Mineral processing techniques dedicated to the recycling of river sediments to produced raw materials for construction sector

Mathieu HENRY
Centre Terre et Pierre, Tournai (Belgium)

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FEDER
LE FONDS EUROPÉEN DE DÉVELOPPEMENT RÉGIONAL ET LA WALLONIE INVESTISSENT DANS VOTRE AVENIR
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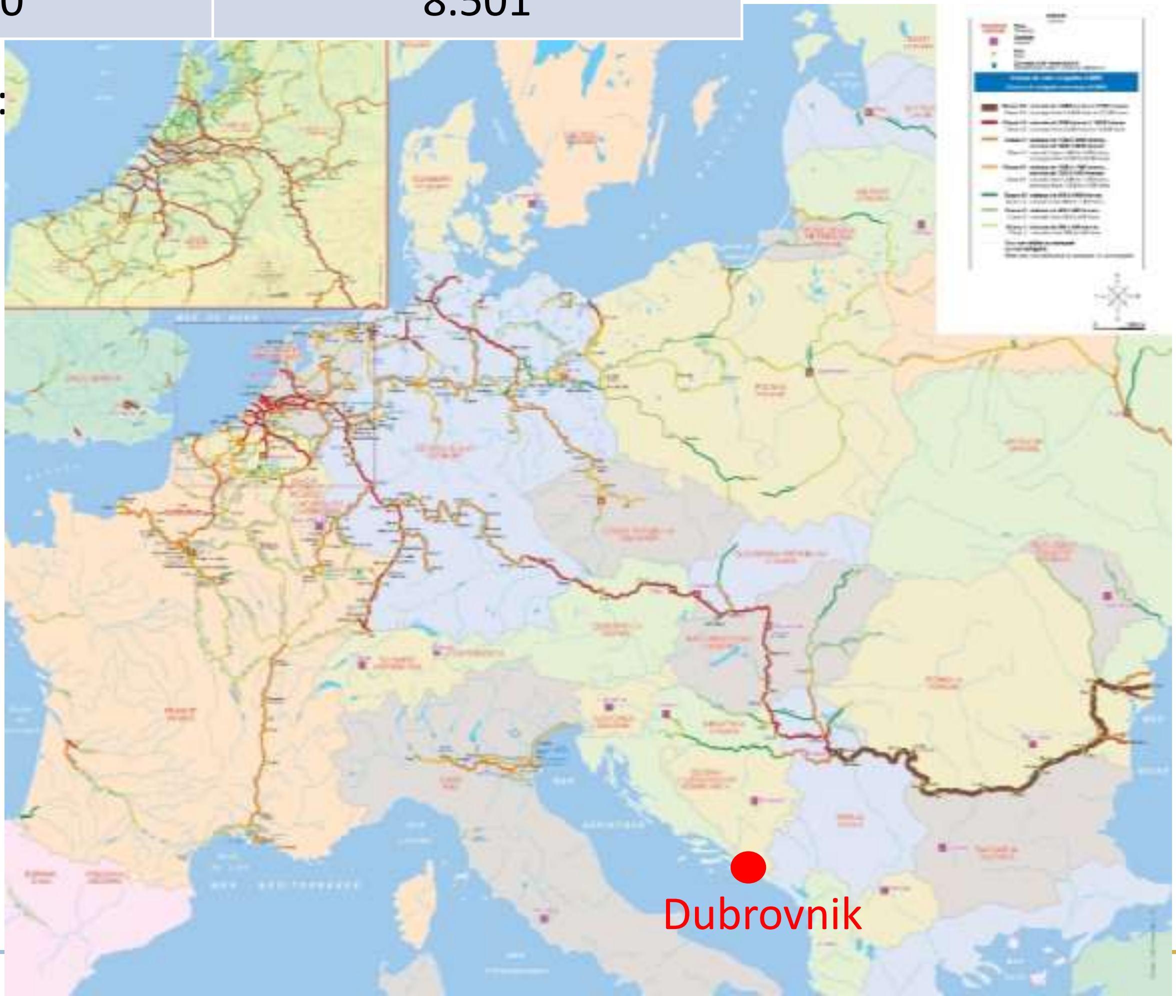
River Sediments

