

# Potential of Namibia encroacher bush biomass in a green circular economy: A research perspective

Habauka M. Kwaambwa & Marius Mutorwa

Namibia University of Science and Technology (NUST)

Contact Email Address: [hkwaambwa@nust.na](mailto:hkwaambwa@nust.na)



# Outline of Presentation

- Introduction – Green Circular Economy
- Basic and Applied Biomass Research
- Research Capacity
  - Equipment/Infrastructure
  - Lessons learned from Moringa tree research
- Conclusion

# Potential for circular biobased value chain to contribute to achieving UN's SDGs

<b>SDG 2:</b>	<b>End hunger, achieve food security and improved nutrition, and promote sustainable agriculture</b>
SDG 6:	Ensure access to (clean) water and sanitation for all
SDG 7:	Ensure access to affordable, reliable, sustainable, and modern energy for all
SDG 9:	Build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation
SDG 12:	Ensure sustainable consumption and production patterns
SDG 13:	Take urgent action to combat climate change and its impacts
SDG 15:	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

# Potential for circular biobased value chain

Ecosystems protection  
& climate change  
mitigation

Access to Clean  
Water

**Biomass**

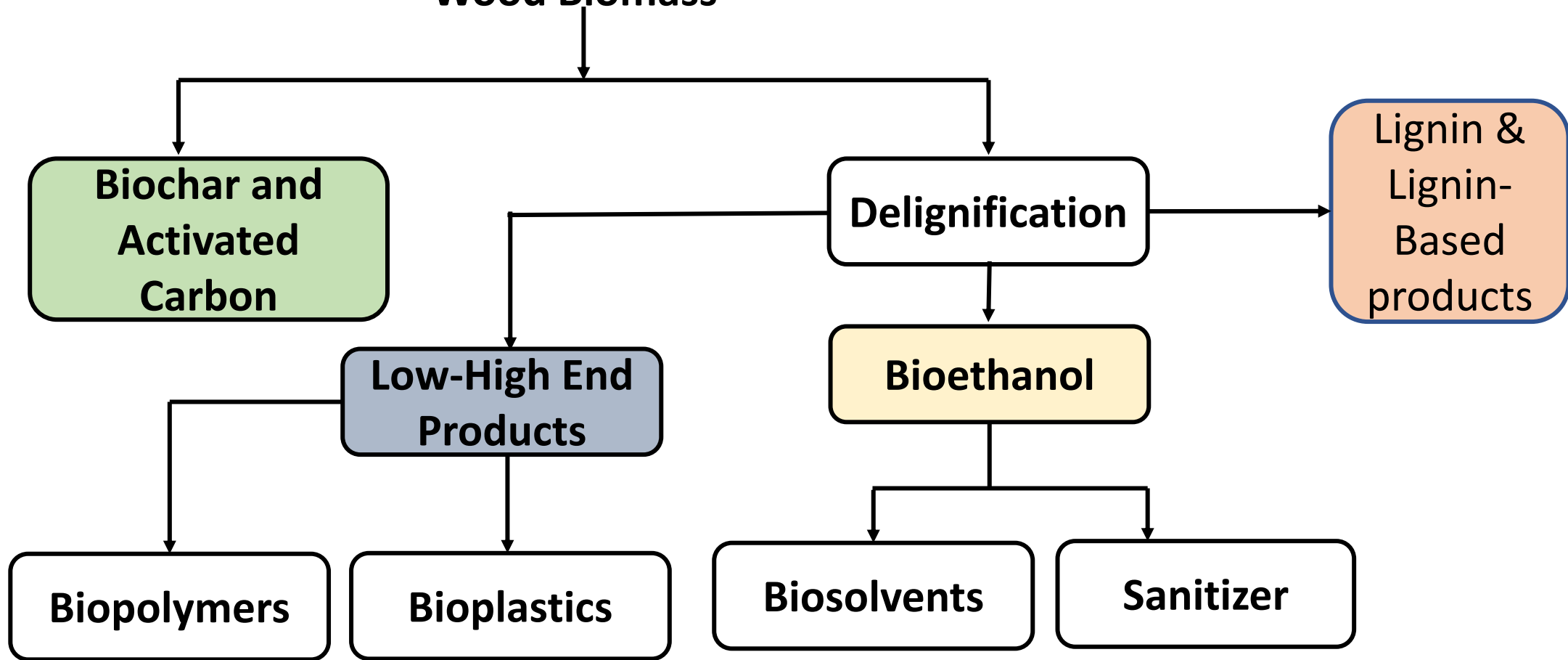
Bioenergy

Animal Feed

Biomaterials

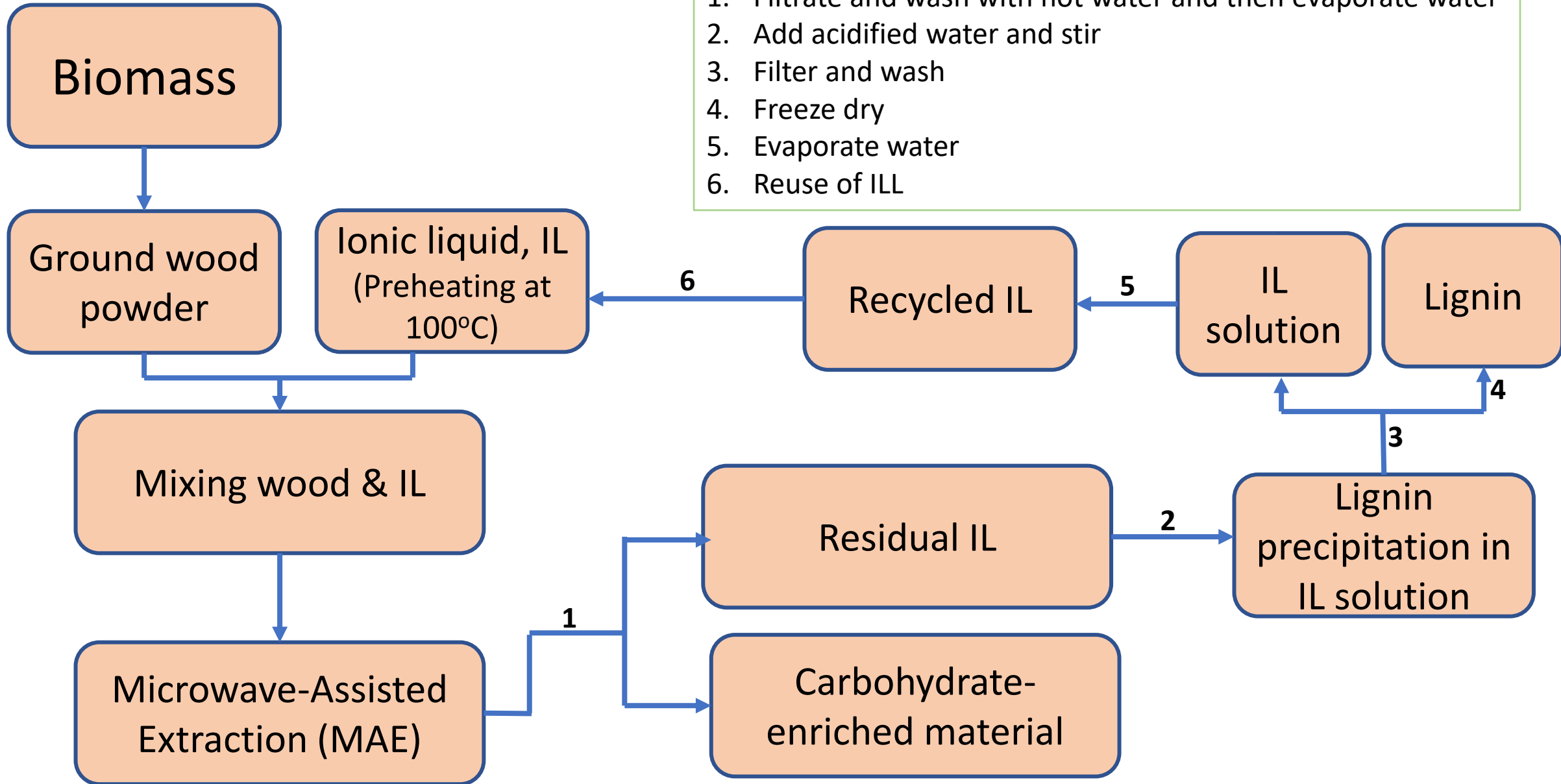


**Wood Biomass**



# Green Process of Extraction of Lignin

1. Filtrate and wash with hot water and then evaporate water
2. Add acidified water and stir
3. Filter and wash
4. Freeze dry
5. Evaporate water
6. Reuse of ILL



