Fuel properties characterization of hydrochars derived from agricultural digestate

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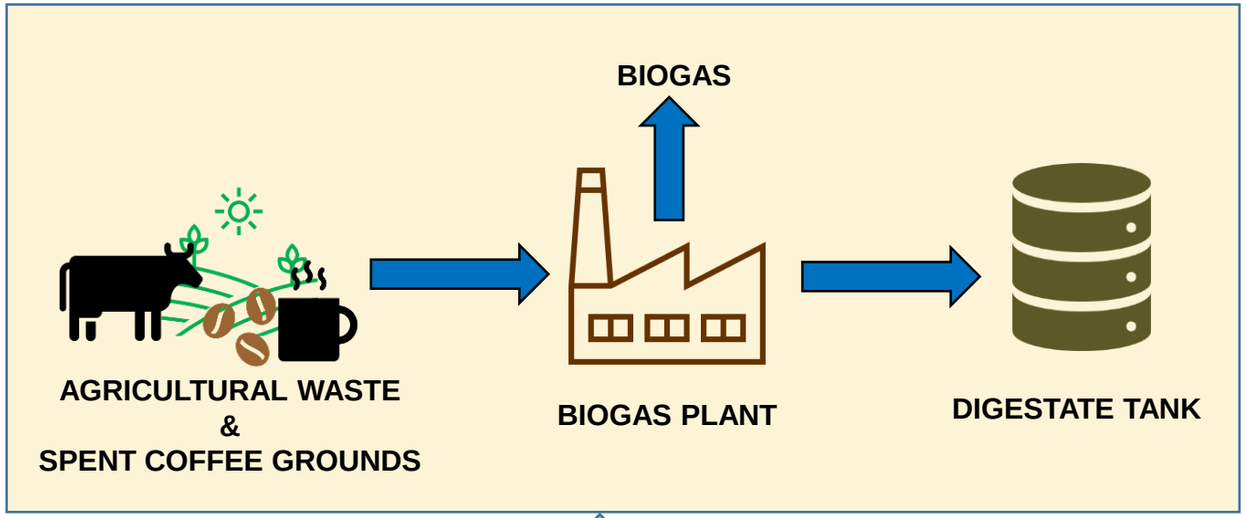
Agenda

1. Agricultural digestate
2. Hydrothermal carbonization process (HTC)
3. Material and methods
4. Analytical methods for hydrochars
5. Results

Agricultural digestate

- The main product in biogas plants is biogas and the by-product is digestate.
- Digestate is a mixture of solid and liquid phases stored in special tanks.
- Its composition is variable and depends mainly on the feedstock used in the biogas plant.



Hydrothermal carbonization process (HTC)

- Hydrothermal carbonization proces is applied to feedstock with a high moisture level.
- The feedstocks are mainly biomass, sewage sludge and food waste.
- Temperature and residence time are crucial parameters that affect the properties of the final products:

➢ Temperature is in the range of 160 – 220 °C;

➢ Residence time is in the range of 0.5 – 8 h.

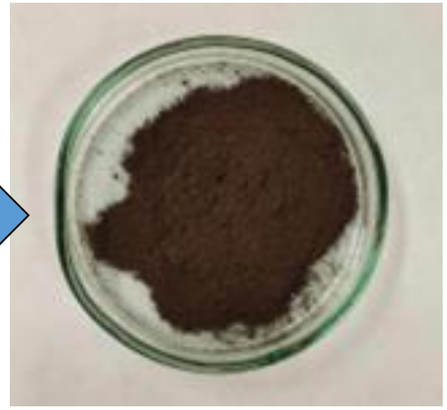
Fig 1. HTC reactor

HTC products

MIXTURE OF DIGESTATE AND WATER

HTC PROCESS

- **HYDROCHAR**



- **PROCESS WATER**
- **GASEOUS PRODUCT**

Material and methods

- Digestate was delivered from the agricultural Biogas Plant BUTOR.
- It consisted of straw, cattle manure and coffee grounds.
- The parameters of the HTC process were as follows:

Temperature:

- **190, 200 and 210 °C**

Residence time:

- **0.5, 1, 1.5 and 2 h**

Fig 2. Raw digestate

Analytical methods for hydrochars

Ultimate analysis - Elemental Analyzer LECO CHNS628.

