Characterization of a landfill using boreholing

M. TERESA CARVALHO*, GRAÇA BRITO**, JOÃO BRISSOS** ANDRÉ SANCHES**, BRUNO GUEDES*

* CERENA,INSTITUTO SUPERIOR TÉCNICO, LISBON UNIVERSITY

** GEOBIOTEC, FCT, UNIVERSIDADE NOVA DE LISBOA

Contents

What is “landfill characterization”?

CHARACTERIZE FOR WHAT?

Position, deliniation, extension, etc

Geotechnical (stability, draining, saturation levels, materials cohesion) and Environmental (e. g. leachate and gases concentration control) monitoring

Infrastructure survey

Biogas production rate control

Evaluation of the mining potential and processability (recovery of materials)

HOW TO “CHARACTERIZE”?

Remote sensing (Yan et al, 2014)

Geophysical methods (Carlo et al, 2013)

- electrical resistivity,
- electromagnetic induction,
- magnetometry,
- ground penetration radar

Others

Sampling

Reserves evaluation – mineral deposits

Minimum standards for Public Reporting of minerals Exploration Results, Mineral Resources and Ore Reserves

For instance:

JORC Code NI-43-101 → Australia

JORC Code NI-43-101 → Canada

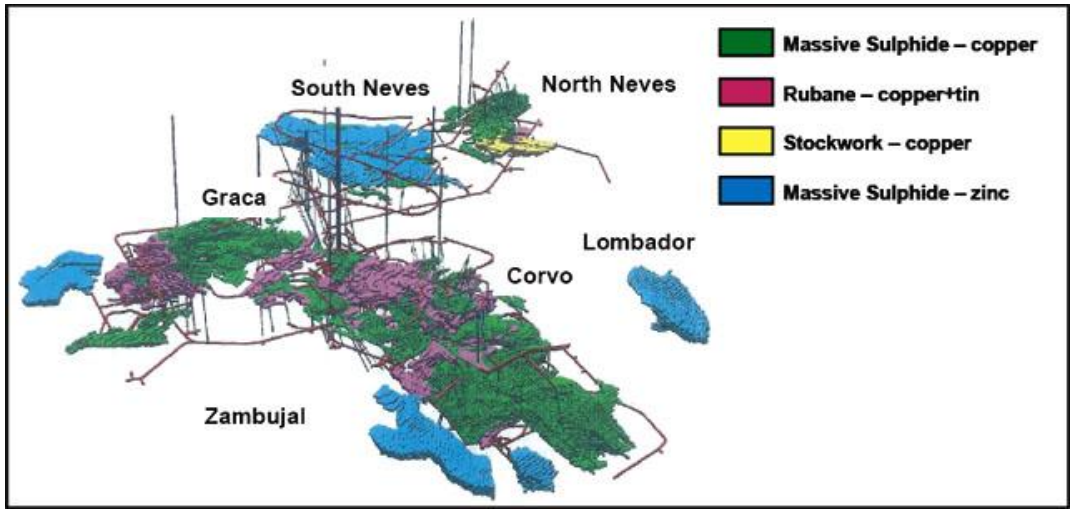
Average contents (grade) in the valorized minerals

Average contents (grade) in the penalizing minerals

Spatial distribution of the minerals

Quantities

Cut-off grade



Information gathering - Sampling

Position, number and distribution of samples (drill core)

Sample size

Preparation of samples (e.g. sub-division)

Analysis

Deposit type

Objective

Available capital

Access to the deposit

Level of accuracy (inversely related with cost)

Representative sample ⟺ redundancy?

Sampling

Homogeneous material

exact operation

no sampling errors are produced

Heterogeneous material

fundamental error (s^2)

constitution error (the elements of the material are not all equal)

→ intrinsic characteristic of the material – it cannot be canceled

grouping and segregation errors

distribution errors (the composition is not equal in the whole space occupied by the lot)

→ function of the fundamental error,
the spacial/time distribution of the critical component
the observation scale, i. e., of the sample volume.