# Wood Plastic Composites (WPCs)

## Production Process



Thermoplastics	m.p. (°C)
Low density polyethylene (LDPE)	115
Medium density polyethylene (MDPE)	126-128
High density polyethylene (HDPE)	130
Polypropylene (PP)	170
Polyvinyl chloride (PVC)	212
Polystyrene (PS)	240
Polyethylene Terephthalate (PETE)	250-255
Recycled and waste thermoplastics	

<b>Coupling agents or Compatibilizers</b>
Maleic anhydride grafted polypropylene
Itaconic acid grafted polypropylene
<b>Others</b>
Lubricants, UV stabilizer, Fungicides, Algaecides

### Wood flour/Saw dust (filler)

- Ratio of wood to plastic in the wood plastic composite is critical because it determines its performance when it undergoes production.
- The melt flow index (MFI) of the resultant product depends on the percentage of wood in the WPC.
- Percentage of wood in the final product is inversely proportional to the melt flow index.
- WPC sheets have the appearance of wood with improved strength, which makes it preferable over conventional wood products.

**Challenges of WPCs manufacturing in Namibia:** Cost of an extruder can vary from US\$150000 for a simple screw extruder to over US\$1m for a complete wood plastic composite lumber extrusion system.

# WPC Product Formulations

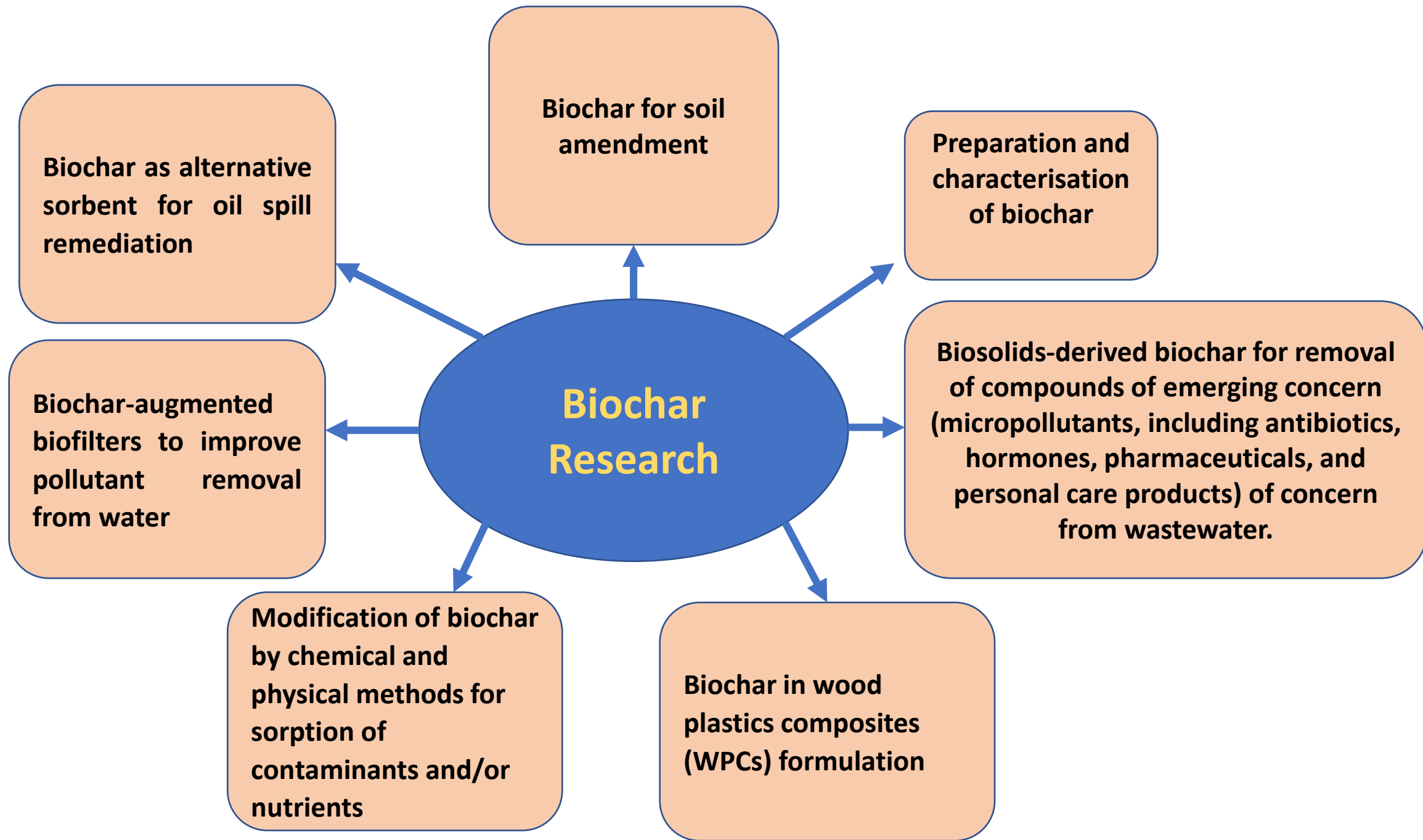
Product	Wood flour (%)	PP (%)	MAPP (%)	MDPE (%)	MAPE (%)	Biochar (%)
WPC1	45	50	5	0	0	0
WPC2	45	0	0	50	5	0
WPC3	45	25	2.5	25	2.5	0
WPC4	45	27.5	0	27.5	0	0
BWPC1	30	60	4	0	0	6