Proszę powiększyć C na osi

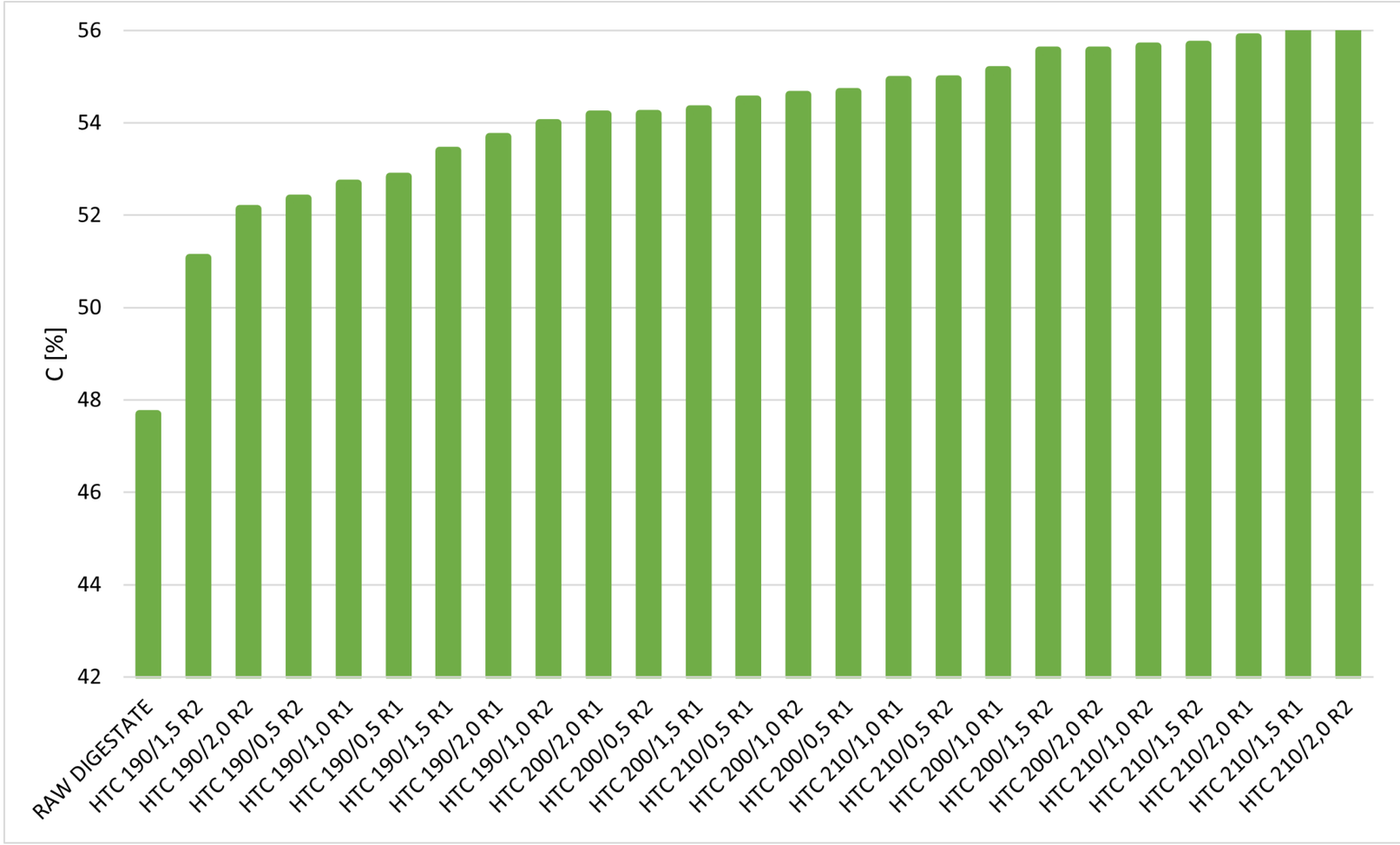


Fig 3. Carbon content in hydrochars and raw digestate

Proszę dodać opis H i N większy, bo nic nie widać najlepiej gdzieś wyżej ze strzałką