P. Gy (1982) showed that it is $\leq s^2$
It can be reduced by homogenization of the material to be sampled
Practice: calculate s^2 and, conservatively, multiply it by two to obtain the total sampling error

operational errors

human action and devices project and operation

→ may be canceled

Sampling - the simplification of Pierre Gy

variance of the fundamental error (critical component)

Pierre Gy , 1982,
"Sampling of Particulate Materials
Theory and Practice"

$$s^2 = C\left(\frac{1}{M_s} + \frac{1}{M_L}\right)$$

M_L: Lot mass

M_s: Sample mass

$$C = f\ g\ l\ m\ d^3$$

size of the largest particle

shape
f=0.2 for gold ores; f=0.5 for flat ores

constitution of the sampled lot
expressing the mineralogical composition

size distribution
g=0.25 for most ores ; g=0.5 for calibrated ores

liberation degree of the critical component
l=0 for non liberated ores; l=1 for completely liberated ores, in most cases, l=0.2

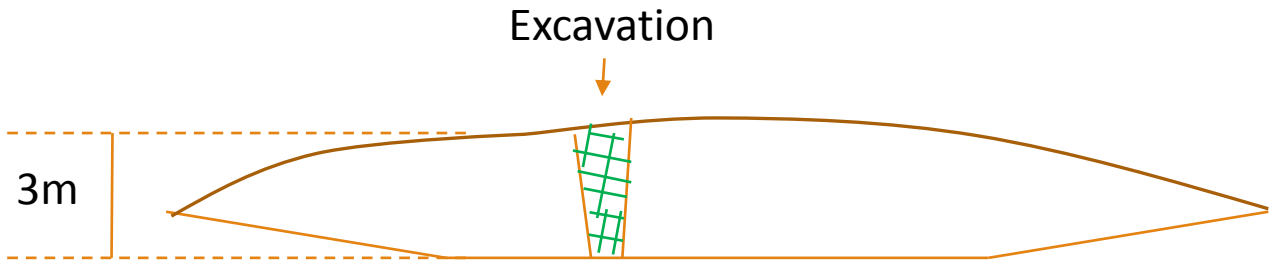
Mineral Deposits versus Landfills

MINERAL DEPOSIT	LANDFILLS
Homogeneous and known structure	Heterogeneous and unknown tipology
Known geomechanical properties	Variable geomechanical properties
Known geological structure	Anisotropic structure
Natural freatic level	Level of leachate variable

Sampling in landfills

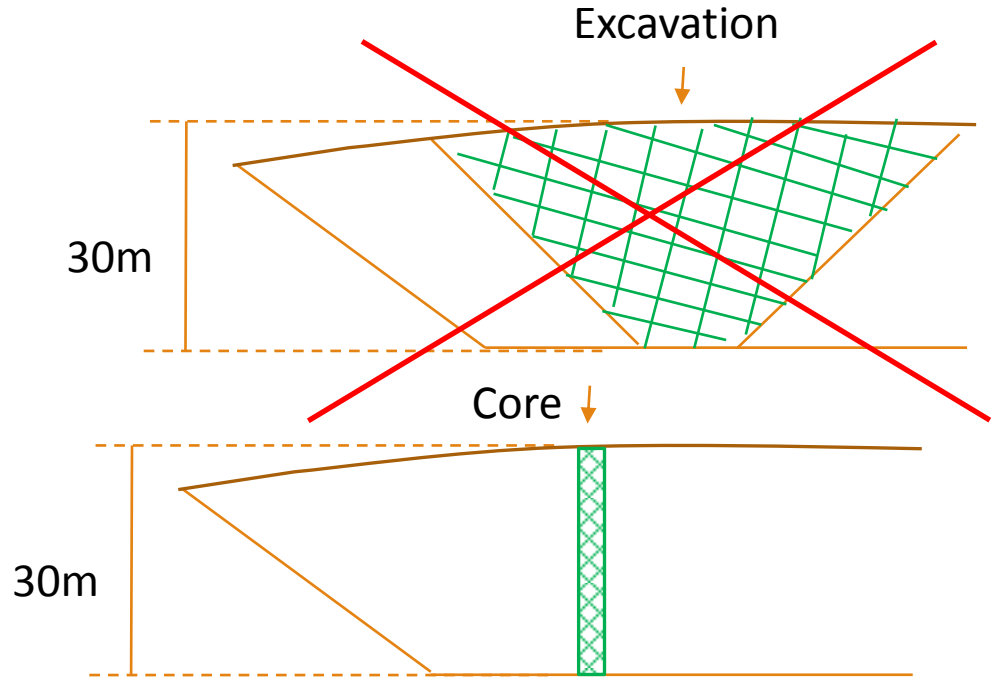
BACKHOE MACHINE, HYDRAULIC EXCAVATOR

Only for small depth – max 3 m



BOREHOLING (SPIRAL AUGER, CORING)

