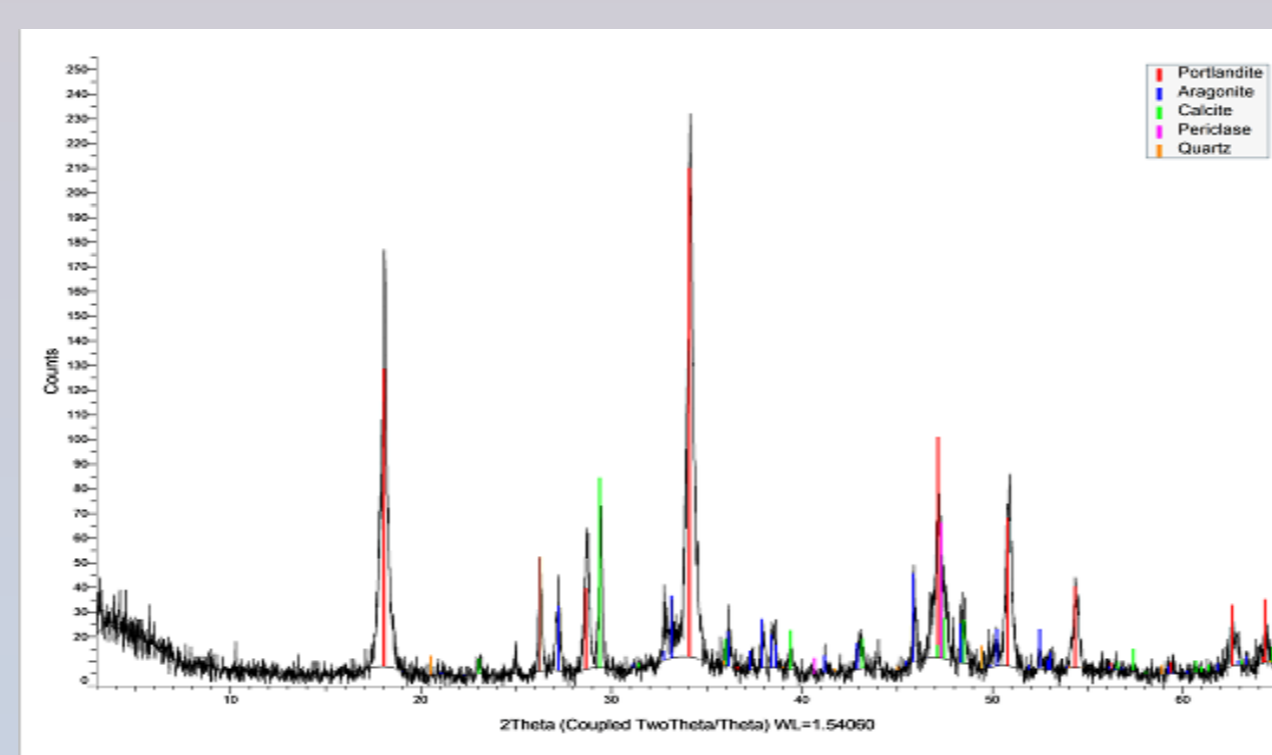
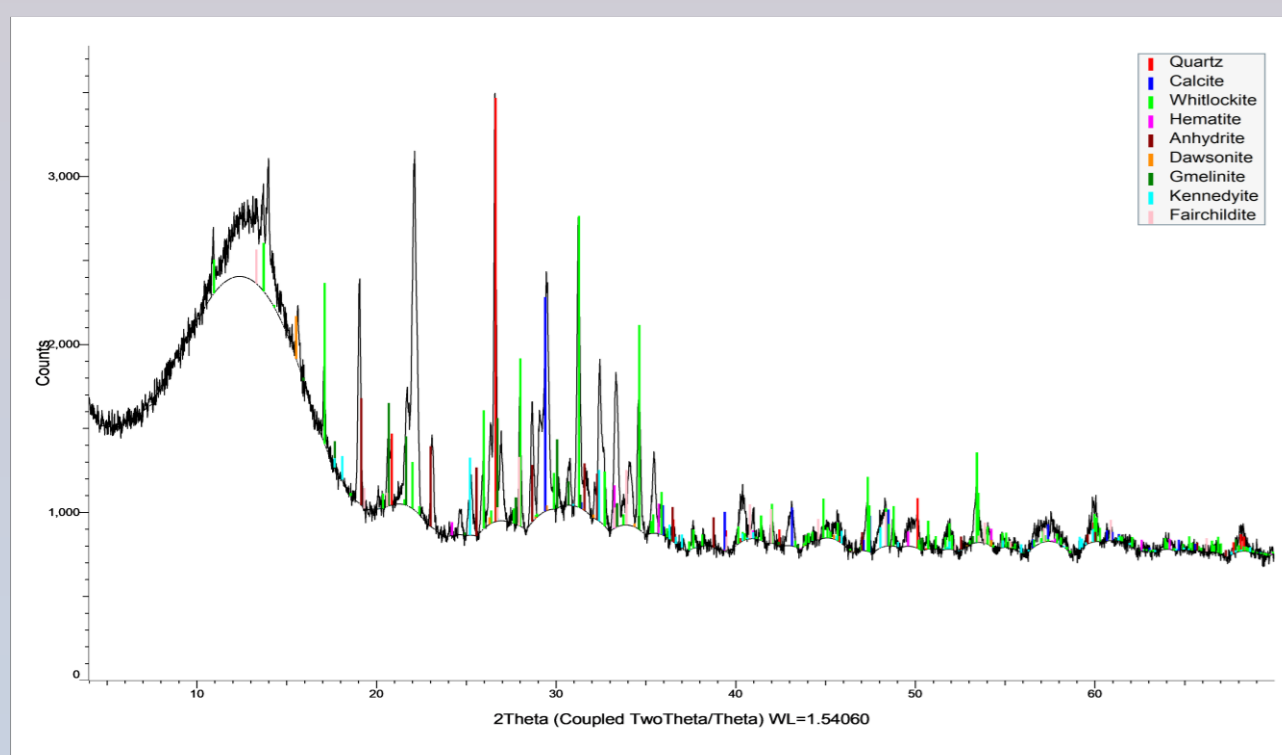
Ca/C	Composition of gas (mol %)					HHV (MJ/m <sup>3</sup> )	H <sub>2</sub> /CO
	H <sub>2</sub>	CO <sub>2</sub>	CO	CH <sub>4</sub>	C <sub>x</sub> H <sub>y</sub>		
0	33.29	10.1	55.5	1.0	0.2	11.8	0.69
1	54.2	2.0	40.9	2.8	0.05	13.2	1.82
2	68.0	1.2	27.9	2.8	0.04	13.4	2.40

