Results from BioNorm II, Work Package I

Task I.1 Sampling and sample reduction

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Jönköping, February 4, 2009

Disposition

- Objectives of BioNorm II, WP I, Task I.1
- Description of experimental design
- Choices of statistical methods
- Results from WP I, Task I.1

Objectives of Task I.1: Sampling and sample reduction

- Assess the bias introduced in samples taken from heap compared to moving streams
- Define the numbers and size of increments needed to provide a representative bulk sample
- Assess methods for sample reduction

Partners in WP I

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- Ms. Chiara Mengarelli

Materials

- Bark of pine (< 45mm)
- Wood chips (< 16 mm)
- Pellets (6 and 8 mm diameter)
- Olive residue (< 3 mm)
- Grape residue (< 16 mm)

Results from sample reduction

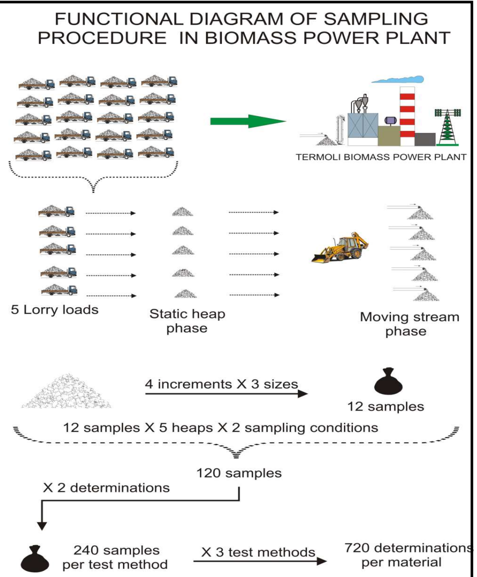
- **The table shows the reduction method with the highest precision for each material and parameter**
- **No significant difference in precission was found between the sample reduction methods**

Material	Moisture	Ash	Gross calorific value	Particle size distri-bution	Nitrogen	Potassium	Mechanical durability
Olive residue	LP	RB	-	-	RB	C&Q	-
Grape residue	RB	C&Q	-	-	LP	LP	-
Bark	C&Q	LP	LP	-	-	-	-
Wood chips	RB	RB	-	RB	-	-	-
Pellets (8mm)	-	RB	-	-	-	-	LP
Pellets (6mm)	-	RB	-	-	-	-	RB

EXPERIMENTAL DESIGN FOR SAMPLING

- 5 lorry loads
- 2 sampling methods
- 4 increments
- 3 increment sizes
- 3-10 test methods
- 2 determinations/increment and test methods

∑ 720-2400 determinations/material



Choices of methods

	Sampling methods	Test methods	Increment sizes	Reduction method
Bark	Heap, stopped conveyor	Moisture, ash, gross calorific value	20L,10L and 5L	Coning & quartering
Wood chips	Heap, falling stream	Moisture, ash, particle size distribution	10L, 4L and 2L	Riffle box
Pellets (6 & 8 mm)	Heap, bag/moving stream	Moisture, ash, mechanical durability	8L, 4L and 2,5L	Riffle box
Olive residue	Heap, falling stream	Moisture, ash, 8 major elements (Al, Ca, Mg, Na, P, Si, K, N)	10L, 5L and 2L	Riffle box
Grape residue	Heap, falling stream	Moisture, ash, 8 major elements (Al, Ca, Mg, Na, P, Si, K, N)	10L, 5L and 2L	Coning & quartering

Statistical methods - Sampling

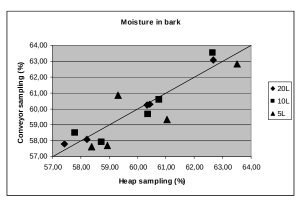
Bias between sampling methods:

- Paired comparison design of differences
- Normality test of differences
- Significance test of average of differences
- Graphical presentation

	Heap	Conv-eyor	Diff
	62,68	63,08	-0,40
	58,22	58,06	0,16
20L	57,41	57,79	-0,38
	60,42	60,28	0,14
	60,34	60,24	0,11
	62,65	63,55	-0,90
	58,73	57,90	0,83
10L	57,79	58,48	-0,69
	60,37	59,66	0,71
	60,76	60,58	0,18
	63,51	62,84	0,67
	58,95	57,71	1,23
5L	58,39	57,63	0,75
	61,05	59,34	1,70
	59,31	60,85	-1,55
Average	60,04	59,87	0,17
Std.dev.	1,875	2,033	0,856
		t=	0,78
		t_{crit}=	2,14