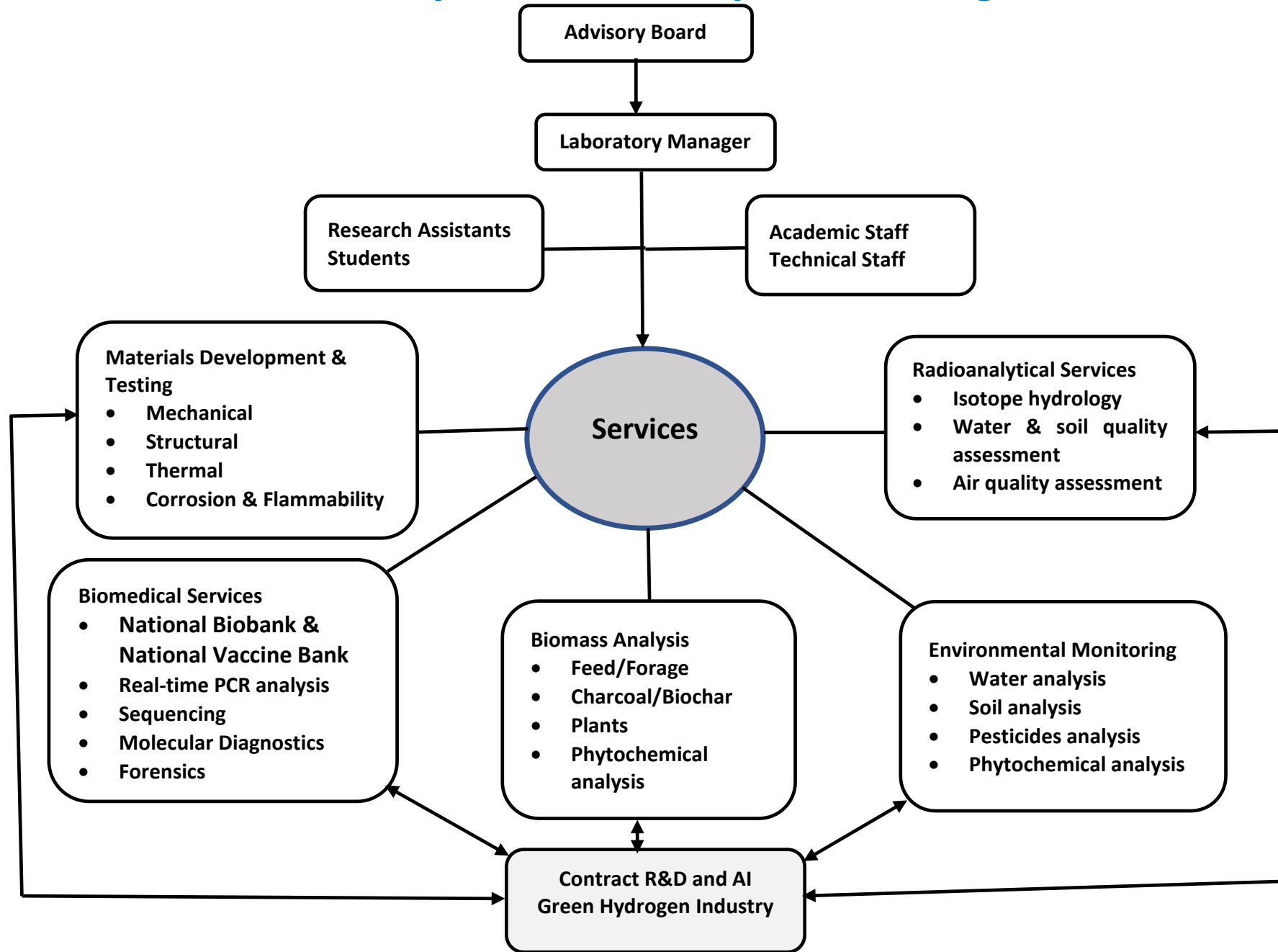
## Acronyms

PP	Polypropylene
MDPE	Medium density polyethylene
MAPP	Polypropylene-graft-maleic anhydride
MAPE	Polyethylene-graft-maleic anhydride





# Envisioned NUST Analytical Laboratory Services Organisational Chart



# Launch of the NUST BUSH Laboratory for Biomass Testing (27/11/2020)



Programme	
<b>Biomass Utilisation by Sustainable Harvest (BUSH) Project - Launch of the NUST BUSH Laboratory for Biomass Testing</b>	
Director of Ceremonies <b>Dr Marius Mutorwa</b> Senior Lecturer, Faculty of Health and Applied Sciences	
<b>Date:</b>	Friday, 27 November 2020
<b>Venue:</b>	Faculty of Health and Applied Sciences Auditorium, NUST Lower Campus
<b>Time:</b>	10:00 - 11:30
10:05	<b>Welcoming Remarks</b> Dr Onesmus Shungula Dean, Faculty of Health and Applied Sciences
10:10	<b>Opening Address</b> Dr Andrew Njikando Acting Vice-Chancellor, Namibia University of Science and Technology (NUST)
10:20	<b>Remarks</b> Mr Joseph Hailwa Director: Ministry of Environment, Forestry and Tourism (MEFT)
10:30	<b>Remarks</b> Ms Gerlinde Sauer Counsellor for Development Cooperation German Embassy, Windhoek
10:35	<b>Remarks on the relevance of the testing laboratory to the biomass industry</b> N-BIG
10:40	<b>Overview presentation about the NUST Laboratory</b> Prof Habauka Kwaambwa Laboratory Analytics Development Sub-project Leader and HoD: Natural and Applied Sciences (NAS)
10:50	<b>Handover Address</b> GIZ
11:00	<b>Laboratory Tour / Demonstrations and Photo Shoot</b> Dr Marius Mutorwa and Dr Julien Lusilao Senior Lecturers, NAS
11:30	<b>Refreshments</b>



# Instruments for Biomass Testing - BUSH Project

## 1. Furnace



- Ash content
- Moisture content

## 2. Kjeldahl Nitrogen Analyser



- Nitrogen and Protein analysis

## 3. Bomb Calorimeter



- Calorific value (energy content)

