



Solution Architect for Global  
Bioeconomy & Cleantech Opportunities



16.1.2017

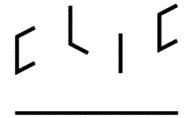
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# Recyclable materials as raw materials for composites

- 1. Raw material sources**
- 2. Case studies**
- 3. Conclusions**



# Raw material sources

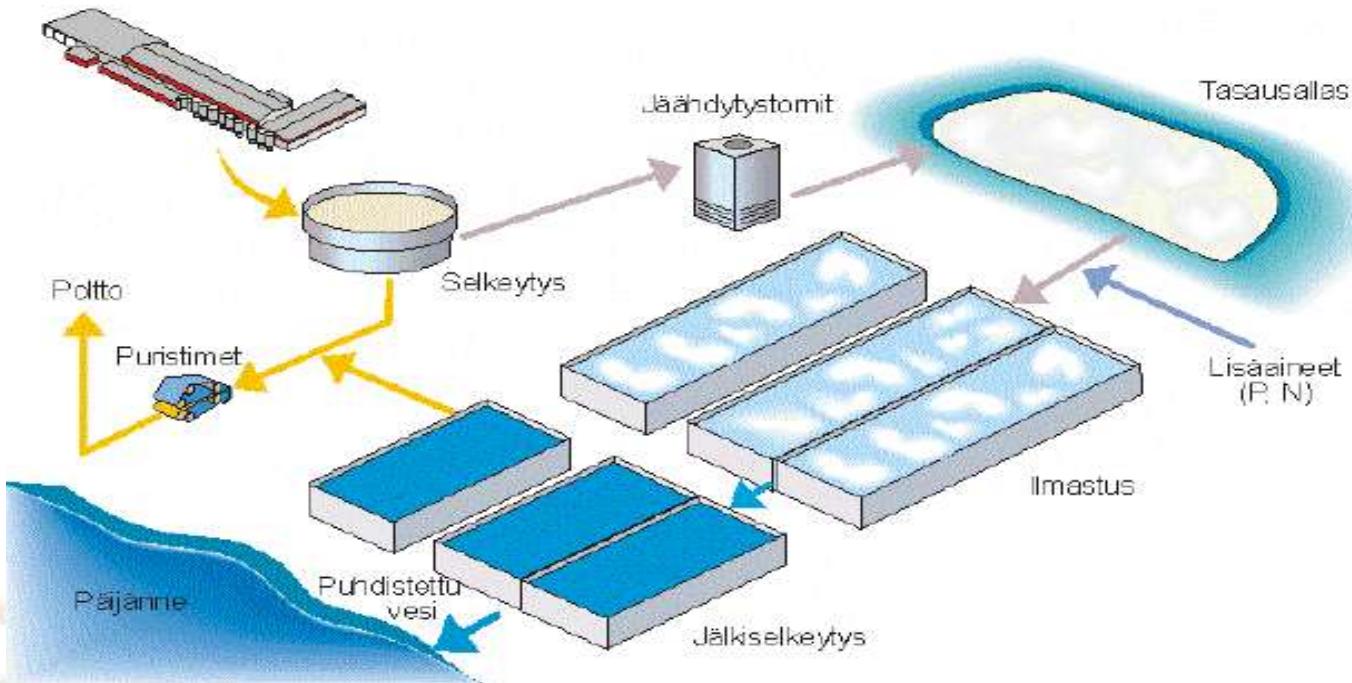
- C&D waste plastics
- Waste water treatment plant sludge