Analytical methods for hydrochars

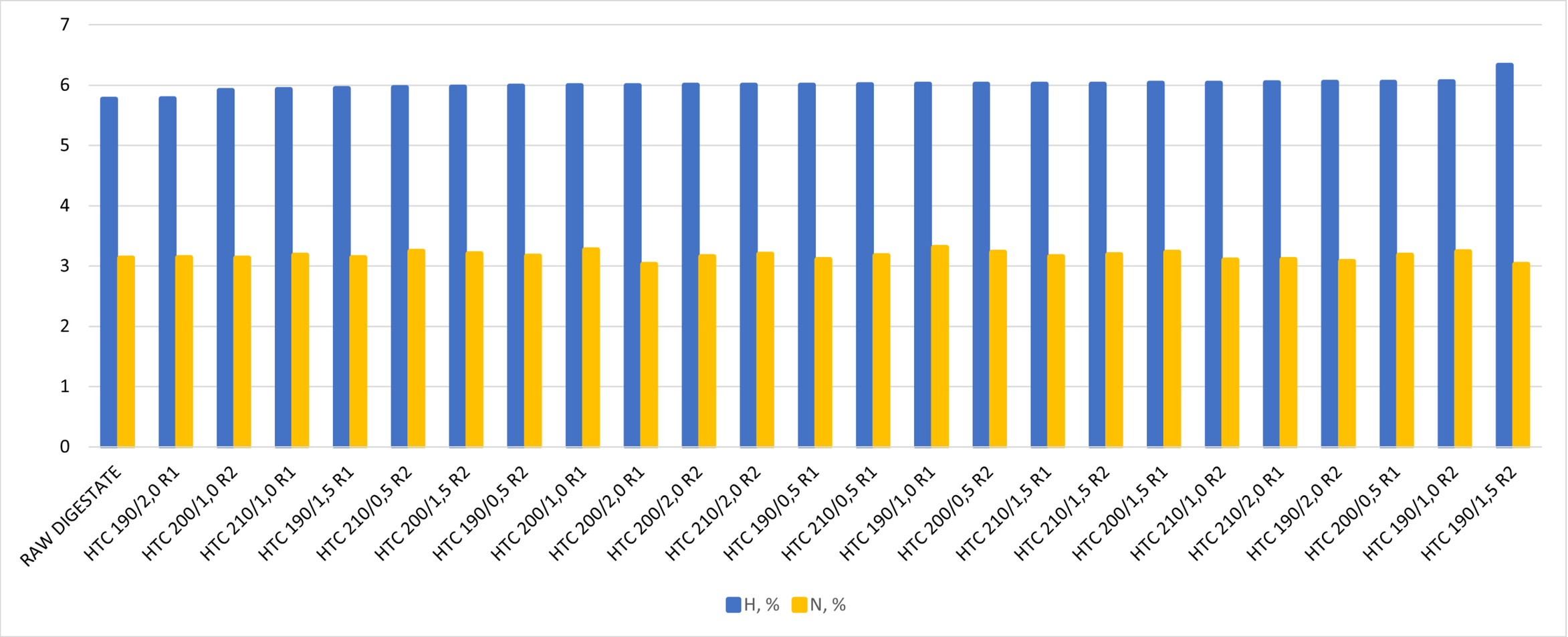


Fig 4. Hydrogen and nitrogen content in hydrochars and raw digestate

Name	Moisture, %	Ash, %	Volatile matter, %
HTC 210/1,0 R2	1,29	7,62	68,74
HTC 210/0,5 R2	1,36	7,9	68,98
HTC 200/1,5 R2	1,47	7,23	70,43
HTC 210/1,5 R1	1,72	7,92	68,02
HTC 190/2,0 R1	1,73	8,69	67,78
HTC 200/1,0 R1	1,81	7,54	70,39
HTC 200/1,0 R2	1,84	8,52	68,46
HTC 210/1,5 R2	1,87	8,52	65,68
HTC 200/0,5 R1	1,91	7,03	72,03
HTC 210/2,0 R2	1,92	8,76	67,44
HTC 210/2,0 R1	2,04	8,29	67,87
HTC 210/1,0 R1	2,14	7,31	69,13
HTC 200/2,0 R2	2,22	7,44	68,36
HTC 200/0,5 R2	2,29	7,12	71,79
HTC 190/1,0 R1	2,31	7	69,61
HTC 210/0,5 R1	2,52	7,37	68,17
HTC 190/0,5 R1	2,74	6,71	71,29
HTC 190/1,0 R2	2,79	6,71	70,14
HTC 200/1,5 R1	3,03	8,03	69,11
HTC 200/2,0 R1	3,03	7,4	67,87
HTC 190/0,5 R2	3,06	7,16	71,08
HTC 190/1,5 R1	3,26	7,67	67,49
HTC 190/2,0 R2	4,75	8,97	65,14
HTC 190/1,5 R2	5,03	6,92	66,43
RAW DIGESTATE	5,75	7,86	70,3

