PULP AND PAPER INSTITUTE, LJUBLJANA
Innovative Cellulose Products

Invasive alien plants as an interesting raw material for bio-based products

Tea Kapun, Janja Zule, Andrej Šinkovec (Pulp and Paper Institute, Slovenia)

Blaž Likozar, Miha Grilc (National Institute of Chemistry, Slovenia)

MORE ABOUT THE PROJECT: https://www.ljubljana.si/sl/moja-ljubljana/applause/

UIA URBAN INNOVATIVE ACTIONS

PULP AND PAPER INSTITUTE, LJUBLJANA
Innovative Cellulose Products

About the project **Applause**

- Co-financed by the European Regional Development Fund (Urban Innovative Actions)
- Project estimation cca 5 mio €, co-financed cca 4 mio €
- Project duration: 1.11.2017 – 31.10.2020
- **Addresses unresolved issues regarding the management of invasive alien plants in terms of zero waste and a circular economy**
- 15 partners

University of Ljubljana

PULP AND PAPER INSTITUTE

TISA d.o.o.

City of Ljubljana

GDi

IJS

snaga

SPACE-SI
SLOVENIAN CENTRE OF EXCELLENCE FOR SPACE SCIENCES AND TECHNOLOGIES

NATIONAL INSTITUTE OF CHEMISTRY

tipoRenesansa

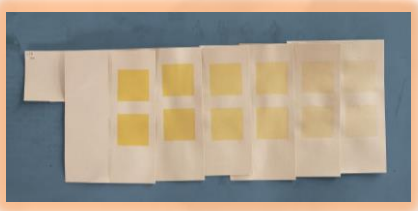
What are **invasive alien species**?

- Quick spreading to the natural environment
- IAPS replace native species, change ecosystems, cause economy harm or even endanger human health
- IAPS being composed or burnt

PULP AND PAPER INSTITUTE, LJUBLJANA
Innovative Cellulose Products

Useful purposes…

- Wooden letters for printing
- Color coatings for textiles / paper
- Extracts for controlling pest of plant (eg. snails)
- Liquefied wood – coatings, adhesives and insulating foams
- IAPS as a source of food
- Wood residues into microbe media / enzyme processing



!!! Development of new tools for identifying invasive alien plants (analysis of ortho photo and satellite pictures)
!!! Development of Business model