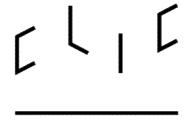




# TYPICAL WWTP

The Biofore Company



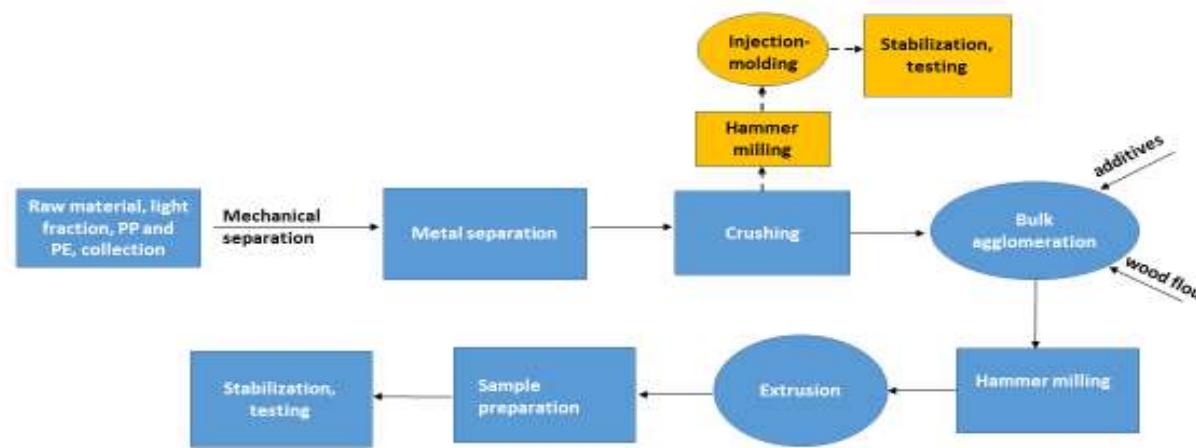


# Case study 1.

## New products from CDW

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# Scheme for plastic recycling and composite manufacturing in study





# Recycled plastic blends

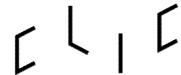


Sample	PE, wt%*	Tensile strength, MPa		Tensile modulus, GPa	Elongation at break, %H
		Yield	Ultimate		
HDPE	100.5 (1.9)	28.1 (0.83)	28.1 (0.83)	1.21 (0.09)	550 (160)
70PE/30PP	70.7 (1.7)	30.4 (0.39)	30.4 (0.39)	1.45 (0.06)	25 (10)
50PE/30PP	49.1 (1.8)	34.2 (0.47)	34.1 (0.69)	1.66 (0.06)	19 (13)
30PE/70PP	29 (0.5)	39.9 (0.42)	35.6 (0.9)	1.77 (0.04)	4.6 (0.57)
PP	0.94 (0.3)	36.5 (1.16)	36.5 (1.16)	1.77 (0.06)	16 (4.2)
PB1	54 (3)	19.3 (0.59)	19.9 (1.12)	0.77 (0.07)	240 (160)
PB2	69 (2.6)	16.2 (-)***	18 (1.42)	0.46 (0.06)	390 (43)
PB3	72 (3)	19 (0.59)	21.2 (1.04)	0.74 (0.09)	360 (24)
PB4	69 (4)	19.2 (0.57)	19.9 (0.68)	0.77 (0.06)	190 (55)
PB5	57 (5)	17.9 (0.38)	17.9 (0.38)	0.79 (0.04)	13 (3)
PB6	77 (11)	no yield	17.6 (1.0)	0.39 (0.04)	190 (55)
PB7	64 (6)**	17.5 (0.28)	18.5 (0.78)	0.62 (0.05)	310 (30)
PB8	62 (2)**	no yield	20.8 (1.03)	0.57 (0.09)	360 (34)
PB9	52 (2)	25.3 (0.65)	24.9 (1.16)	1.28 (0.07)	5.2 (1)
PB10	-	17.3 (0.96)	16.8 (1.34)	1.05 (0.1)	3.9 (3)



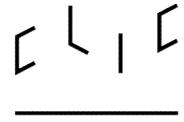
# Contents and mechanical properties of composites