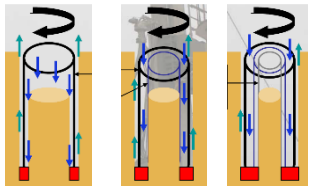
Depth – up to at least 30 m



Drawings not at scale

Drilling (rotative)

- Continuous sampling
- Double or triple sampler
- Diamond or tungsten crown



Sample collection examples (2008-2016)

Area (m^2)	Weight (ton)	Landfill depth (m)	Sampling machine	Number of places/sites	Total Number of samples	Size of each **primary** sample	sample pattern
108 800		3		4	12	150 kg	
1 286 200		8.0- 13	cactus grab crane	6	38	1X1x15	
10 000					7		
		24	Borehole (12 cm)	9	22	50 kg	Systematic (100*100)
15 000		1.5-2	Excavator	7	7	2 200 kg (total)	
	1 000 000	30		1	14	2-5 kg	
			Borehole (0,9 m)	3	6	2-11 kg	
			Borehole (0,9 m)	4	7		

Characterization/Macroscopic Classification/analysis* examples (2008-2016)

Particle size classes (mm)	Number of Material fractions	Materials	Objective of characterization
+25 (global); 25-50; +50	10	Me, Plast, Pa, Tex, St&C, Gl, Wood, Rb, Fo, Oth	Distribution over LF and depth (3 m)
+10, -10	8	Me, Plast, Pa&C, Tex, Gl&C, St, Wood, Oth	Distribution over LF
+100; 40-100;20-14;-20	7	Me, Plast, Pa&C, Tex, Soil, Wood, Oth	Contents by particle size
+10, 4-10	5	Me, Plast&Pa&C, Tex, Gl&St, Oth	
+10; 5-10	7	Me, Plast, Pa, Tex, Gl, St, Oth	
	7	Me, Plast, Pa&C, Tex, Gl&Ce&St, Wood, Oth	Distribution by depth (30 m)

Metals-Me; Plastics-Plast; Paper- Pa; Cardboard-C; Glass – Gl; Ceramics – Ce, Stones – St; Soils-Soil; Rubber – Rb; Foam – Fo; Textiles-Tex; Wood- Wood; Others - Oth

*On primary or secondary samples

A TASK FOR WG 4

Sampling in landfills…

- Each case is a case, it depends very much of the aim of the work/project:
  - Contents (% of materials, organics, fines)
  - Calorific value
  - Biochemical methane exploitation potential
  - Distribution of materials by particle size
  - Distribution of materials over the landfill
  - Materials degradation
  - Etc.
- Representativeness is in most of the cases virtual (sometimes it is an illusion)
- (Journals reviewers work is sometimes poor)