**Table 3** Characteristic leaching parameters of the biochar through the soil

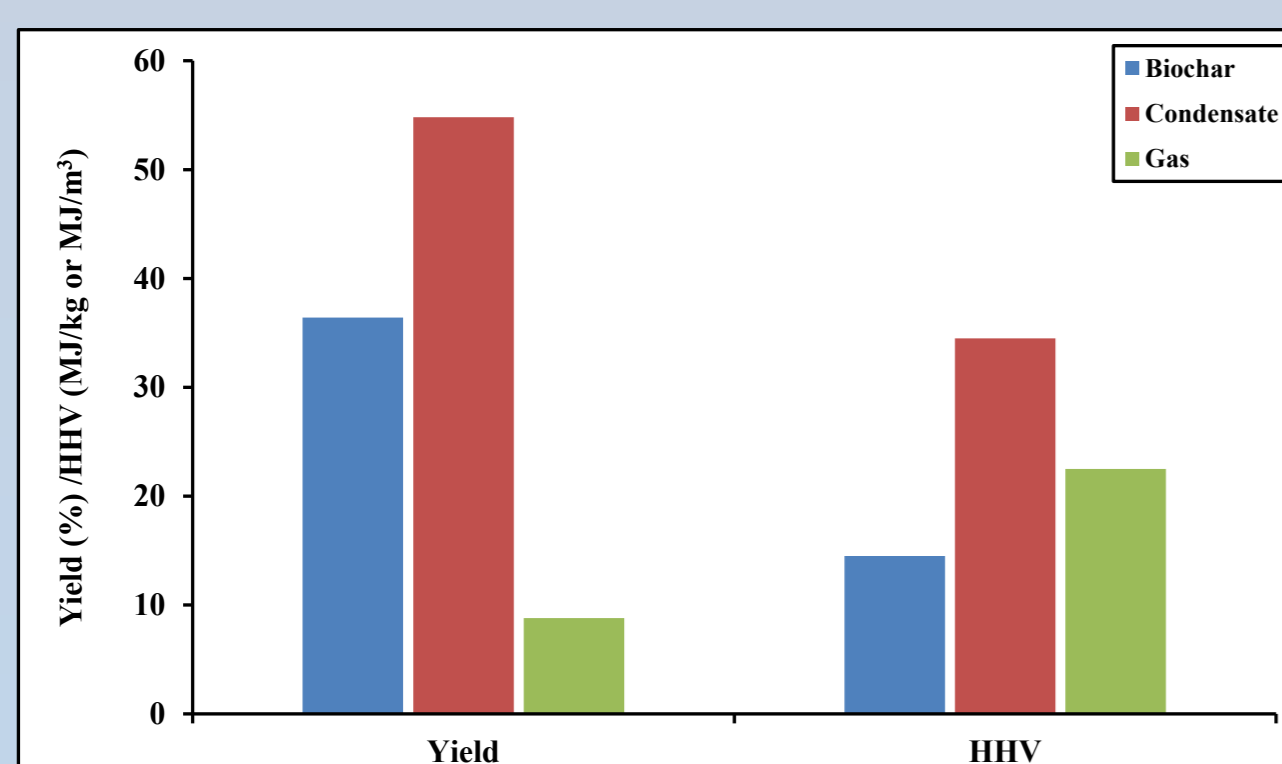
Sample	Leaching Time (days)					
	1	8	22	36	60	90
pH	7.0	7.2	7.6	7.8	7.9	8.0
EC (mS/cm)	0.7	0.6	0.5	0.4	0.2	0.2
COD (mg/L)	50.0	-	-	-	-	-
NO <sub>3</sub> <sup>-</sup> (mg/L)	37.0	34.0	33.0	31.0	26.0	22.0
PO <sub>4</sub> <sup>3-</sup> (mg/L)	-	-	-	-	-	-
Phenols (mg/L)	-	-	-	-	-	0.6