Bias between sampling methods

Moisture in bark:



Statistical methods - Sampling

Differences in variance between increment sizes and sampling methods:

- Analysis of variance (ANOVA)
- F-test of mean square between increment sizes
- F-test of mean square between sampling methods
- Graphical presentation of confidence interval of sampling error vs increment numbers and sub-sample tests

Statistical methods - Sampling

- MS_B = mean square for batches
- MS_S = mean square for increments
- MS_T = mean square for sub-sample tests

Differences in variances between increment sizes

Moisture in bark:

	20L	10L	5L
Heap	MS_B = 34,4 MS_S = 9,61 MS_T = 0,293	MS_B = 28,4 MS_S = 8,78 MS_T = 0,459	MS_B = 34,7 MS_S = 12,2 MS_T = 0,773
Conveyor	MS_B = 36,4 MS_S = 10,6 MS_T = 0,680	MS_B = 39,5 MS_S = 9,74 MS_T = 0,728	MS_B = 39,2 MS_S = 11,9 MS_T = 1,148

Individual variances

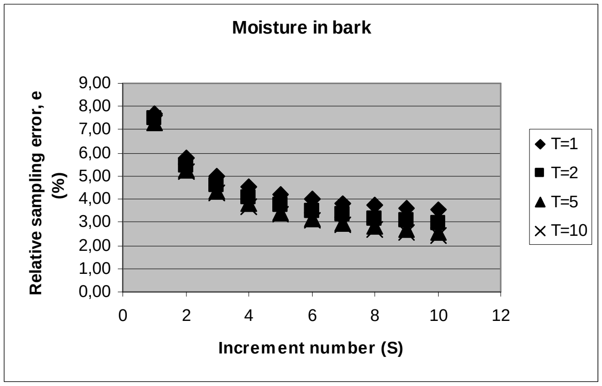
Moisture in bark:

$MS_B = ST\sigma^2_B + T\sigma^2_S + \sigma^2_T$ ⟶ $\sigma^2_B = 3,12$

$MS_S = T\sigma^2_S + \sigma^2_T$ ⟶ $\sigma^2_S = 4,89$

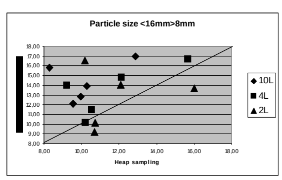
$MS_T = \sigma^2_T$ ⟶ $\sigma^2_T = 0,68$

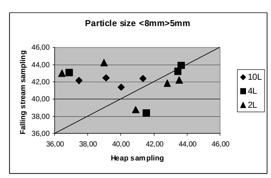
Relative sampling error in one batch

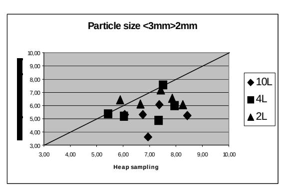


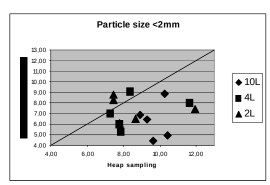
Results from sampling - bias

Wood chips:





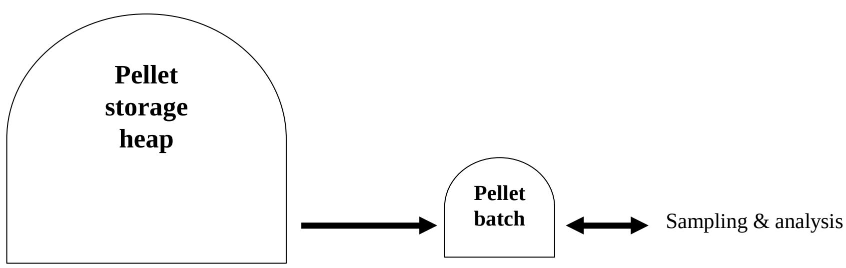




Results from sampling - variances

- Various differences in variances were found between increment sizes and sampling methods
- In many cases the results were contradictory