# Instruments for Biomass Research - BUSH Project

## 4. Near Infrared Reflection Spectrometer



- Plastics identification

## 5. Universal Testing Machine (UTM)

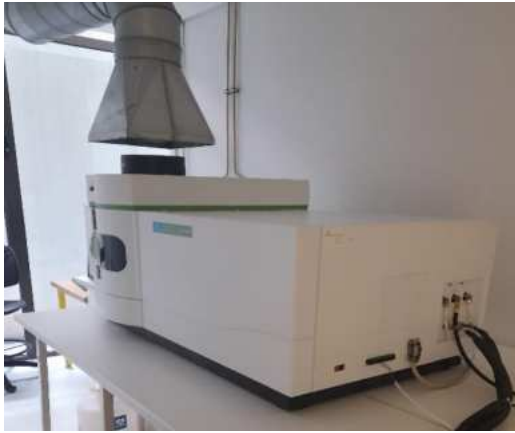


Mechanical properties of materials, e.g. WPCs

- Tensile strength
- Compression (Flexural) Test

# Instruments for Biomass Testing and Research - NUST

## 1. ICP-OES



- Mineral content

## 3. HPLC



- Compositional analysis, e.g. aflatoxins, lignin

## 2. GC-MS



- PAHs, PCBs & VOCs

## 5. UV-Vis Spectrophotometer



← Surface area using methylene and iodine numbers

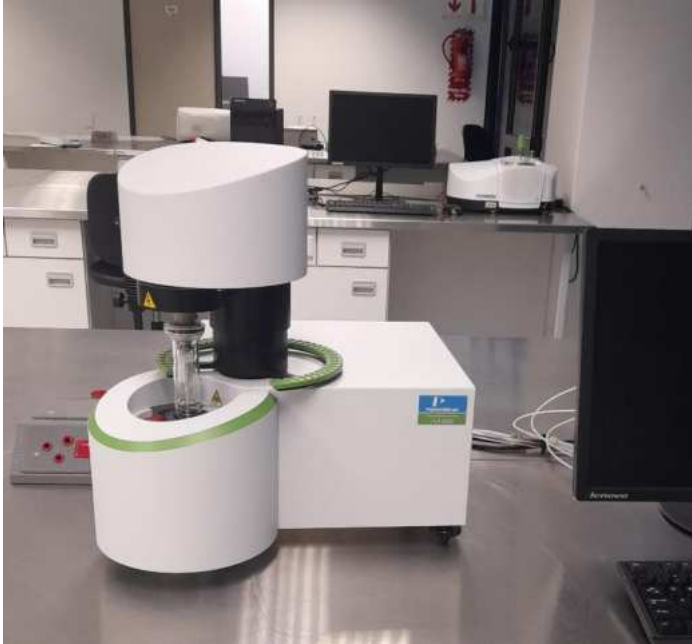
## 4. FTIR



- Functional groups →