Proximate analysis - calculated by the EVAL 5E–MAC6710 thermogravimetric analyzer

Van Krevelen

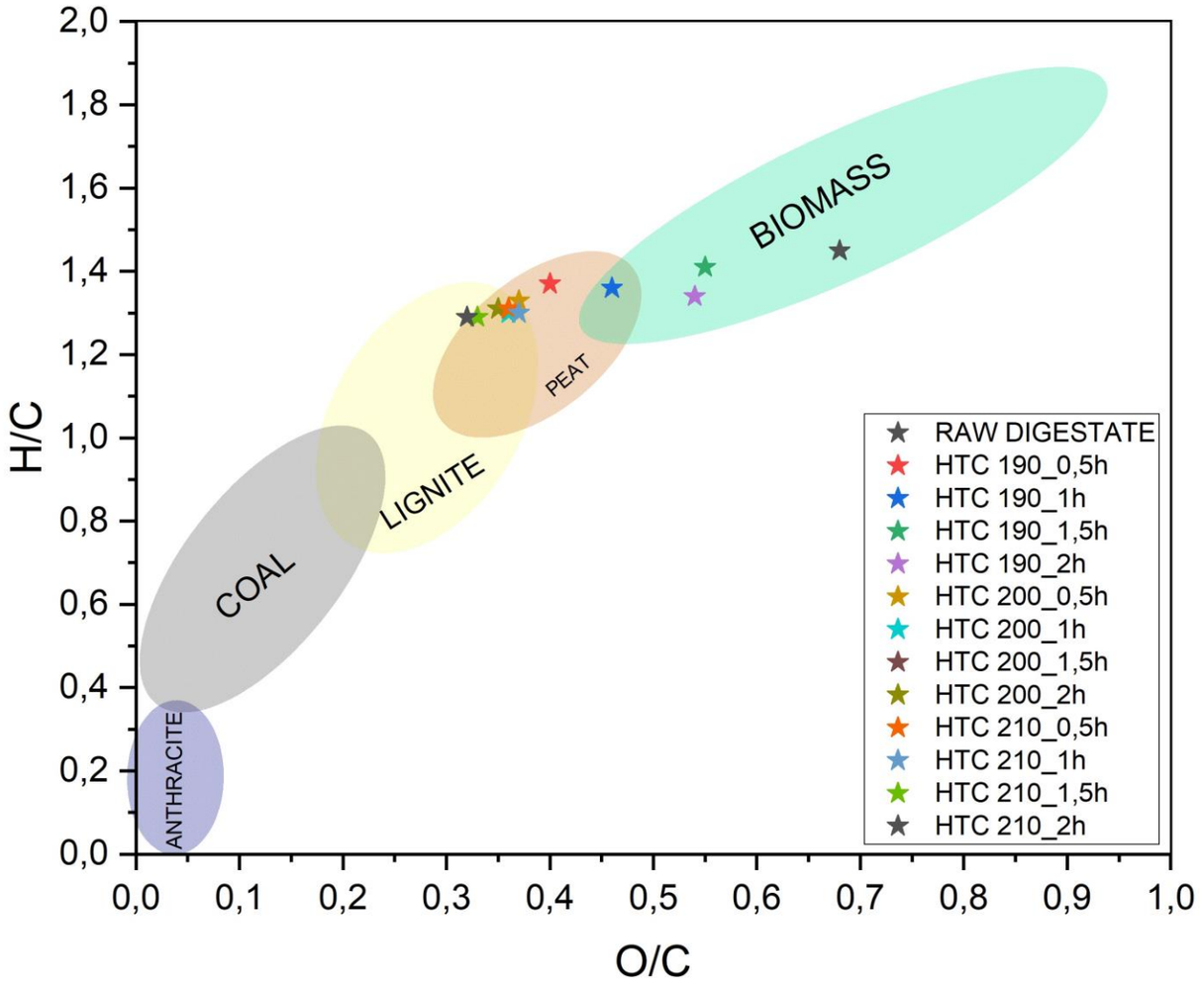


Fig 6. Van Krevelen diagram

- **The high heating values (HHV) -** LECO AC500 calorimeter