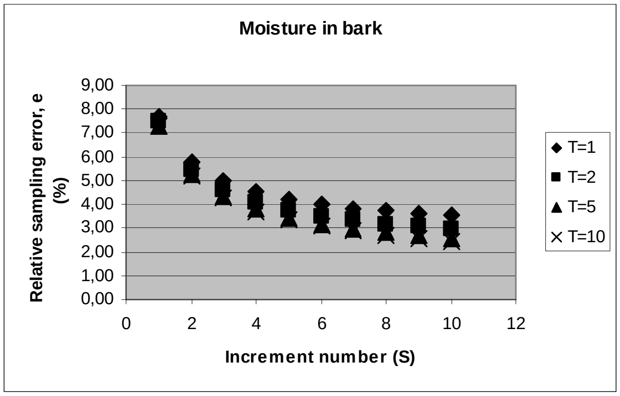
Relative sampling error



$$e = t^*\left(\sqrt{\sigma^2_S/S + \sigma^2_T/T}\right)/\ \hat{y}\ {}^*100$$

(analysis of batch)

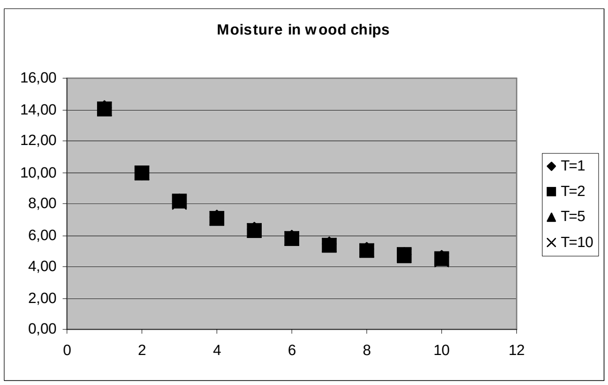
Effect of increment and test numbers on relative sampling error



$\sigma^2_S =$ 4,89

$\sigma^2_T =$ 0,68

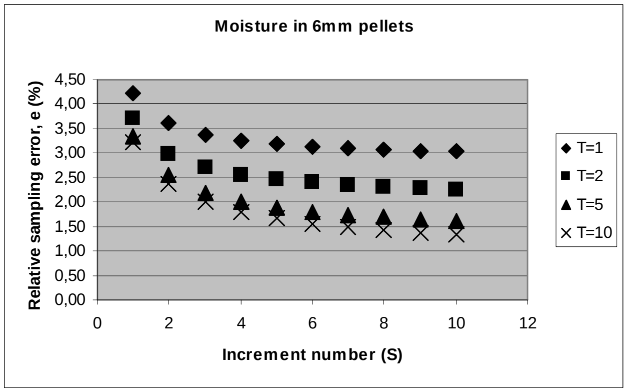
Effect of increment and test numbers on relative sampling error



$\sigma^2_S =$ 10,5

$\sigma^2_T =$ 0,0587

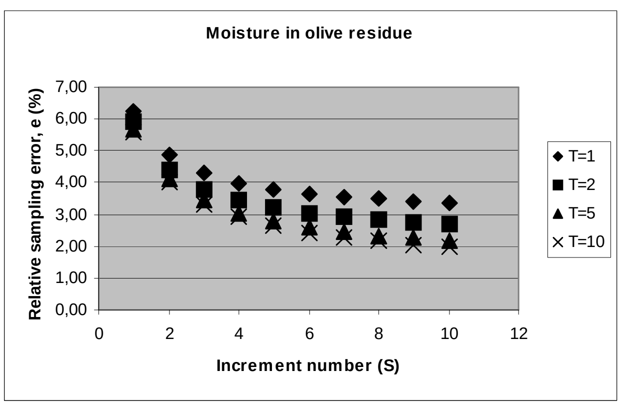
Effect of increment and test numbers on relative sampling error