# Instruments for Biomass Testing and Research – NUST – Cont'd

## 6. TGA



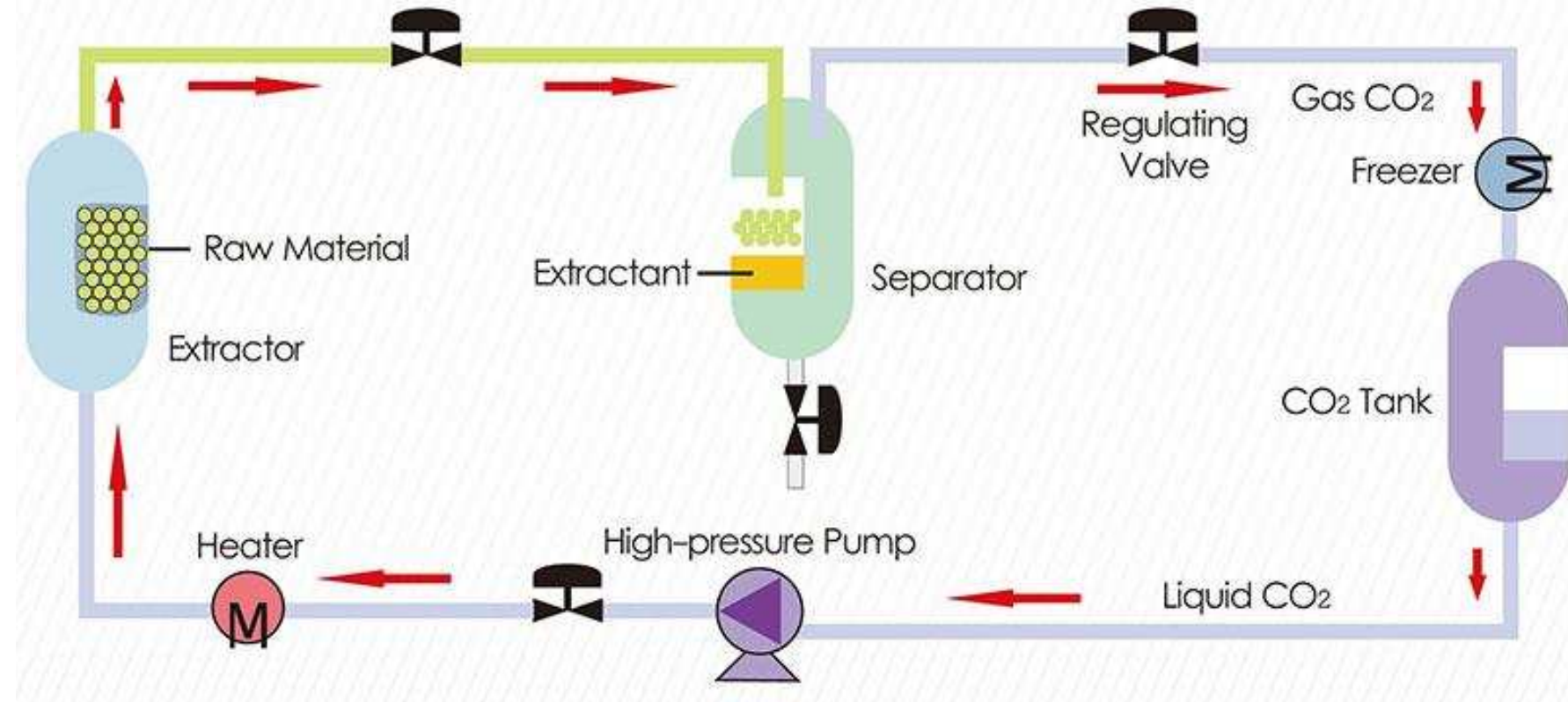
- Thermal stability

## 7. CHNS/O Elemental Analyzer



- Rapid determination of carbon, hydrogen, nitrogen, sulfur and oxygen content in organic and other types of materials

# Supercritical CO<sub>2</sub> Fluid Extraction Equipment



## Pre-treatment of lignocellulosic biomass

- Cellulose, hemicelluloses and lignin bonded together in a heterogeneous matrix
- Matrix highly recalcitrant to chemical or biological conversion processes
- An efficient pretreatment technique must be selected and applied to this type of biomass in order to facilitate its utilization in biorefineries