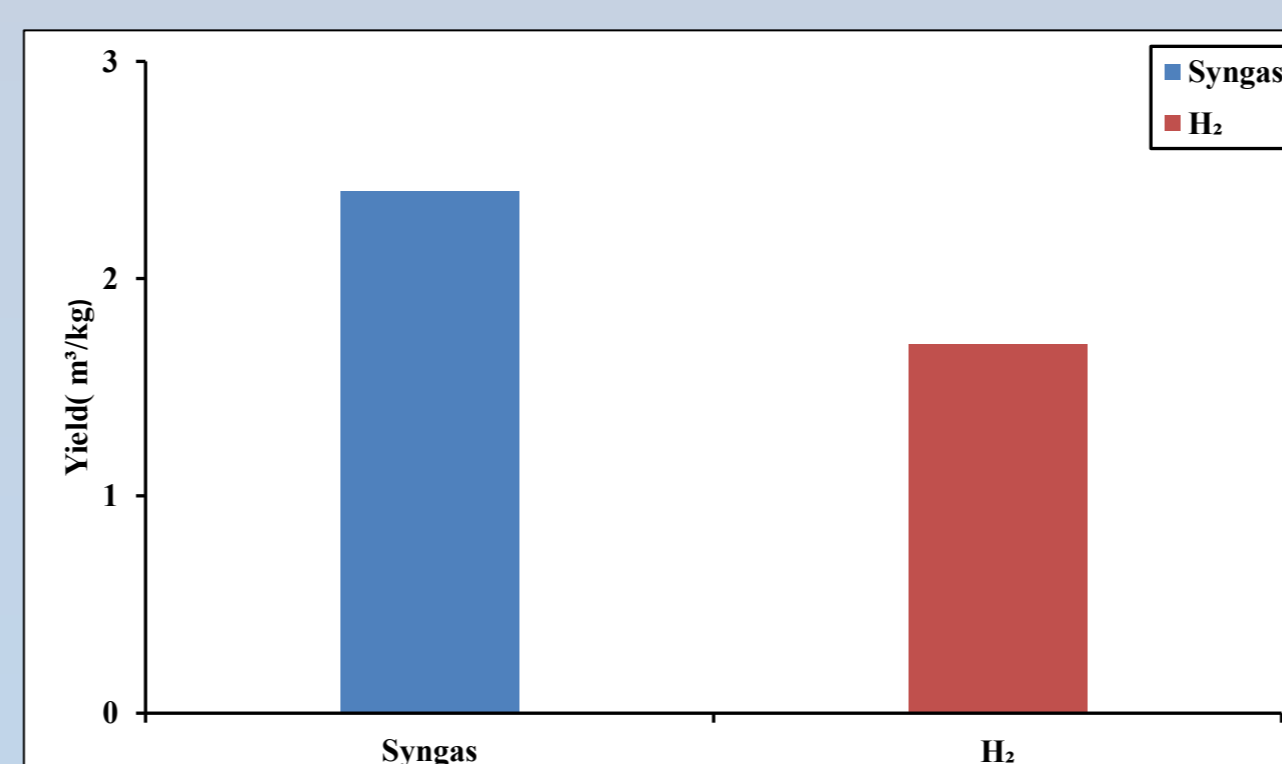
**Figure 1:** Experiment set up.



