BIOREFINERY OF SWEET SORGHUM FOR A CIRCULAR ECONOMY

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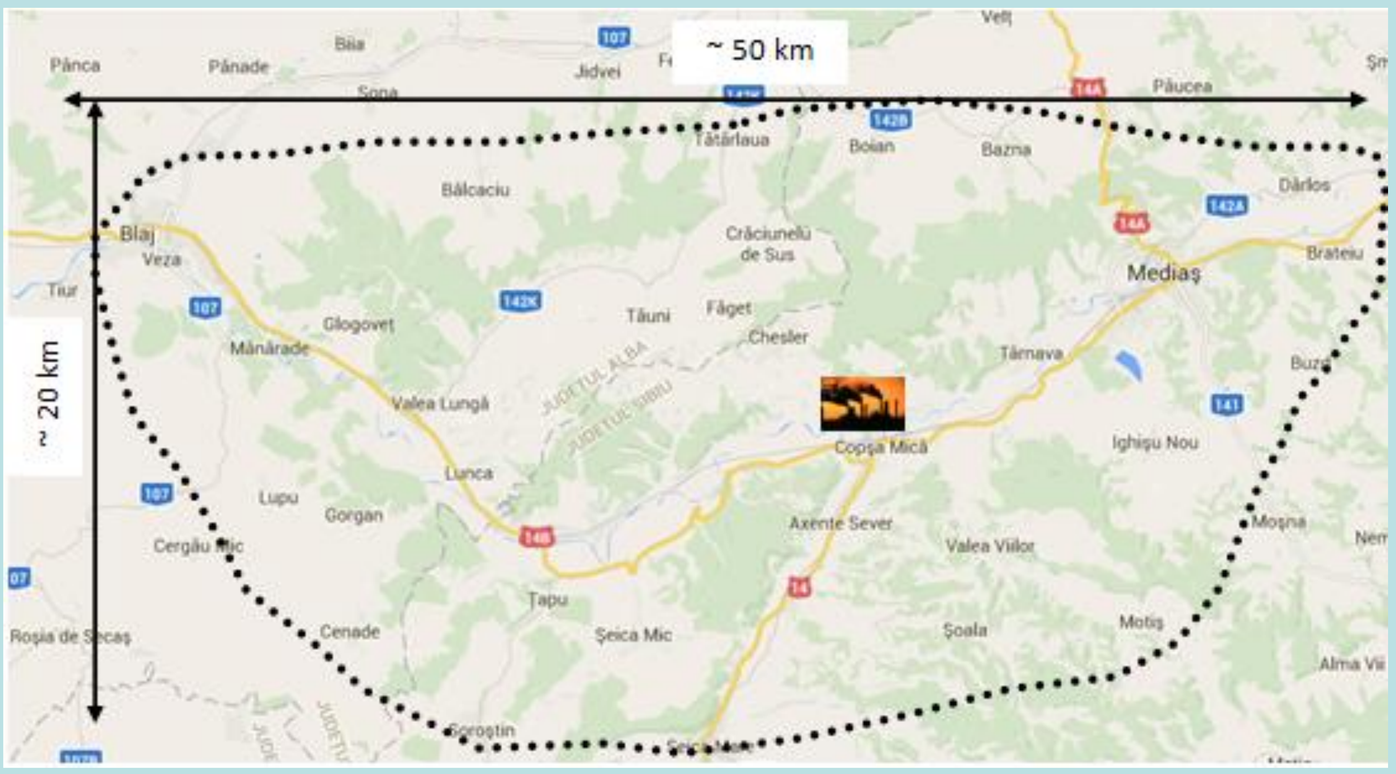
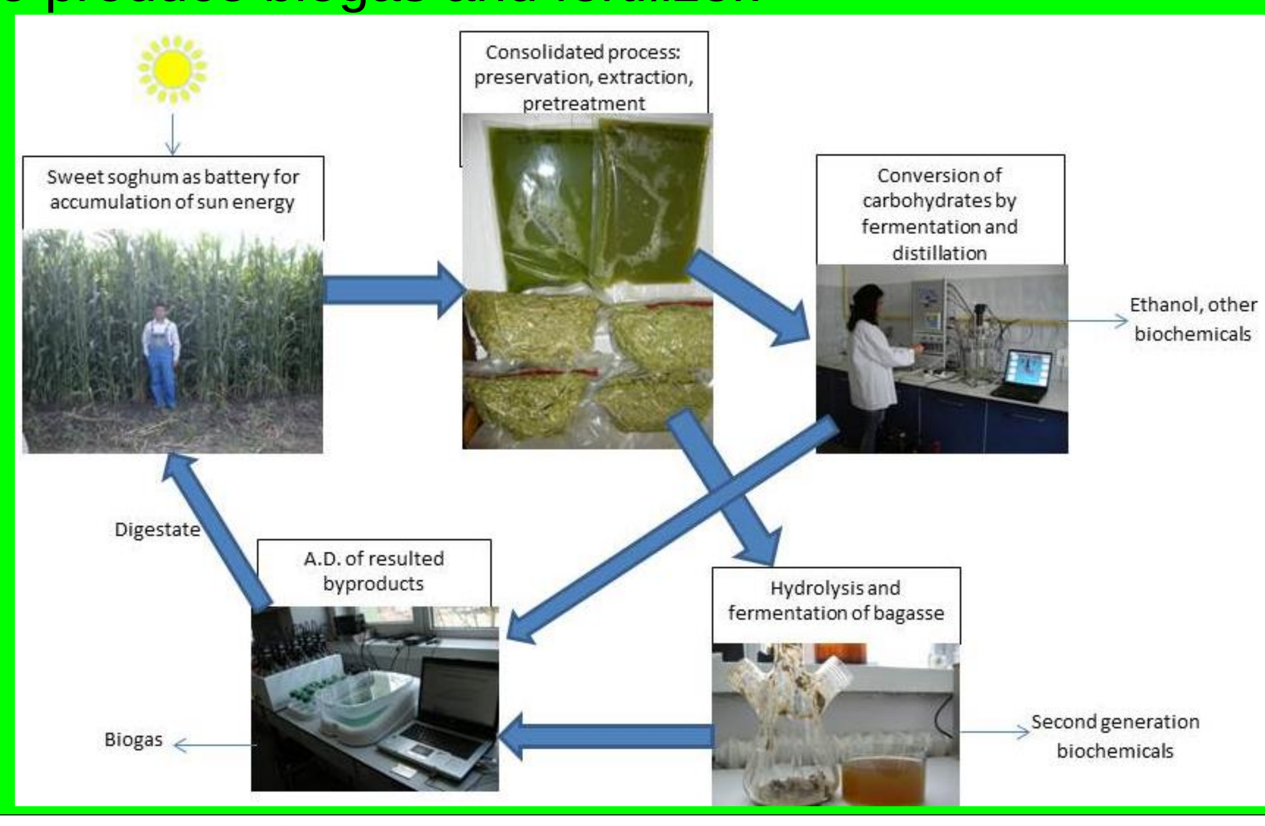
Our team applyied cascade processing of sweet sorghum biomass (variety Sugargraze) cultivated in a heavy metals polluted area (Zn, Cu, Pb, Cd). We applied biotechnologies connected in a biorefinery process to produce first generation ethanol, lactic acid and biogas, in order to quantify the production potential of energy and biochemicals using sweet sorghum as energy carrier. Polluted zone: ~ 1000 km^2. The area is inappropriate for food and feed production, due to high levels of heavy metals in agriculturl products, but is suitable for energy crops for biofuels production.