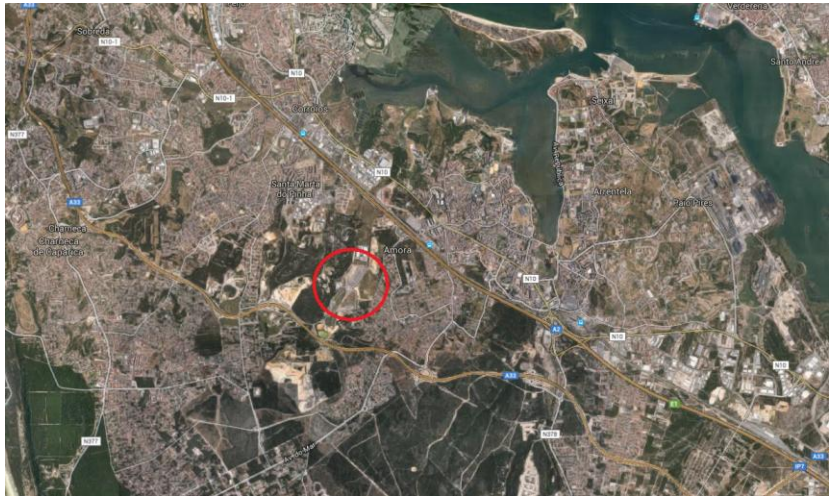
Case study

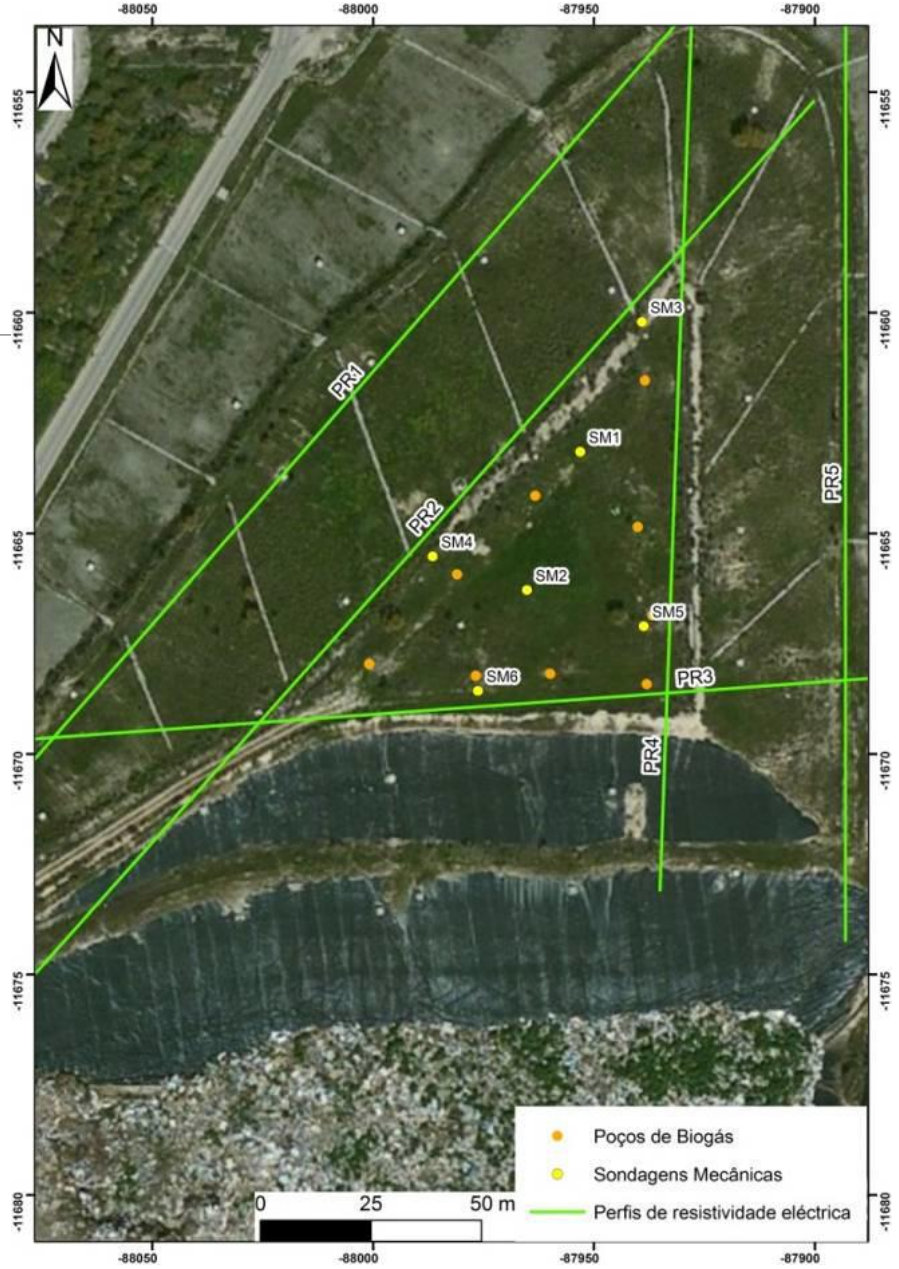
AMARSUL landfill, Ecoparque do Seixal, Cell nº2