σ^2_S= **0,0164**

σ^2_T= **0,0141**

Effect of increment and test numbers on relative sampling error



σ^2_S= **0,105**

σ^2_T= **0,0286**

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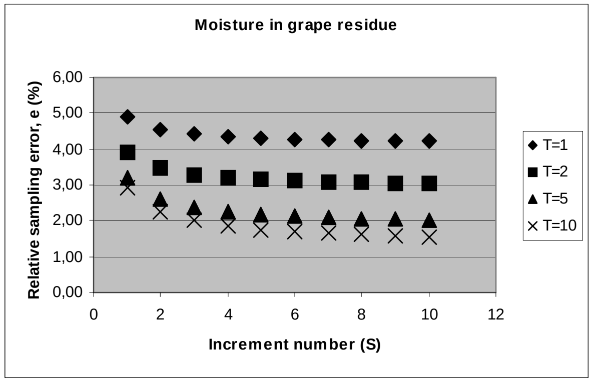
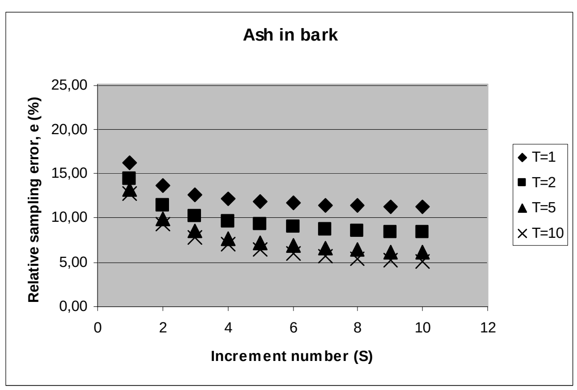
Effect of increment and test numbers on relative sampling error



σ^2_S= 0,746

σ^2_T= 1,88

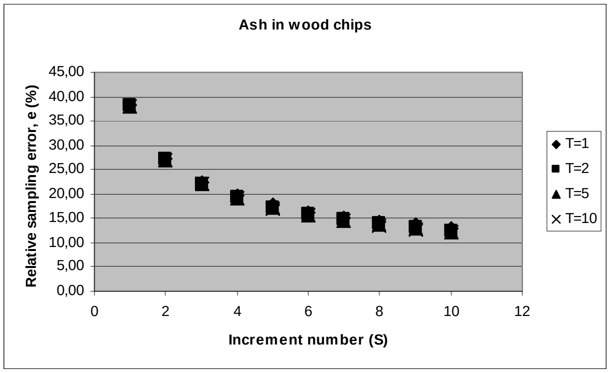
Effect of increment and test numbers on relative sampling error



σ^2_S= 0,0256

σ^2_T= 0,0187

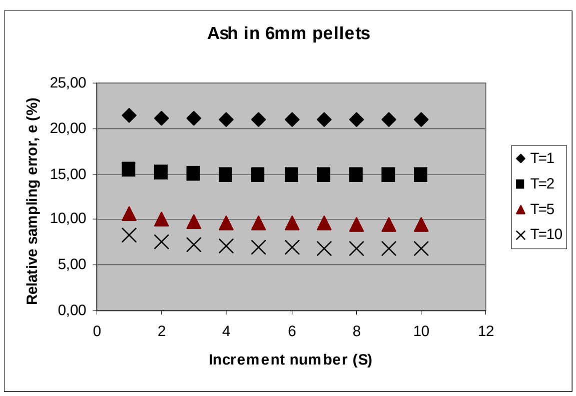
Effect of increment and test numbers on relative sampling error



$\sigma^2_S =$ 0,0231

$\sigma^2_T =$ 0,00040

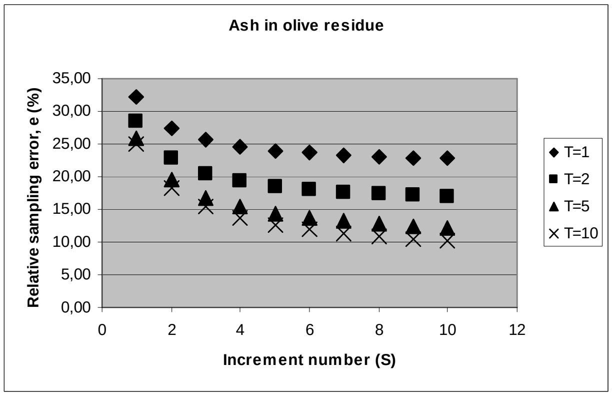
Effect of increment and test numbers on relative sampling error