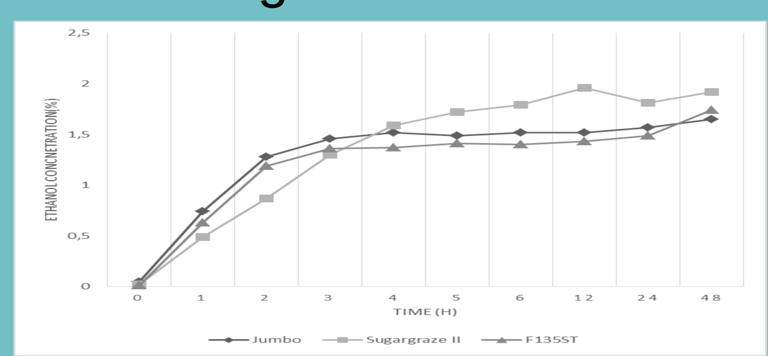
Sorghum biomass was harvested after 135-150 days of cultivation and the sugars-reach content of the sorghum stems have been extracted by pressing and by a patented process (P.R. registration no. A/00334, OSIM – Romania). The juice was fermented to produce first generation ethanol and lactic acid for PLA production. The resulted bagasse have been enzymatically hydrolysed and fermented to produce second generation ethanol. The residues obtained after hydrolysis and fermentation have been anaerobicaly digested to produce biogas and fertilizer.