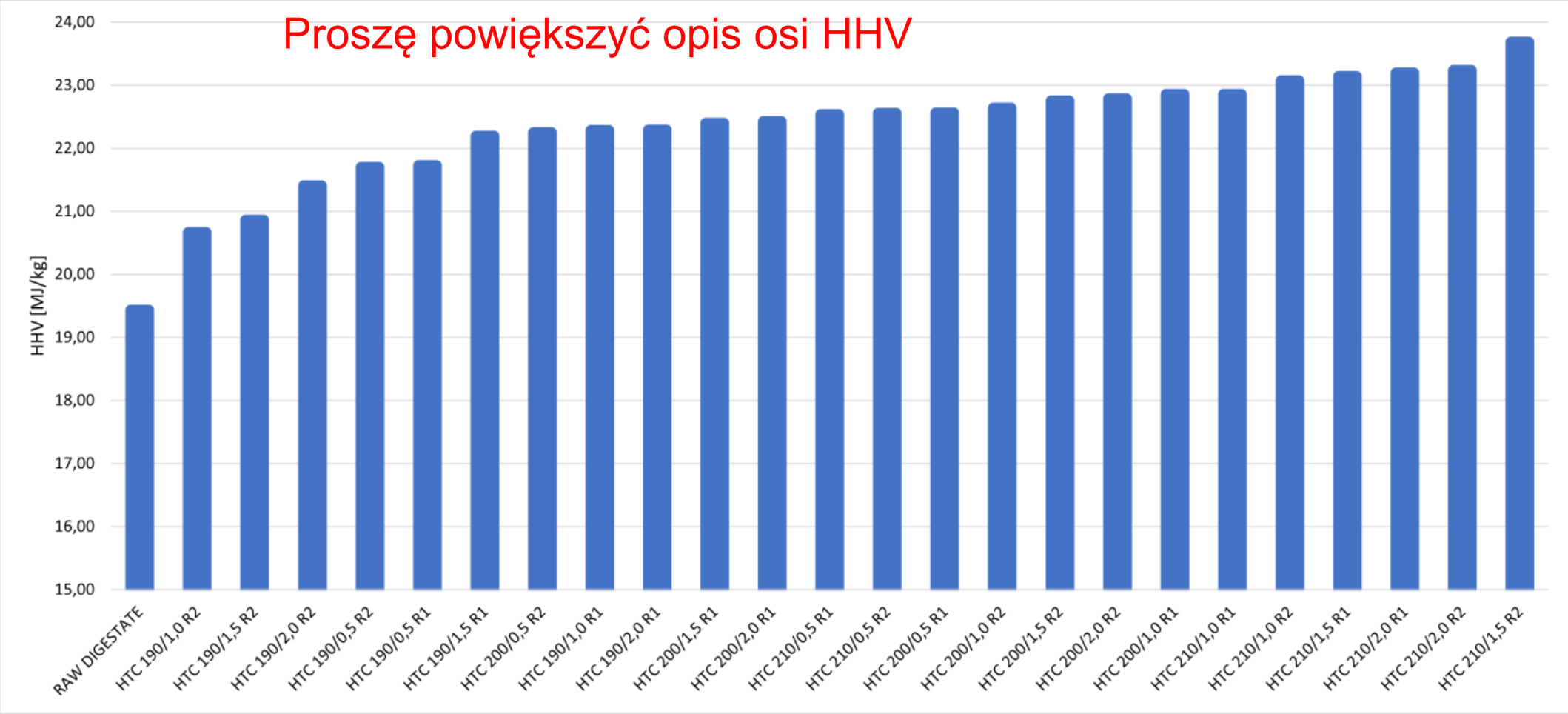


Fig 7. High heating values for hydrochars and raw digestate

- **Thermogravimetric analysis (TGA)** – Netzsch STA 449 F3 Jupiter using a standard DSC/TG sample carrier