- Regular dredging to maintain shipping and hydraulic flow

	Annual dredging (m³/year)	Inland waterways (km)
Flanders	1.850.000	990
Wallonia	120.000 to 250.000	450
France	2.800.000	8.501

- Generally considered as waste: therefore landfilled
- However, potential source of mineral materials:
  - Granulates
  - Sand
  - Silt
  - Clay

  Mainly for building sector
- Can be obtained by mineral processing techniques:
  - Simple
  - Cheap
  - Without chemicals



CHALLENGES IN THE USE OF SEDIMENTS

- Social: Citizen acceptance of construction materials made from secondary and polluted materials

- Legislation: 

    - Lower and lower organic and inorganic pollutants maximum levels, without taking account (or lesser) to leaching behavior
    - Stringent legislations in valorization: doesn't allow all valorizations

- Economics: treatment costs in addition of dredging, transportation,… costs
    - Calcination: generally expensive (> 90€/ton DM)
    - Stabilization/solidification: use of reactants, generally expensive (50-75€/ton DM)
    - Size classification: lot of steps (± 30€/ton DM)
    - Flotation: use of expensive reactants (10-40€/ton DM)

  In comparison with cheap materials (clay [40-50€/ton], sand [± 40€/ton], …)

- But also technical/scientific challenges

River sediments	Building materials	Dehydration	Size classification	Organic matter	Pollutants (organics and inorganics)	Crystalline phases	Other
Raw	Concrete		X	X			Increase of water demand
	Road Building	X	X	X	X	X	
	Cement	X		X	X		
	Asphalt		X		X		
Granulates	Concrete		X				
	Road Building		X				
Sand	Concrete			X			
	Road Building			X	X	X	
Silt	Embankment			X	X		
Fines (Clay / fine silt)	Brick			X	X	X	• Brick aspect (color, efflorescence) • ↗ porosity and water adsorption (thawing freeze)
	Expanded clay				X	X	• SiO_2 and Al_2O_3 contents modify viscosity • Lack of iron oxide

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- Combination of sieving, drying and disagglomeration to create a bicycle path in concrete with sediment

Refusal → Exogenous: stones, bottles, glass, wood

Passing ↓

→

DIRECT INTEGRATION OF RIVER SEDIMENTS IN CONCRETE

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Fractions	Mass (kg)	
Start	1109	100,0%
(-5 mm)	849	76,6%
(+5 mm)	101,6	9,2%
Water loss	158,4	14,3%

DM: ±70%

Substitution of 50% of the sand by sediments

Laboratory works under progress at IMT Lille Douai

Disagglomerated material
DM: ±85%
< 5 mm

IMT Lille Douai
École Mines-Télécom
IMT-Université de Lille

MINERAL PROCESSING TREATMENT

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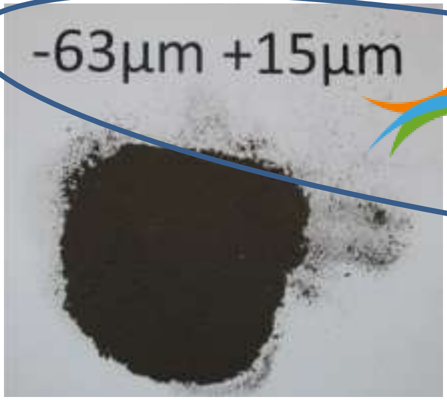
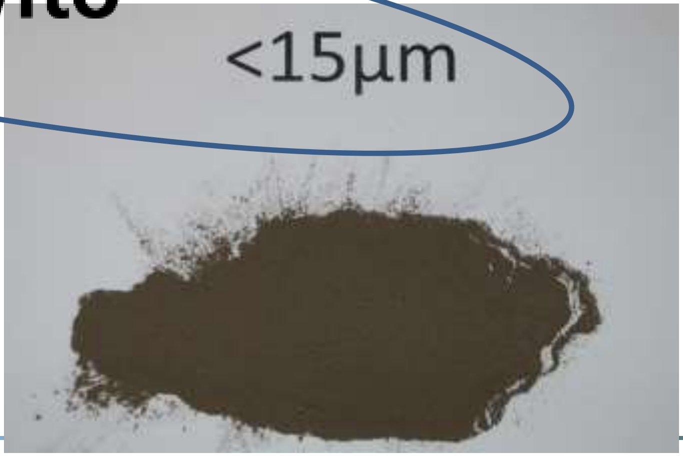
- Aim: separate sediment components:
  - +2 mm: all exogenous (stones, wood, bottle, glass,…)
  - -2 mm; +250 µm: coarse sand
  - -250; +63 µm: fine sand
  - -63; +15 µm: silt
  - -15 µm: clay and fine silt