Production of ethanol, first generation

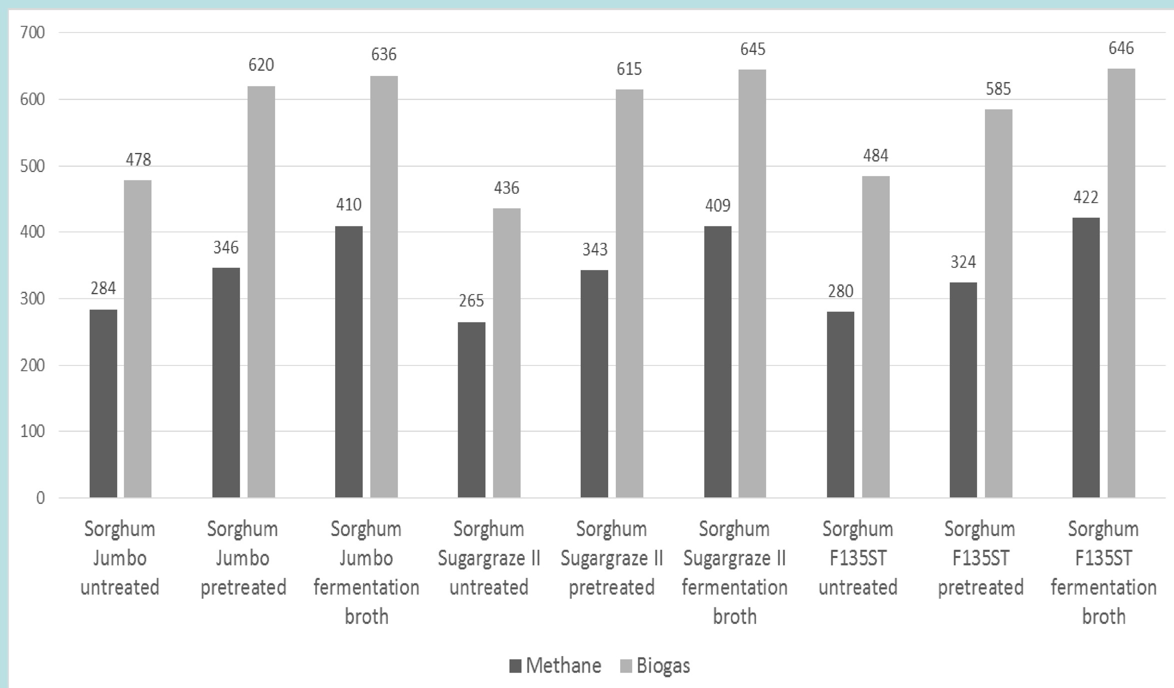
	Process	Brix	Reducing sugars, g/l	Volume liquid L/t biomass	Producțion[1] of ethanol L/t biomass	Producțion[1] of ethanol L/t biomass D.M.	Average ethanol production liter / ha[2]
1	Classic extraction by pressing	16,2	70-84	250	18,75	26,79	940
2	Solid state fermentation – SSF of ensiled sorghum	6,4	58	-	50	217,39	2500
3	One-time extraction of sugars from sorghum stems, patented technology (A)	14	122	600	65,4	311,43	3270
4	Extraction of sugars from sorghum bagasse	21,6	223	300	33,3 (+18,75)	133,20 (+26,79)	1665 (+940)
5	Multiple extraction of sugars, patented technology (B, C, D)	14	115	750	51 (+65,4)	242,86 (+311,43)	2550 (+3270)

Production of ethanol, second generation



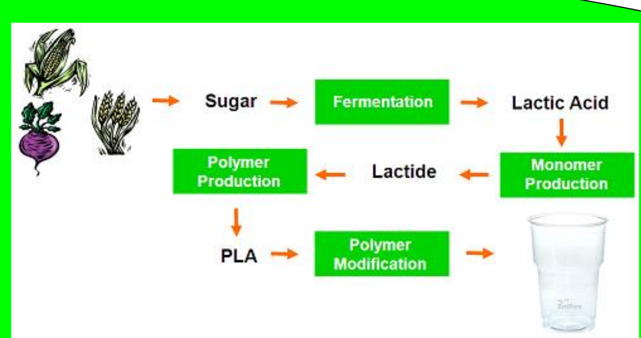
Calculating the ethanol yields, the following yields where obtained in the three sorghum hybrids:
0.33g/g Jumbo biomass,
0.34 g/g F135ST biomass and 0.38 g/g Sugargraze II biomass,
(all reported to dry matter).