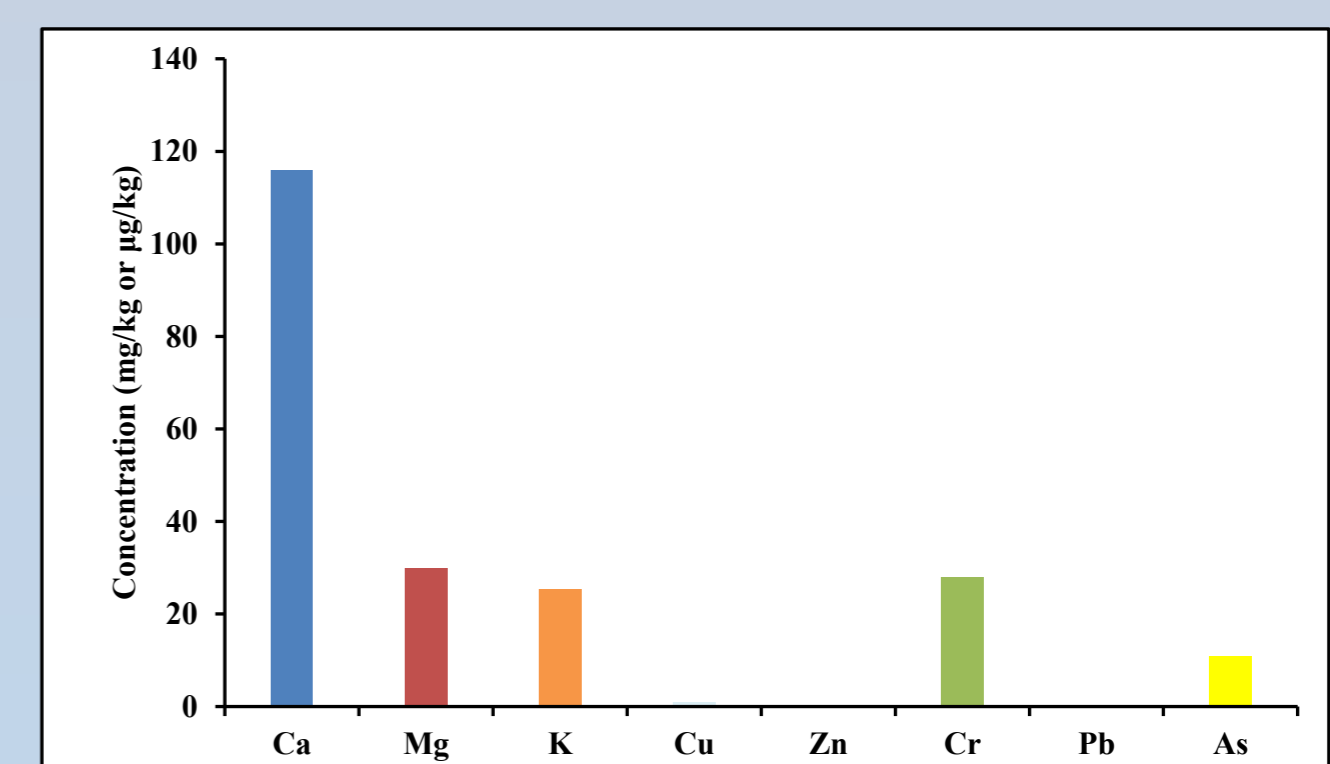
**Figure 2:** XRD spectra of BSL ash, sorbent and soil.



**Figure 3:** Yield and higher heating value of pyrolysis products.



**Figure 4:** Yield of syngas and hydrogen of biochar.



**Figure 5:** Cumulative leached elements from soil/biochar (Ca, Mg, K in mg/kg).

## Conclusions

By addition of waste concrete fines sorbent, 88% of carbon dioxide from the steam gasification of the bio-solid studied was captured, the molar fraction of hydrogen in the generated gas increased from 33.2% up to 68%, the hydrogen-to-carbon monoxide molar ratio was 2.4 and the yield of hydrogen 1.7 m<sup>3</sup>/kg char. During leaching some nitrates were retained on biochar's surface, while the release of phosphorus was negligible. Alkali cations presented higher mobility, whereas the leachability of heavy metals was extremely low.