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REMOVAL OF EXOGENOUS AND COARSE SAND

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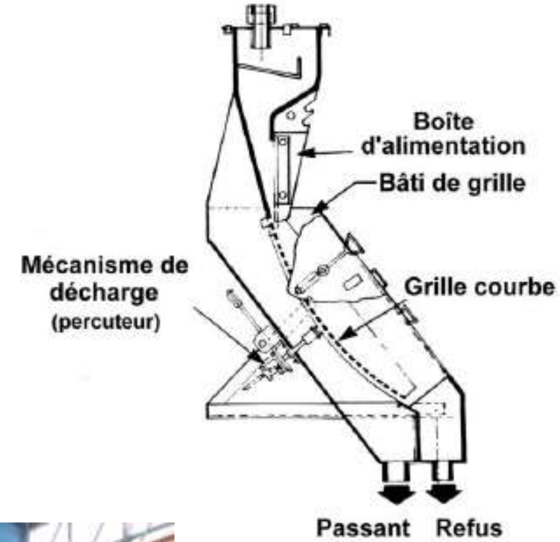
Input

1,2 t/h DM
40-80% DM

Exogenous:
+2 mm



1,2 t/h DM
30-40% DM

-2 mm

Coarse sand:
-2mm;+250 µm

1,2 m^3/h
10-20 % DM

-250 µm

REMOVAL OF FINE SAND

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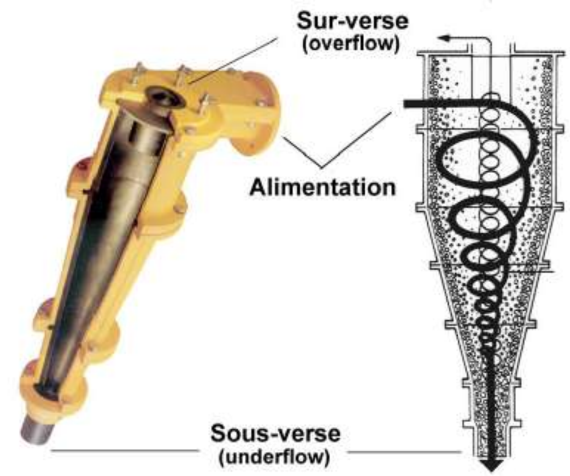
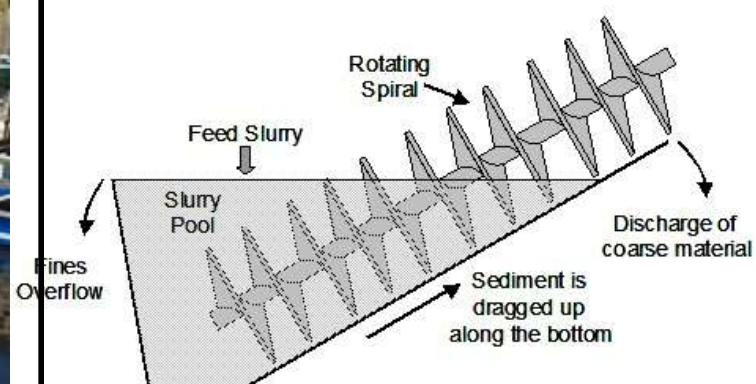
-250 µm