# Typical analyses for bush-based livestock feed, charcoal/biochar, biomass, wood flour and chips, soil and water

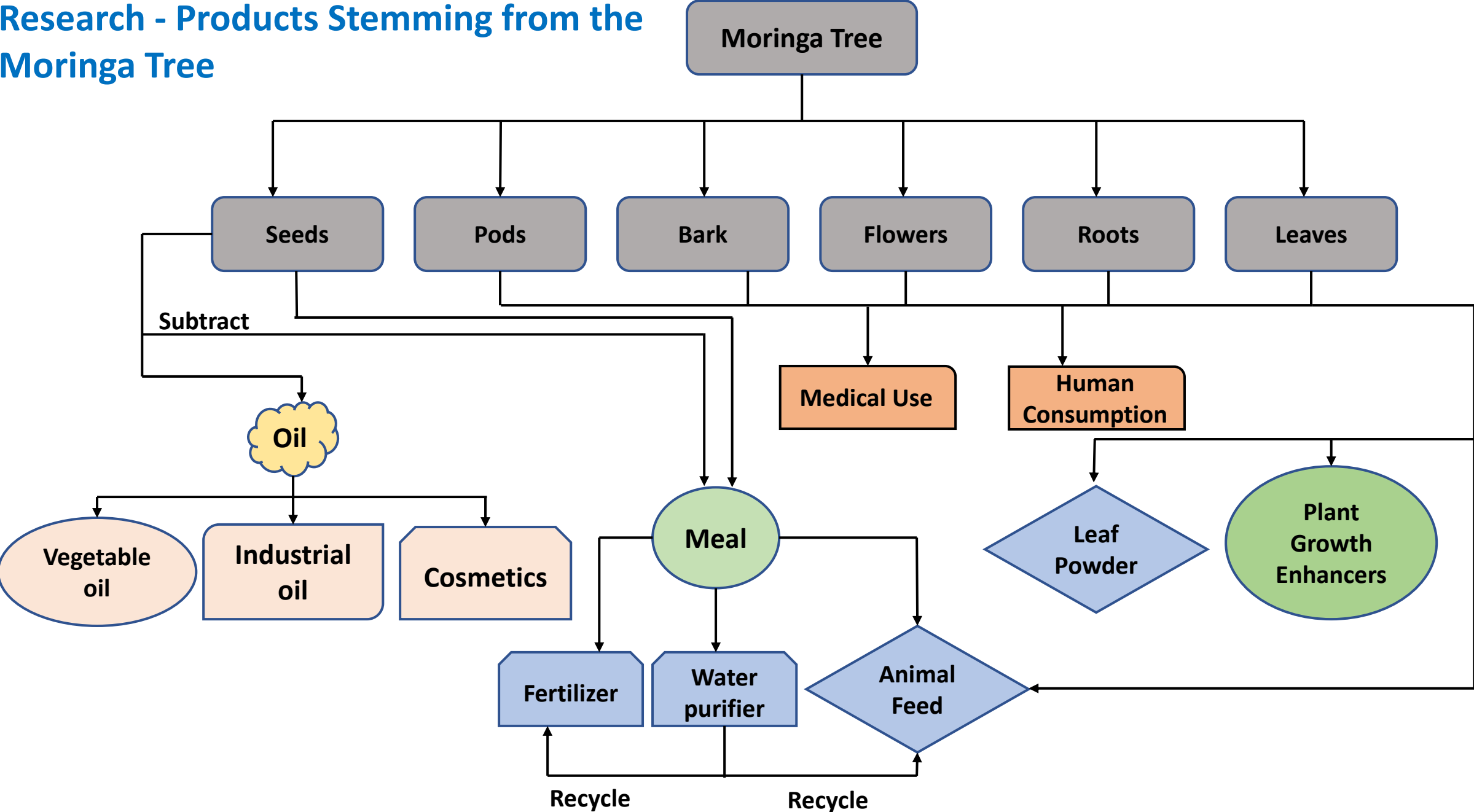
<b>Charcoal/Biochar</b>	<b>Available</b>
Bulk Density	Yes
Calorific Value	2022
Ash Content	Yes
Moisture Content	Yes
Fixed Carbon	Yes
Volatile Matter Content	Yes
Size Fractions	Yes
Surface Area	Yes
Surface Charge	Yes
Cation Exchange Capacity (CEC)	Yes
Functional groups analysis	Yes
PAHs, PCBs, VOCs	Yes
Elemental Analysis	2022
Ultimate and proximate analysis (Volatiles, Fixed Carbon, Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur, Chlorine)	2022