A.D. of sorghum biomass using AMPTS (Bioprocess Control)



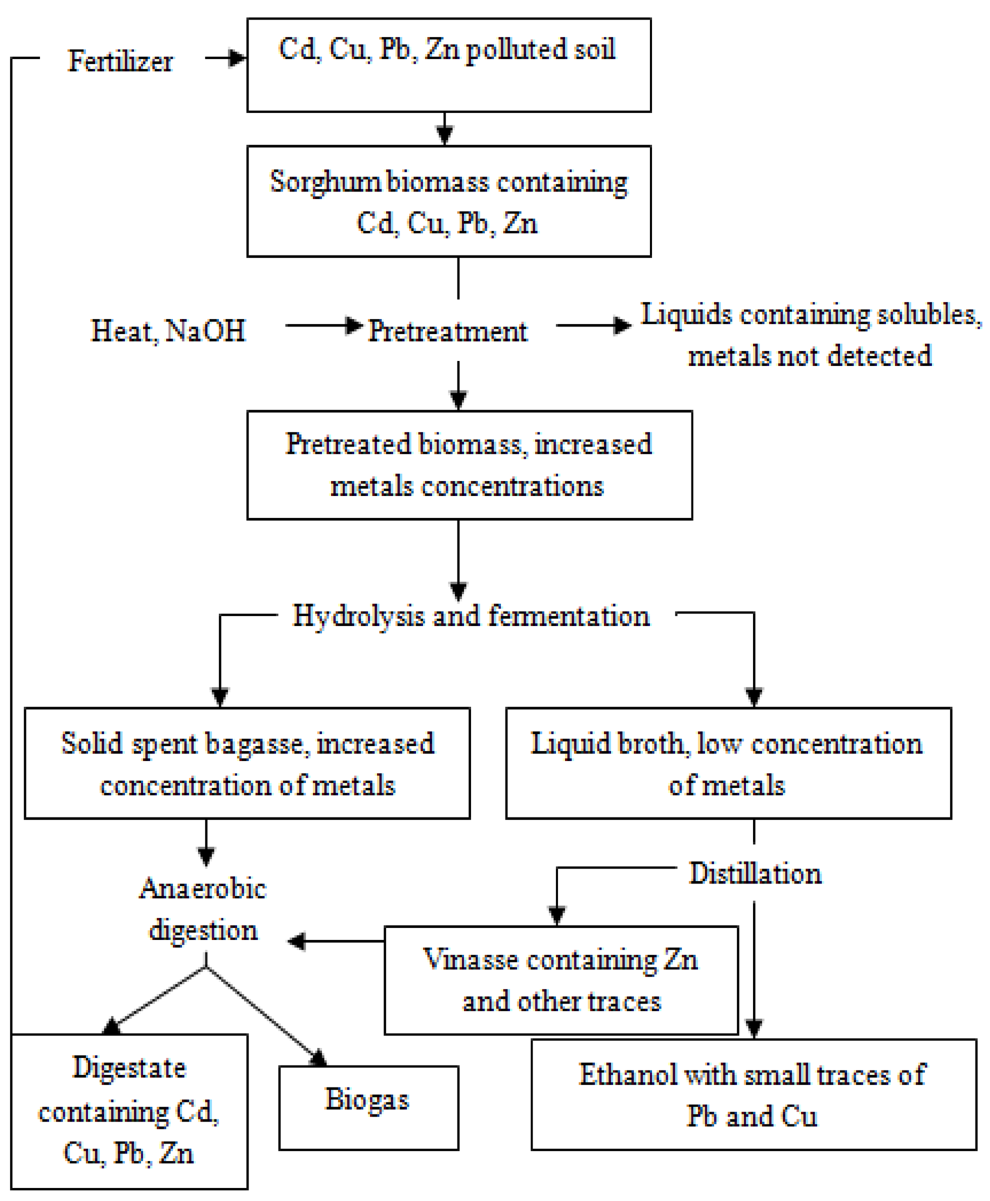
These results indicates that more energy is produced if the biomass is processed in cascade, by the combination of studied technologies: extraction of sugars, lignocellulosic ethanol production and biogas production of the resulted bagasse.

Other biochemicals readily obtainable by fermentation of sugars: PLA



From 1 Ha of land cultivated with sweet sorghum, in a pesimistic scenario of 50 tons of fresh biomass production:

- **Around 6800 liters ethanol first+second generation (about 90000 km driving a car consuming 7,5 liters / 100 km);**
- **And 380 c.m. methane/ton D.M., around 260 c.m. methane/to fresh biomass, resulting 13000 c.m. methane / hectare (one year consumption of 7 houses 140 q.m.)**
- **OR: 5-5,5 tons of lactate for PLA (replacing plastic waste generated by 360 romanians / year)**
- **And the 13000 c.m. methane (one year consumption of 7 houses)**



In conclusion:
Sorghum crops cultivated on heavy metals polluted soil can be used as biomass for second generation biofuels and biochemicals production. The main part of metals remains in the solid residue, a small part in the distillation residue, and traces of Pb and Cu could be found in the distilled ethanol. The digestate obtained after anaerobic digestion and biogas production can be returned in the same site as fertilizer, maintaining soil fertility and confining pollutants strictly in the polluted area.

Acknowledgements: This work was supported by a grant of the Romanian Ministry of Education, CNCS – UEFISCDI, Project number: PN-II-ID-PCE-2012-4-0311