1,2 m³/h
DM: 10-40%



0,8 m³/h
DM: 10-40%

Fine sand:
-250;
+63µm



Separation of silt and clay

-63µm

0,8 m³/h; DM: 5-30%

Clay -15µm

32 m³; 0,5 m³/h

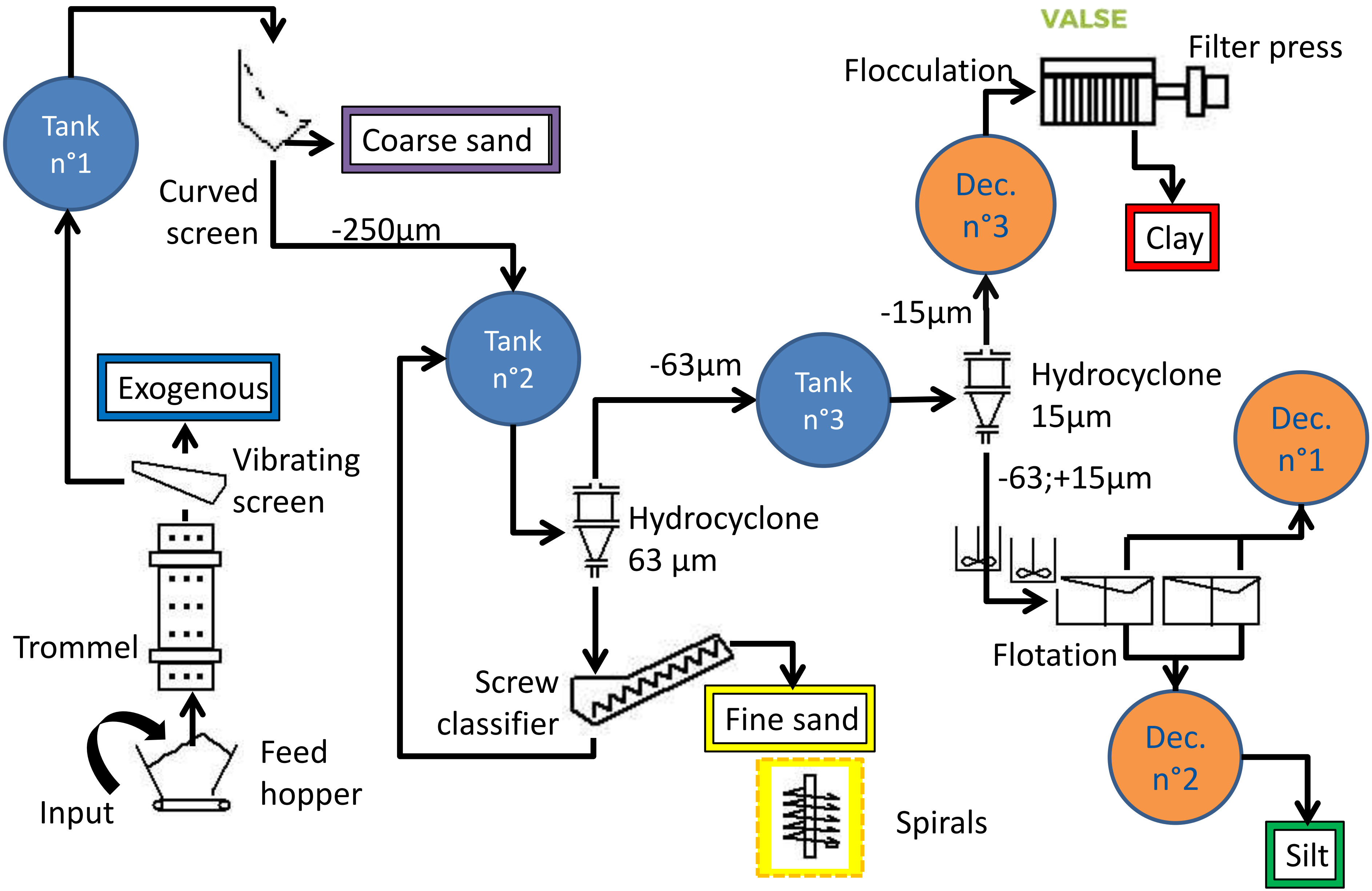
30 plates 800 x 800 mm; 15 bar
0,5 m³/h; 1 ton DM/batch