Sample	PE, wt%	Flexural properties		Tensile properties		Impact strength, kJ/m <sup>2</sup>	Hardness, N/mm <sup>2</sup>	E <sub>b</sub> , %
		Strength, MPa	Modulus, GPa	Strength, MPa	Modulus, GPa			
Reference LDPE/WF	100	19.0(0.87)	1.6(0.1)	15.5(0.58)	2.08(0.08)	8.53(0.9)	4.06(0.28)	1.7(0.2)
PB_C1	54(3)	14.5(0.9)	2.64(0.23)	11.34(0.62)	3.18(0.28)	3.79(0.45)	5.05(0.48)	0.5(0.08)
PB_C2	69(3)	15.02(0.49)	2.55(0.08)	11.18(0.66)	3.02(0.1)	4.32(0.38)	4.47(0.44)	0.6(0.06)
PB_C3	72(3)	15.98(1.04)	2.94(0.16)	12.51(0.48)	3.41(0.1)	3.63(0.3)	4(0.97)	0.5(0.04)
PB_C4	69(4)	14.81(0.98)	3.0(0.25)	11.58(0.77)	3.44(0.16)	3.39(0.24)	3.73(0.52)	0.44(0.06)
PB_C5	64(6)	14.97(0.49)	2.23(0.14)	11.02(0.56)	2.57(0.15)	4.56(0.46)	4.7(0.74)	0.74(0.1)
PB_C6	62(2)	15.27(0.44)	2.7(0.19)	11.85(0.69)	2.9(0.13)	4.82(0.35)	4.4(0.44)	0.72(0.1)
PB_C7	32(2)	14.09(0.73)	3.55(0.19)	10.75(0.78)	3.9(0.19)	3.09(0.25)	4.98(1.1)	0.28(0.04)
PB_C8	52(2)	13.83(1.14)	2.75(0.29)	10.64(0.81)	3.34(0.24)	3.49(0.15)	4.64(0.58)	0.4(0.04)
PB_C9	83(8)	12.61(0.45)	1.95(0.1)	9.89(0.23)	2.42(0.12)	6.18(0.69)	3.05(0.49)	0.96(0.18)
PB_C10	-	10.45(0.56)	2.83(0.23)	5.85(2.6)	2.32(0.83)	2.94(0.26)	4.27(0.44)	0.3(0.06)



# Contents of recycled polymer blends, SEM-EDS

Sample/ element	C	Mg	Si	Ca	Ti	Al	Cl	O	Fe	Ba	K	Br	Na	S
PP	99.8					0.28								
HDPE	92.0		0.16			0.19					0.01		0.1	0.01
PB1	97.9	0.13	0.13	0.8	0.48	0.52								
PB2	97.9	0.02	0.15	0.37	1.15	0.3	0.01		0.01					
PB3	97.9			0.9	0.68	0.5								
PB4	98.5		0.12	0.44	0.51	0.45								
PB5	99.3		0.1	0.18	0.12	0.53								
PB6	98.1		0.11	0.61	0.39	0.2	0.52							
PB7	96.9	0.21	0.35	0.67	0.01	0.99	0.79		0.02					
PB8	97.5	0.26	0.55	0.32		1.29								
PB9	98.5	0.07	0.34	0.27	0.66	0.12						0.06		
PB10	84.2		0.15	0.36	0.33	0.44	1.6	12.0	1.0	0.1				



## Case study 2.

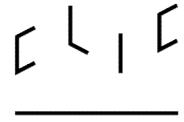
# Industrial waste streams as raw materials for composites



# Sludge separation

- 2 primary sludges from different processes
- Separation with Milston Hero sludge separator
  - Rannan teollisuuskone Oy
  - Sludge separators for agriculture, biogas production, food and process industry
  - UPM A: 0,5% -> n. 25-31%
  - UPM B: 1,6% -> n. 15-17%





