EFFECT OF ALDERS (ALNUS SP.) ON TECHNOSOLS DEVELOPMENT ON LIGNITE COMBUSTION WASTES DISPOSAL

35th Annual Meeting of the American Society of Mining & Reclamation

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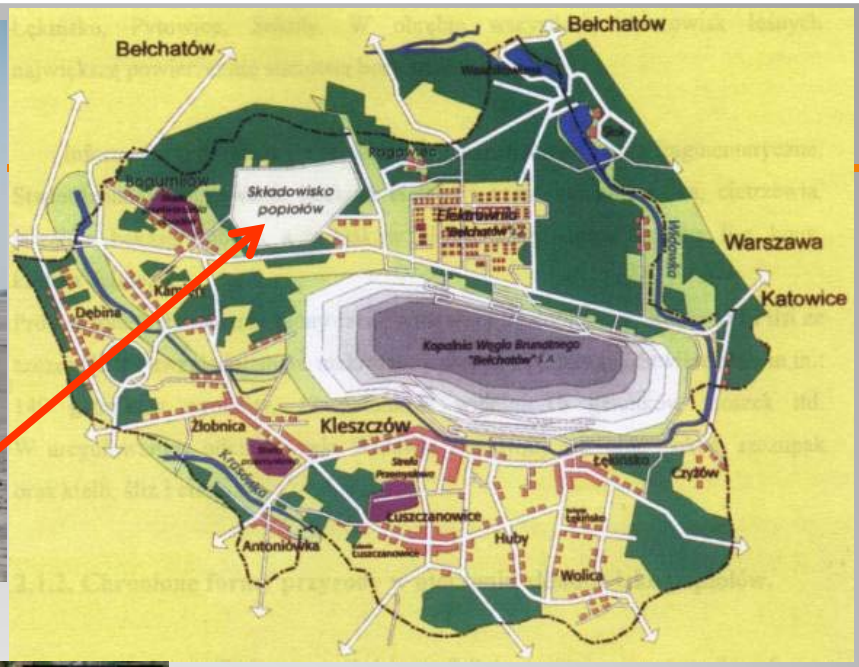
Study Financed by National Science Centre POLAND .Grant No. 2015/17/B/ST10/02712

LOKALIZATION

Fot. M. Pietrzykowski



Source http://maps.google.pl/

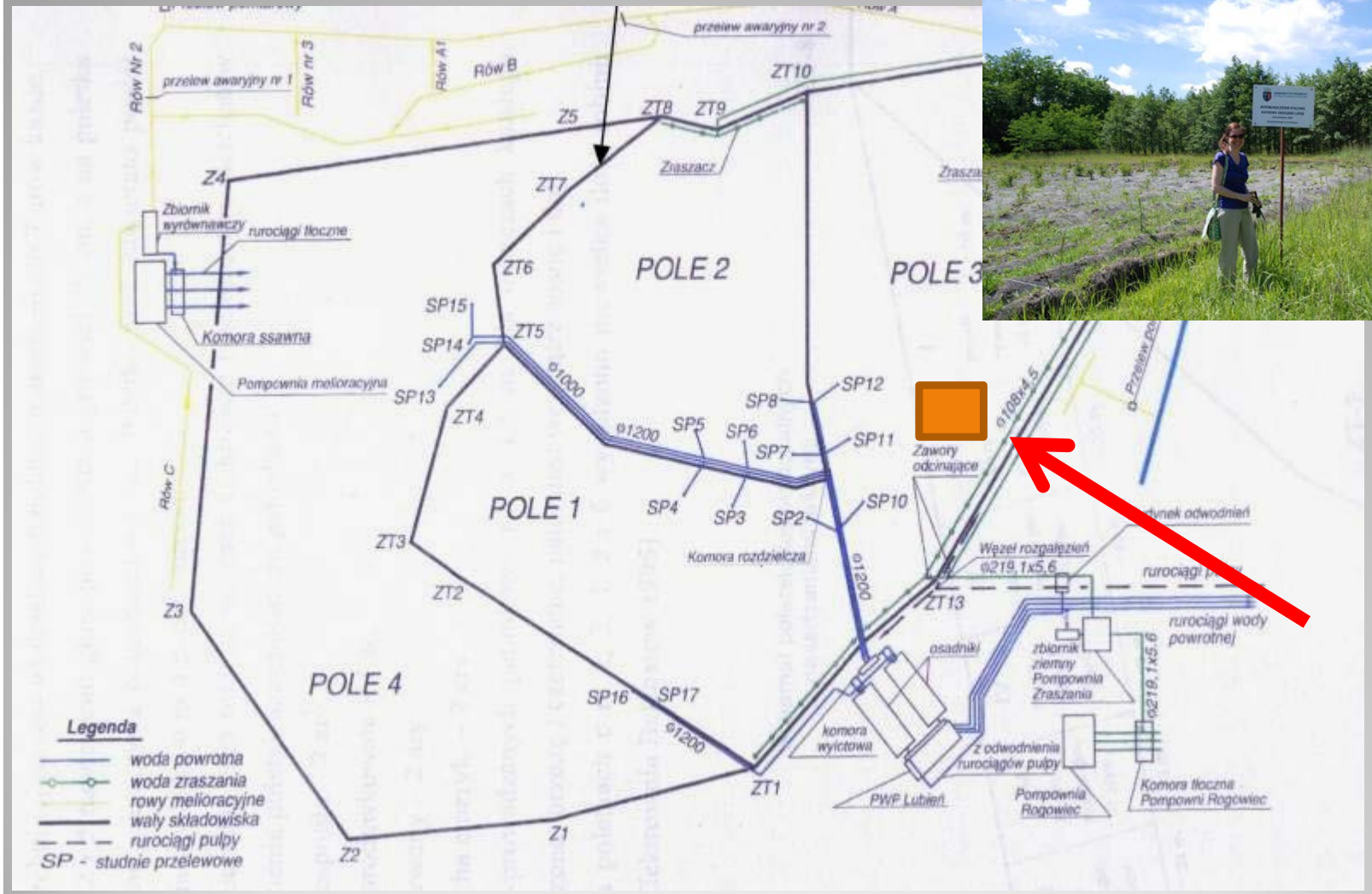
Amount of combustion waste produced in the "Bełchatów" Power Plant - SELECTED PARAMETERS