<b>Bush Based Livestock Feed</b>	<b>Available</b>
Moisture content	Yes
Gross energy	2022
Dry matter	Yes
Ash content	Yes
Crude Fat (routine)	Yes
Nitrogen and Crude protein	Yes
Crude fiber and lignin content	2022
Neutral and Acid detergent fiber (routine)	2022
Organic matter digestibility	2022
Calcium and Phosphorus	Yes
Aflatoxins	Yes
Elemental Analysis (Cu, Zn, K, Na, Fe, Ca, Mg, Mn, P, S, N)	Yes

<b>Wood Flour/Chips</b>	<b>Available</b>
Calorific Value	2022
Ash Content	Yes
Moisture Content	Yes
Bulk Density	Yes
Bulk Volume	Yes
Size Fractions	Yes
Elemental Analysis	Yes

<b>Soil/Water</b>	<b>Available</b>
Electrical Conductivity	Yes
pH	Yes
Settleable Matter	2022
Dissolved and Undissolved Substances	Yes
Acidity (Base Capacity)	Yes
Alkalinity (Acidity Capacity)	Yes
Calcium and Magnesium	Yes
Microbiological tests (E. coli, Coliform bacteria, Total bacterial count)	Yes
Specialised Soil Analyses (Mesh size, Hydrolytic acidity, i.e. H-value, Exchangeable basic Substances, i.e. s-Value, Exchange Capacity, Carbonate Content, Sodium Absorption Ratio, i.e. SAR-Value)	Yes
Elemental Analysis (Cu, Zn, K, Na, Fe, Ca, Mg, Mn, P, S, B)	Yes
Anions (Chloride, Cyanides, Nitrate, Nitrite, Sulphate)	Yes
Kjeldahl Nitrogen	2022

# Experience in Circular Biobased Economy Research - Products Stemming from the Moringa Tree



Moringa Seeds Circular Economy



Seed shells and husks for manure, animal feed and activated charcoal



Water Treatment



Seed Powder Capsules



- Cooking Oil → Commercial & Industrial
- Cosmetics → Emollients
- Personal Care → Bath soaps
- Perfumery
- Industrial Oil → Biodiesel
- Lubricants



Water Treatment



Protein bioflocculant capsules for water treatment

Fertilizer/Soil Conditioner





**Moringa Honey**



**Agroforestry**



**Flowers**



**Tea Bags**



**Biostimulant (Plant growth enhancer)**



**Feed for Livestock, Poultry and Fish**



**Leaf Powder**



**Moringa Tea**



**Leaf Powder Capsules**

## CONCLUSION & RECOMMENDATIONS

- Biomass is significant in a green circular economy
- Instruments and systems available for the characterization of biomasses for energy and industrial use
- Analyses are conducted in accordance with the methods developed based on standard methods in literature
- Accreditation of the laboratory (long term)



Thank You!