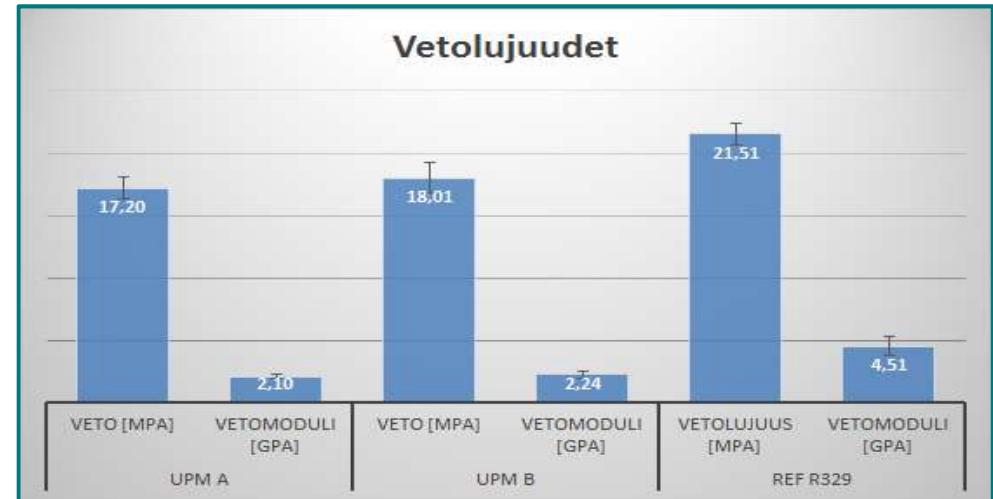
# LUT Pilot



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# Results



Composite	<u>Tensile properties</u>		<u>Flexural properties</u>		<u>Impact</u>	
	Strength (MPa)	Modulus (GPa)	Strength (MPa)	Modulus (GPa)	Hardness (MPa)	Strength (kJ/m <sup>2</sup> )
Reference	21.51 ± 0.91	3.63 ± 0.33	20.53 ± 0.69	2.29 ± 0.12	5.06 ± 1.13	4.25 ± 0.51
Primary sludge - HDPE	21.60 ± 0.85	3.78 ± 0.77	22.27 ± 1.66	1.82 ± 0.15	7.11 ± 0.49	6.37 ± 0.66

CLIC

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# Conclusions

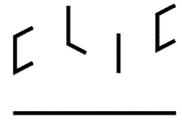
# Composite applications



## Usability of the separated plastics 1/2

MUOVITYYPPI OMINAISUUDET		YLEiset OMINAISUUDET	ESIMERKKEJÄ KÄYTTÖKOHTEISTA JA HYÖTYKÄYTÖSTÄ
Polyeteenitemperoitu laatti PET		Kirkas, kova, kemikaaleja kestävä	Virvoitusjuoma- ym. pullot, tekstiilit. Pullot voi palauttaa kauppojen automaatteihin.
Polyeteeni high-density PE-HD		Samea tai väriillinen, joustava, vahamainen pinta	Mehupullot, ämpärät, virvoitusjuomakoristeet. Soveltuvat energiahänteen keräykseen. Erällä paikkakunnilla voi PE-HD-muovipakkausten kierräyksipisteitä, katso www.usiomuovi.fi.
Polyvinyylikloridi PVC		Erittäin monimuotoinen ja -piiriinen	Putket, letkut, rakennusmateriaalit. PVC-muovia ei saa polttaa eikä laittaa energiahänteen keräykseen, katso www.usiomuovi.fi.
Polyeteeni low-density PE-LD		Pehmeä, joustava, vahamainen pinta	Muovikassit, pussit, kalvot. Soveltuvat energiahänteen keräykseen. Pieniä määriä voi polttaa puun seassa. Pussit voi palauttaa kauppojen palautusautomaattiin yhteydessä oleviin muovihänteen keräysastioihin.
Polypropeeri PP		Jäykkä, sitkeä, hyvin monikäyttöinen	Narut, rasiat, tekniset osat, kalvot. Soveltuvat energiahänteen keräykseen.
Polystyreeni PS		Lasin kirkas tai värijätty, hauras	Rasiat, purkit. Soveltuvat energiahänteen keräykseen.
Muut		Kaikkien ylläolevien yhdistelmät ja muut materiaalit	Soveltuvat vain laitosmaiseen polttoon, joten tämän merkin sisältävien tuotteiden soveltuinen muualle kuin sekajäteeseen pitää tarkistaa paikalliselta jätehuollolta.