Area: 20 000 m^2 Max depth: 20m

Age: 20 years old

Composition: Urban residues and… more





Case study - Equipment

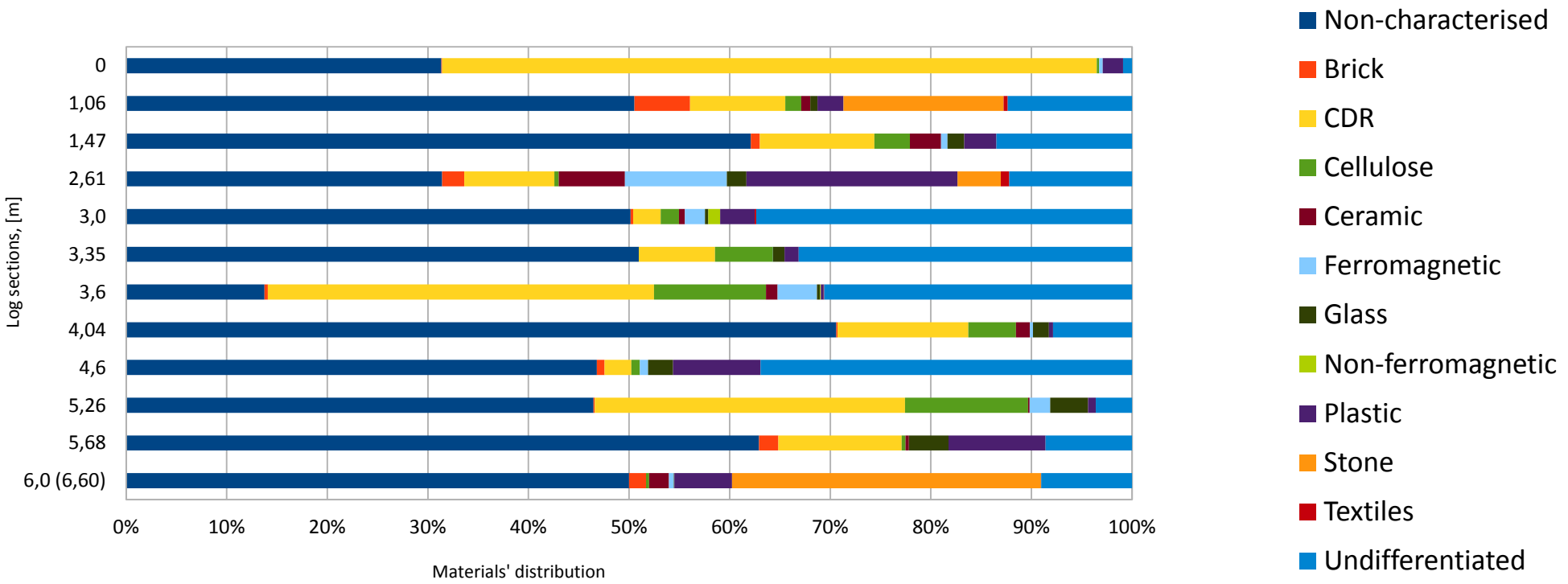
Hydraulic drilling probe OXIDRILL, OG150, crown with tungsten and diamond drill bits teeths;

98 mm diameter with 86 mm sample diameter. Continuous sampling.

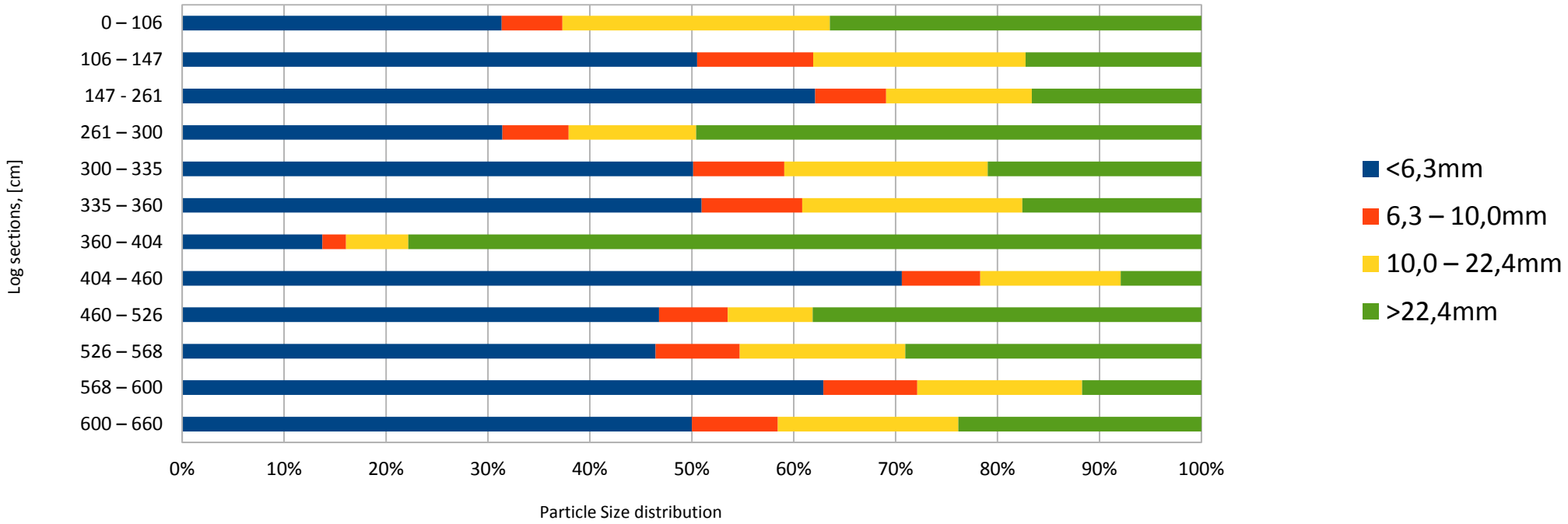
6 drilling holes with variable depth. Drilling stopped at maximum LF depth minus 5 meters