Silt: -63;+15µm

0,8 m³/h
DM: 15-40%

2 x 5 m³

MINERAL PROCESSING TREATMENT



MINERAL PROCESSING PILOT PLANT FOR SEDIMENTS

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- Material balance

Products	Particle size distribution	M_{wet} (kg)	Dry matter (%)	M_{dry} (kg)	M_{dry} (%)
Input	raw	22.635	42,0	9.507	-
Exogenous	+3 mm	2.666	72,4	1.930	20,2
		780	72,4	565	5,9
Coarse sand	-3 mm +250 µm	1.073	50,0	537	5,6
Fine sand	-250 µm +63 µm	2.993	75,0	2.245	23,5
Silt	-63 µm +15 µm	703	46,5	327	3,4
Clay / fine silt	-15 µm	4.570	57,9	2.648	27,8
Loss	-	3.625	35,4	1.282	13,4
			Total :	**9.533**	**100,0**

- Pollutants distribution

Heavy metals (mg/kg dry)	AGW 1995 Cat.A	AGW 1995 Cat.B	Input	Coarse sand	Fine sand	Silt	Clay / fine silt
Hg	1,5	15	1,0	0,6	0,3	0,8	0,3
As	50	100	42,3	37,3	13,9	20,0	**58,9**
Cd	6	30	**18,1**	**21,0**	1,8	**7,5**	**66,7**
Co	25	100	12,7	10,5	16,2	11,7	13,5
Cr	200	460	**203,7**	123,3	81,8	86,8	**378,2**
Cr_{tot}	-	-	224,0	146,7	130,5	110,8	419,5
Cu	150	420	58,3	48,8	67,0	42,0	83,3
Ni	75	300	43,9	35,0	67,3	35,5	44,4
Pb	250	1500	**4.897,6**	**3.938,1**	**416,6**	**1.909,0**	**10.967,9**
Zn	1200	2400	**17.923,3**	**13.254,3**	**1.752,8**	**6.585,9**	**36.273,1**

Pollutants levels according to AGW 30/11/1995

Economic aspects

Economic study of 100.000 tons/year (dry matter) plant building in Wallonia (2010) and based over the pilot plant (with the scheme given previously)

- Investment: 7.346.464€
- Operational costs: 2.878.440€ namely ± 29€/tons (without outlet costs)
- Net present value: 2.748.433€ after 10 years (taking account outlet costs)
  If: 18% valorized as sand, 40% used as non-polluted sediment and 42% landfilled
  Depreciation: 10%/y during 10 years
- Cost-effectiveness at 83.405 tons
- High sensibility:
  - Public contract remains at 82€/tons
  - Sand fraction still commercialized
  - Silts and gravels without contamination
  - Conversion yield reached and maintained
  - Valorization market maintained
  - Outlet costs remain stable

Conclusion

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After characterization, river sediments can be used in building materials: VALSE

- Direct integration in concrete: sieving, drying and deagglomeration necessary

- Extraction of valuable materials
  - Pilot plant for sediment treatment available for testing purpose in CTP (Tournai, Belgium)
  - Based on particle size fractionation
  - Allows to concentrate pollutants in smallest fractions
  - Economically viable if the plant works efficiently and low uncertainty in raw sediment supplying and outgoing products markets

- Recommendations to authorities and market participants:
  - Coherent legislations between regions concerning highest limits and definition of hazardous components, allowed valorization ways
  - Working on citizen acceptance to demonstrate the non-hazardousness of reusing sediment
  - Create a sustainable sector for using valuable materials, namely a link between dredgers and raw materials consumer (e.g. brick producer, concrete producer,…)

ACKNOWLEDGEMENT

VALSE

- Partners:

- Agreement number: 3.5.161
- Project duration: 4 years
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  including ERDF (2.078.862,28 €)

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Thank you for your attention

Centre Terre et Pierre asbl
Mathieu HENRY
Chercheur

Chaussée d'Antoing, 55
B-7500 Tournai, Belgique
T: +32 (0)69 88 42 31
mathieu.henry@ctp.be
www.ctp.be

CTP
member of EMRA