PULP AND PAPER INSTITUTE, LJUBLJANA
Innovative Cellulose Products

The role of ICP in the project Applause

25 IAPS → 7 → 3 for PPP

12.000 kg of biomass ≈ 6.000 kg of cellulose pulp

4.000 kg for pilot papermaking (ICP)
2.000 kg for hand papermaking

Educational publications
Promotional materials
3 Innovative products

PULP AND PAPER INSTITUTE, LJUBLJANA
Innovative Cellulose Products

Selection of seven


Ailanthus


Rhus


Black locust

WOODY SPECIES


Canadian / Giant goldenrod


Rudbeckia

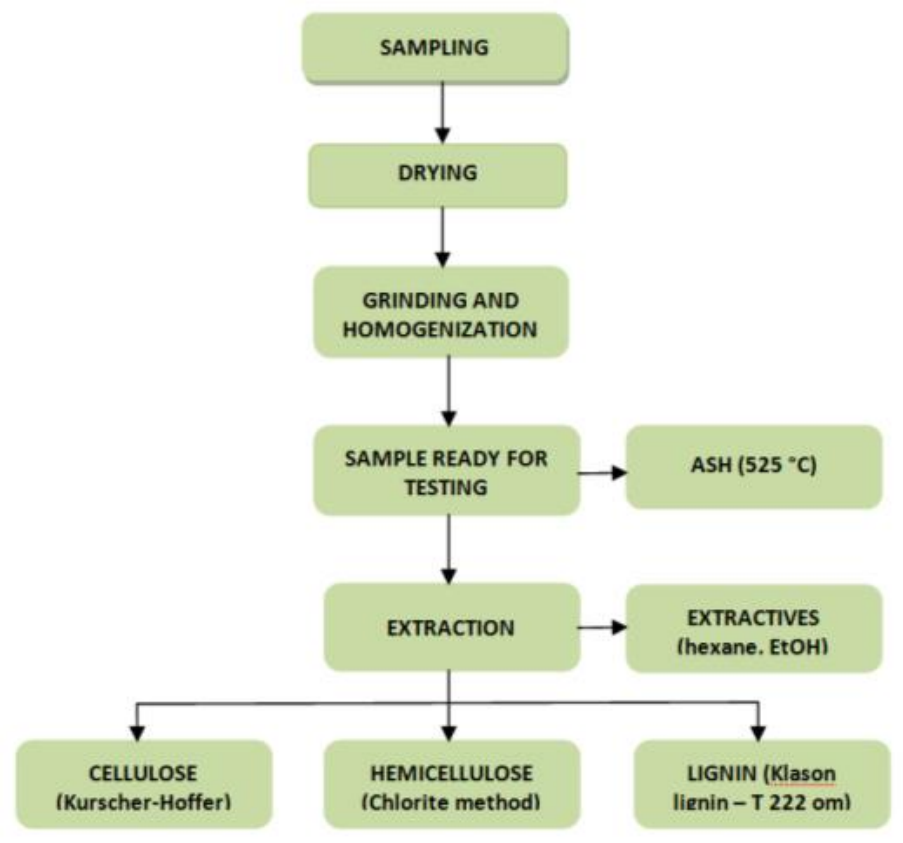

Bohemian knotweed


Japanese knotweed

HERBACEOUS PLANTS

Pictures: www.ljubljana.si

General scheme for chemical characterization of IAPS



Results of chemical characterization

Chemical structure \ IAPS	Ailanthus	Rhus	Black locust	Canadian goldenrod	Rudbeckia	Japanese knotweed	Bohemian knotweed
Ash [%]	2,7	0,3	0,3	2,3	2,8	2,5	1,8
Hexane extractives [%]	1,9	0,7	0,3	0,6	0,6	0,4	0,2
Ethanol extractives [%]	6,6	4,5	4,7	1,6	0,9	1,1	1,2
Cellulose [%]	**27**	**40**	**41**	**37**	**37**	**35**	**36**
Hemicellulose [%]	39,2	37,4	34,7	36,4	38,8	36,6	34,9
Lignin [%]	17,8	16,5	21,9	19,1	16,8	26,8	25,1

IMPORTANT

Cellulose content > 35%

Extractive content < 5%

Ash content < 5%

Lignin content as low as possible – delignification

Delignification

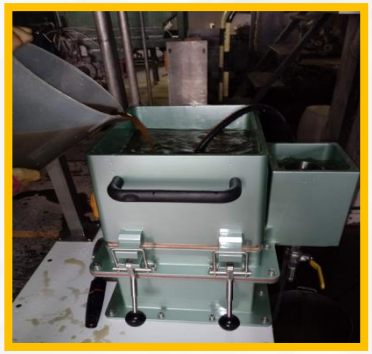
Important parameters:
- chemicals
- delignification parameters: T(p), t
- ratio reagent / SS

Filling the reactor

Reactor during delignification

After delignification: leaching (P+BL), washing, disintegration, screening (fibers + impurities), squeezing, homogenization of fibers