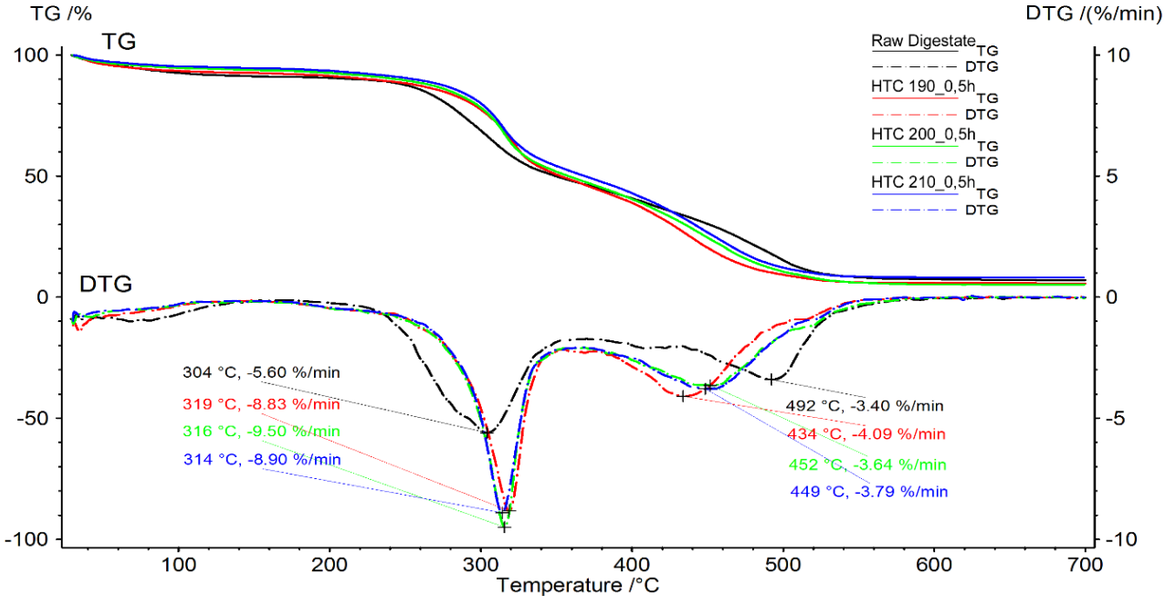


Fig.8 TGA results for raw digestate and hydrochar performed at 190, 200 and 210 °C and 0.5 h of residence time

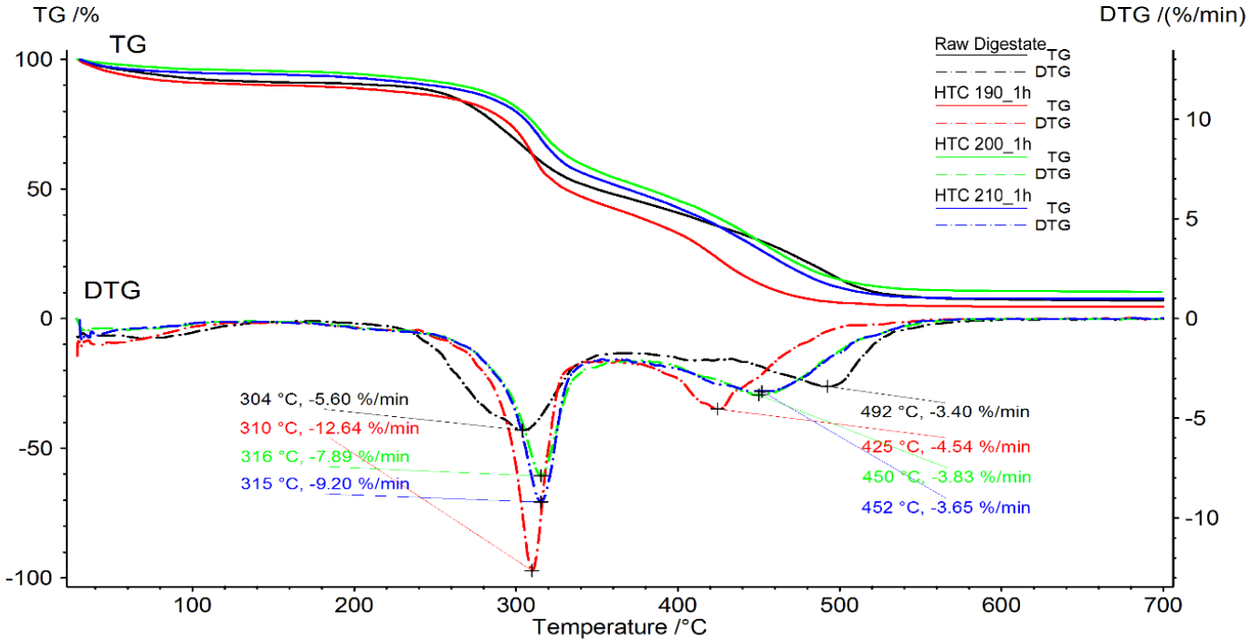


Fig. 9 TGA results for raw digestate and hydrochar performed at 190, 200 and 210 °C and 1 h of residence time