## Usability of separated CDW and sludge in composites 2/2



## Wood stone/paving stone products



The 60 mm thick paving stones are ideal for yard paving and can withstand car traffic. The stones are surface dyed.

The 40 mm thick paving stones are ideal for patio areas and pedestrian or bicycle traffic routes. The stones are dyed throughout.

The standard colours are grey, black, red-black melange and sandy brown. Special colours are available on special order.

### Destaclean paving stones, 40 mm

#### DESTACLEAN PATIO STONE

218x108x40 mm  
10,85 m<sup>2</sup>/pallet, 41 stones/m<sup>2</sup>  
75 kg/m<sup>2</sup>



The stones are dyed throughout.

### Destaclean paving stones, 60 mm

#### DESTACLEAN BLOCK PAVING

278x138x60 mm  
8,78 m<sup>2</sup>/pallet, 26 stones/m<sup>2</sup>  
120 kg/m<sup>2</sup>



#### DESTACLEAN SLAB

138x138x60 mm  
8,08 m<sup>2</sup>/pallet, 52 stones/m<sup>2</sup>  
120 kg/m<sup>2</sup>



#### DESTACLEAN LARGE SLAB

278x278x60 mm  
9,23 m<sup>2</sup>/pallet, 13 stones/m<sup>2</sup>  
120 kg/m<sup>2</sup>



The slabs are surface dyed.

### Destaclean edging

#### DESTACLEAN LAWN EDGING STONE

80x140x250 mm 6,5 kg/stone  
80x140x500 mm 11 kg/stone  
60x130x500 mm 7 kg/stone

#### DESTACLEAN EMBEDDED EDGING STONE

50x250x1000 mm 27 kg/stone



## Wood stone/surfaced paving stones



Surfaced paving stones are ideal for yard paving and can withstand heavy car traffic. The stones are concrete surfaced.

The standard colours are grey, black, red-black melange and sandy brown. Special colours are available on special order.

### Destaclean surfaced paving stones, 60 mm

#### DESTACLEAN BLOCK PAVING

278x138x60 mm  
8,78 m<sup>2</sup>/pallet, 26 stone/m<sup>2</sup>  
126 kg/m<sup>2</sup>



#### DESTACLEAN SLAB

138x138x60 mm  
8,08 m<sup>2</sup>/pallet, 52 stone/m<sup>2</sup>  
126 kg/m<sup>2</sup>



#### DESTACLEAN LARGE SLAB

278x278x60 mm  
9,23 m<sup>2</sup>/pallet, 13 stone/m<sup>2</sup>  
126 kg/m<sup>2</sup>



### Destaclean surfaced paving stones, 80 mm

#### DESTACLEAN BLOCK PAVING

278x138x80 mm  
7,55 m<sup>2</sup>/pallet, 26 stone/m<sup>2</sup>  
168 kg/m<sup>2</sup>. Colours: black and grey.



Coming in summer 2016.

### Destaclean Wood Stone, other products

#### DESTACLEAN BENCH\*

150x400x450 mm (LxWxH)  
weight 85 kg. Colour: grey.



#### DESTACLEAN PLANTER\*

Ø 600 mm, height 500 mm  
weight 120 kg. Colour: grey.

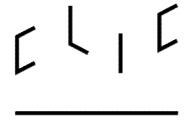


\*Coming in summer 2016.



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# Questions?



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