or when reaching the saturated zone (or due to blocking)

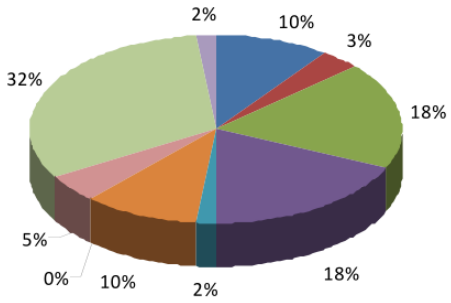
Compositional Analysis (one borehole)

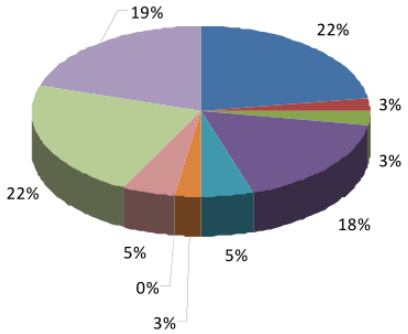


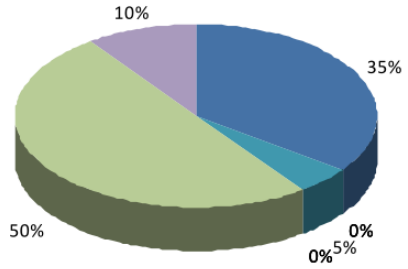
Particle size distribution (one borehole)

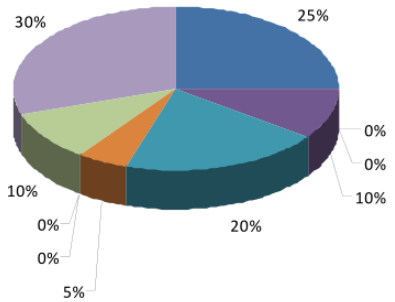


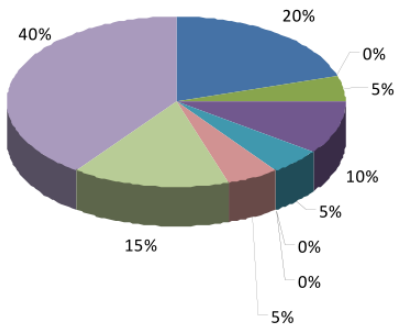
Results (6 boreholes)

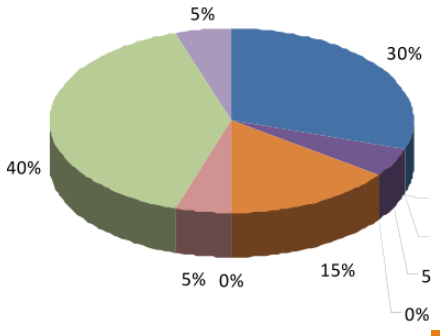












- Soil
- Paper&Cardboard
- Plastics
- Metals
- Textiles
- Organics
- Glass
- Wood
- CDR/stones

Conclusions

- The global composition of the boreholes is mainly soil, construction and demolition residues and organic materials (including plastics).
- It was observed that the global metals content is approximately 5%, varying from 0 to 20% in a few layers.

Conclusions- Difficulties/constraints

Drilling

- Coarse objects ⇒ Clogging ⇒ stop drilling maneuvers and/or equipment loss
- No water during drilling maneuvers ⇒ increasing of drilling temperature
- Hard materials (metals, concrete, RCDs...) ⇒ high temperature at drill bits ⇒ crown fusion may happen
- To avoid temperature increase ⇒ short drilling maneuvers (maximum 0,5 m) ⇒ high cost

Sampling

It would be important to have a comparison between sampling results and mined landfil results

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M. Teresa Carvalho*, Graça Brito**, João Brissos** André Sanches**, Bruno Guedes*