- **Thermogravimetric analysis (TGA)** –Netzsch STA 449 F3 Jupiter using a standard DSC/TG sample carrier

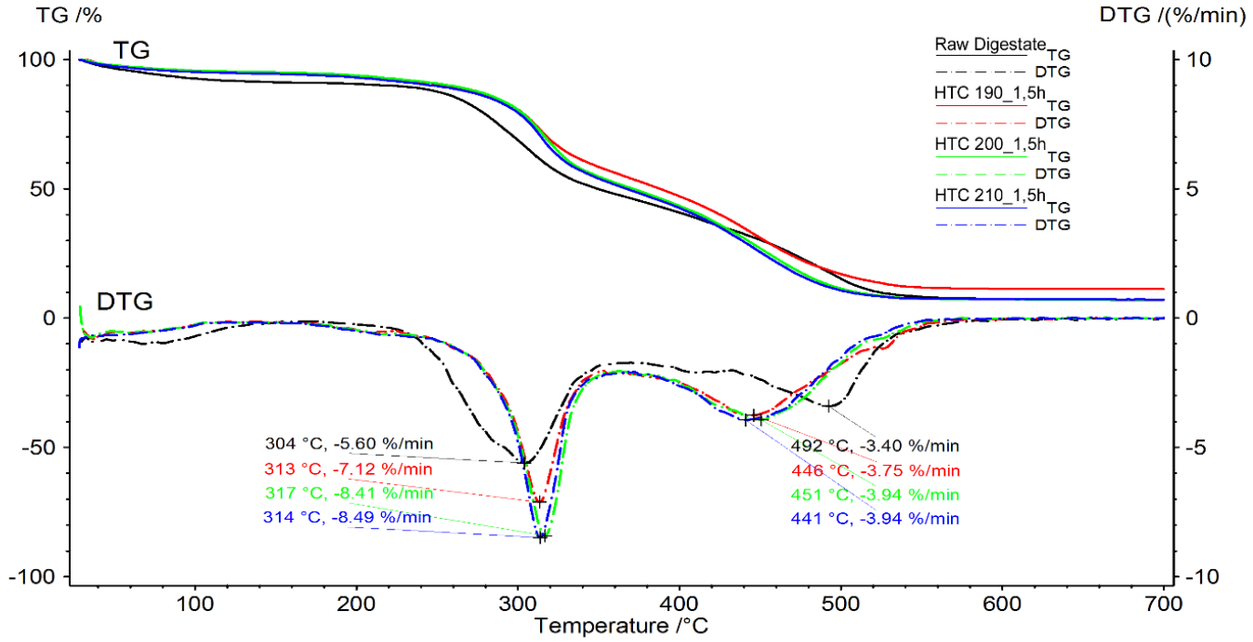


Fig. 10 TGA results for raw digestate and hydrochar performed at 190, 200 and 210 °C and 1.5 h of residence time