$\sigma^2_S =$ 0,000399

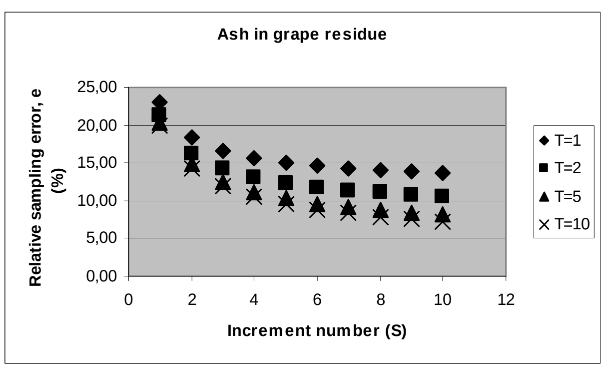
$\sigma^2_T =$ 0,00711

Effect of increment and test numbers on relative sampling error



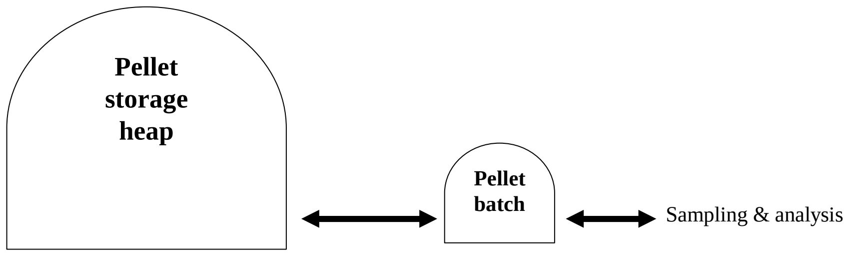
σ^2_S= 0,658
σ^2_T= 0,527

Effect of increment and test numbers on relative sampling error



σ^2_S= 0,519
σ^2_T= 0,202

Effect of S_{incr} and T_{test} on the relative heap error



$$e = t*(\sqrt{(\sigma^2_B/B+\sigma^2_S/BS + \sigma^2_T/BT)})/ \hat{y} *100$$

(analysis of storage heap)

Effect of S_{incr} and T_{test} on the relative heap error

Moisture in 6mm pellets:

Para-meter	Aver. (%)	V_{batch}	$V_{incr.}$	V_{test}	S_{incr}	T_{test}	Rel. samp. error (%)	Rel. heap error (%)
Moist.	8,1	0,0082	0,0164	0,0141	1	1	4,23	4,76
Moist.	8,1	0,0082	0,0164	0,0141	5	1	3,19	3,87
Moist.	8,1	0,0082	0,0164	0,0141	1	5	3,36	4,01
Moist.	8,1	0,0082	0,0164	0,0141	5	5	1,89	2,89

Effect of S_{incr} and T_{test} on the relative heap error

Moisture in wood chips:

Para-meter	Aver. (%)	V_{batch}	$V_{incr.}$	V_{test}	S_{incr}	T_{test}	Rel. samp. error (%)	Rel. heap error (%)
Moist.	45,2	1,985	10,51	0,0587	1	1	14,09	15,36
Moist.	45,2	1,985	10,51	0,0587	5	1	6,37	8,83
Moist.	45,2	1,985	10,51	0,0587	1	5	14,06	15,33
Moist.	45,2	1,985	10,51	0,0587	10	1	4,57	7,63

Effect of S_{incr} and T_{test} on the relative heap error

Ash in 6mm pellets:

Para-meter	Aver. (%)	V_{batch}	$V_{incr.}$	V_{test}	S_{incr}	T_{test}	Rel. samp. error (%)	Rel. heap error (%)
Ash	0,79	0,0004	0,0004	0,0071	1	1	21,46	22,04
Ash	0,79	0,0004	0,0004	0,0071	5	1	21,00	21,59
Ash	0,79	0,0004	0,0004	0,0071	1	5	10,57	11,70
Ash	0,79	0,0004	0,0004	0,0071	1	10	8,25	9,66

Effect of S_{incr} and T_{test} on the relative heap error

Ash in bark:

Para-meter	Aver-age (%)	V_{batch}	$V_{incr.}$	V_{test}	S_{incr}	T_{test}	Rel. sampl. error (%)	Rel. heap error (%)
Ash	2,55	0,383	0,0256	0,0187	1	1	16,20	50,29
Ash	2,55	0,383	0,0256	0,0187	5	1	11,88	49,07
Ash	2,55	0,383	0,0256	0,0187	1	5	13,18	49,40
Ash	2,55	0,383	0,0256	0,0187	5	5	7,24	48,16

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Conclusions

- No bias between sampling methods except for particle size distribution
- Various results in the comparison of the variances for increments and tests
- No reduction method was significant better than the others
- The variation in batches, increments and sub-samples must be known to obtain a suitable sampling plan

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Thank you!