Washed, delignified pulp



Screening

Homogenization of the fibers

Important:
- dry matter content
- yield
- Kappa number

Delignification

Ailanthus

Rhus

Black locust

Canadian / Giant goldenrod

Rudbeckia

Bohemian knotweed

Japanese knotweed

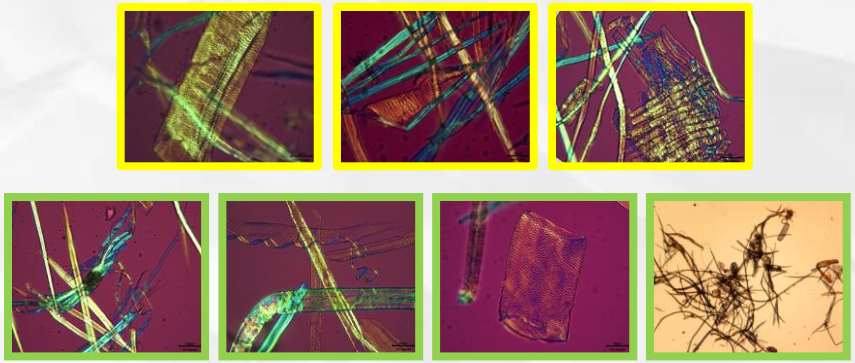
Fiber analysis…

IAPS	Ailanthus	Rhus	Black locust	Canadian goldenrod	Rudbeckia	Bohemian knotweed	Japanese knotweed
Lc(n) [mm]	0,4	0,4	0,5	0,3	0,5	0,4	0,4
FW [µm]	15,3	12,2	12,5	16,1	21,1	19,3	20,3
Curl [%]	5,0	1,5	8,2	5,5	9,7	18,8	8,0
Fines [%]	33,3	18,2	53,8	47,9	33,3	52,3	48,7

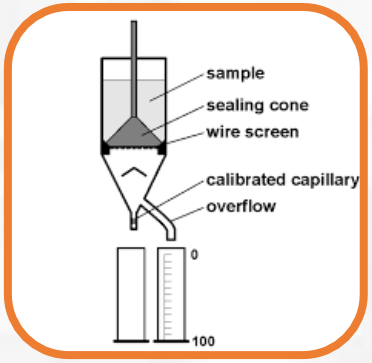
Legend: Lc(n) – arithmetic average fiber length; FW – length-weighted average fiber width; Curl – length-weighted average fiber curl; Fines – fines as percentage of arithmetic distribution

Fiber analyzer

Morphology



Fiber analysis…



Mechanical properties were measured on laboratory sheets

Testing of laboratory sheets

	Ailanthus	Rhus	Black locust	Canadian goldenrod	Rudbeckia	Japanese knotweed	Bohemian knotweed
Drainability [°SR]	27	39,5	24,5	45	46	51	54
Specific volume [cm^3/g]	1,70	1,39	1,78	1,59	1,42	1,53	1,51
Tensile index [Nm/g]	64,49	78,98	65,74	63,92	84,18	66,95	61,56
Breaking length [km]	6,574	8,051	6,701	6,516	8,581	6,825	6,275
Tearing index [mNm^2/g]	5,00	3,91	6,06	2,59	5,59	3,72	3,51
Bursting index [$kPam^2/g$]	3,81	4,54	4,21	3,13	4,70	3,96	3,45
Stifness L&W 15° [mN]	73,8	63,0	90,4	83,6	54,9	47,0	45,6
Air permeability [ml/min]	945,7	104,1	3111,9	290,9	17,3	52,8	94,8

Selection of 3 IAPS for pilot paper making:

- Wood species represents a technological problem
- (1) Japanese / Bohemian knotweed
- (2) Canadian / Giant goldenrod
- (3) Rudbeckia !!!

PULP AND PAPER INSTITUTE, LJUBLJANA
Innovative Cellulose Products

Pilot papermaking


Biomass


Cooking


After delignification


Refining


Pilot paper production

Educational publications
Promotional materials
3 Innovative products

Starting points

Products attributes:

- Innovative
- Environmental friendly
- Biodegradable
- Compliant with circular economy concept
- Zero waste green technology

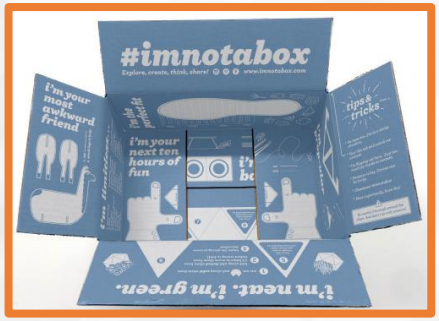
Trends:

- Reduction of plastic products
- Ban on single-use plastic products
- Sustainability

PULP AND PAPER INSTITUTE, LJUBLJANA
Innovative Cellulose Products

4 directions of innovative product development – 3 different target groups

- WASTE COMPOSTING & ODOUR ELIMINATION
- PACKAGING
- TABLE GAMES
- „PICNIC SET“



PULP AND PAPER INSTITUTE, LJUBLJANA
Innovative Cellulose Products

Special thanks to: Matej Šuštaršič, Ema Fabjan, Aleš Rome, Marija Skodlar

URBAN INNOVATIVE ACTIONS