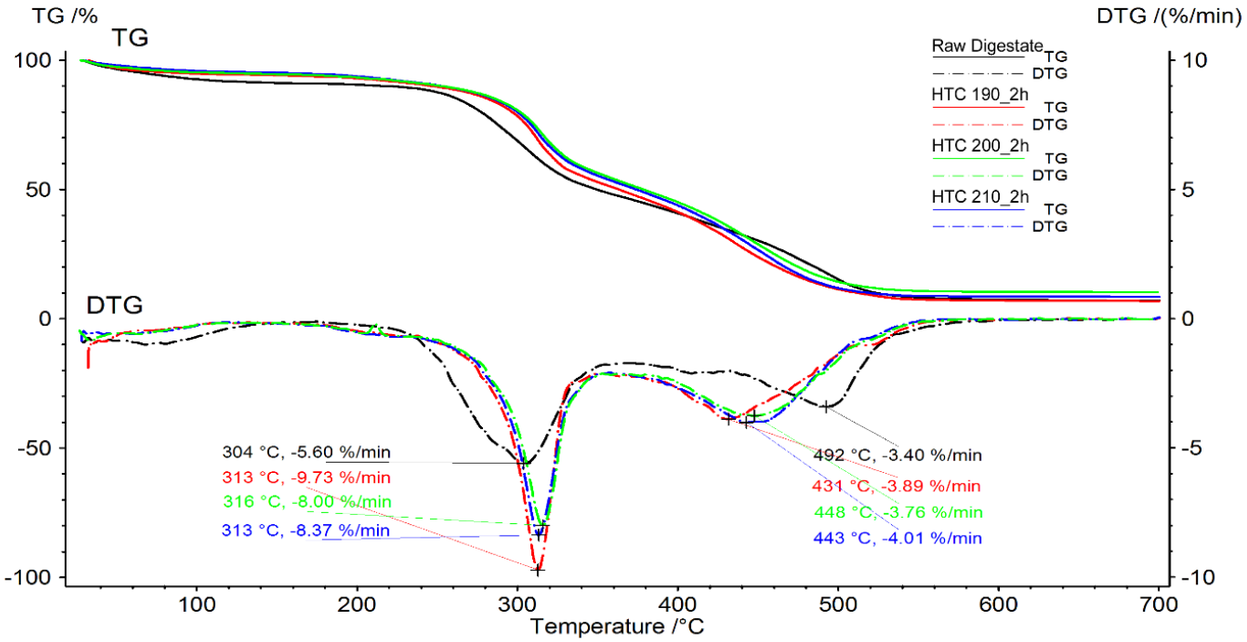
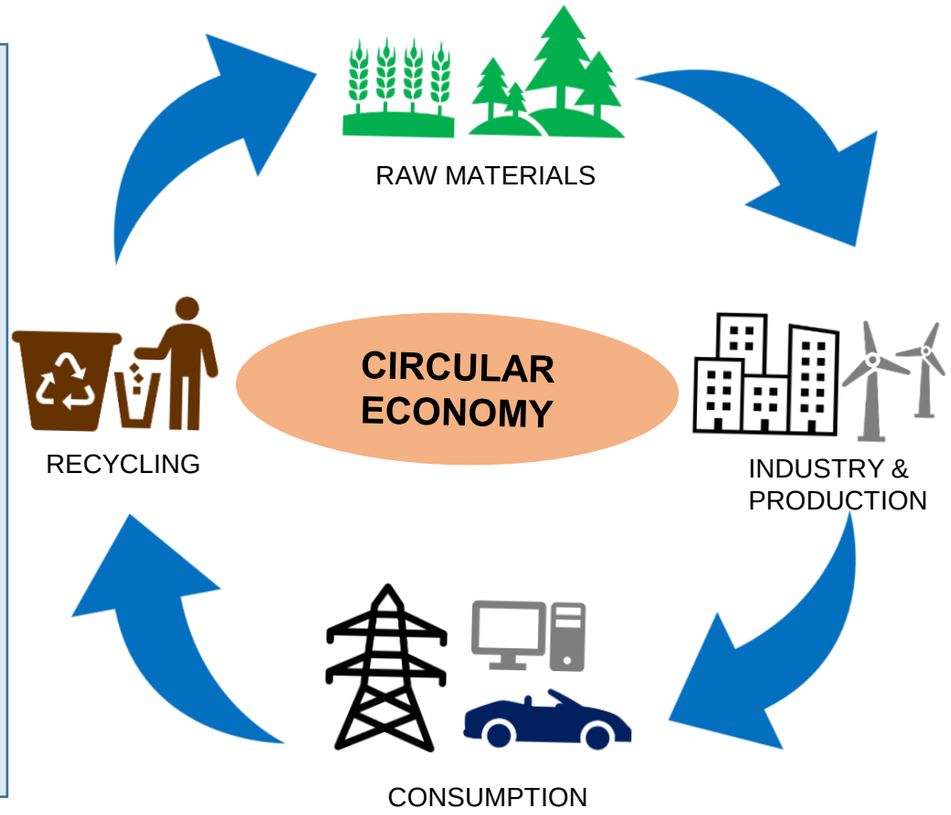


Fig.11 TGA results for raw digestate and hydrochar performed at 190, 200 and 210 °C and 2 h of residence time

Conclusions

- The fuel properties of hydrochars primarily depend on the temperature and residence time of the HTC process.
- HTC process of agricultural digestate increases the carbon content in hydrochars.
- Hydrochars produced at 210 °C have the highest carbon content and higher HHV values.
- Hydrochars performed at 200 and 210 °C for 1.5 and 2 h had similar combustion profiles.



HIGHER TEMPERATURE OF THE HTC PROCESS CAUSES BETTER FUEL PROPERTIES OF HYDROCHARS.

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Thank you!

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