Calorific value [kJ/kg]	*moisture [%]*	*ash [%]*	*Sulfur content [%]*
7967.8	**53.4**	**10.0**	**0.7**

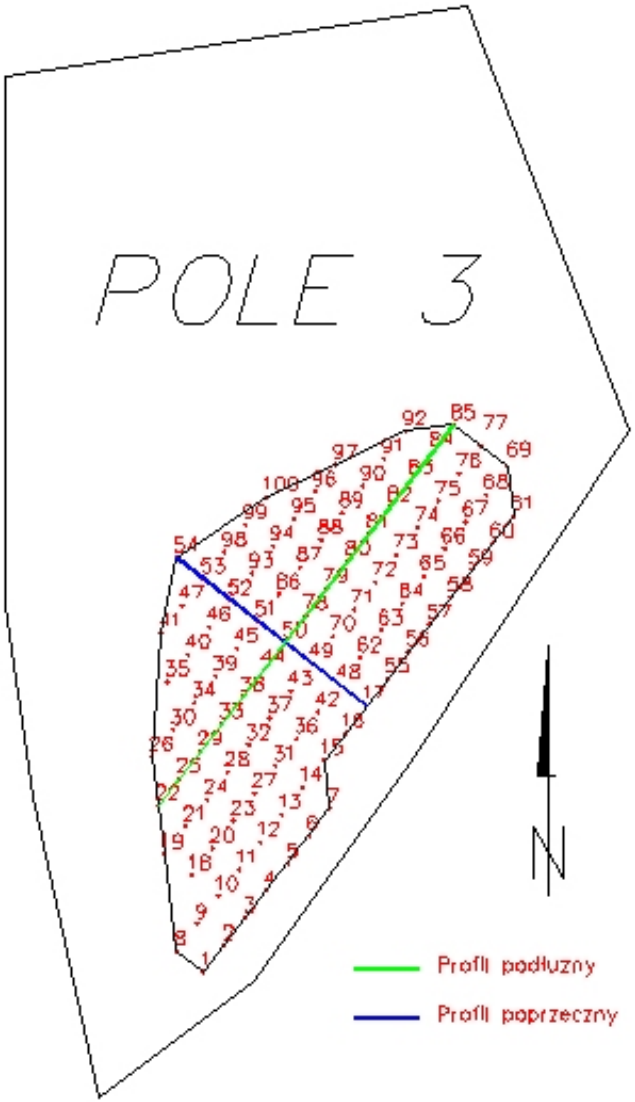
- 2017 – **4.660 mln metric tons /year**

Source : http://www.bip.kleszczow.pl

Photo by M. Pietrzykowski 2015



Lubień combustion waste disposal site – experiment localization



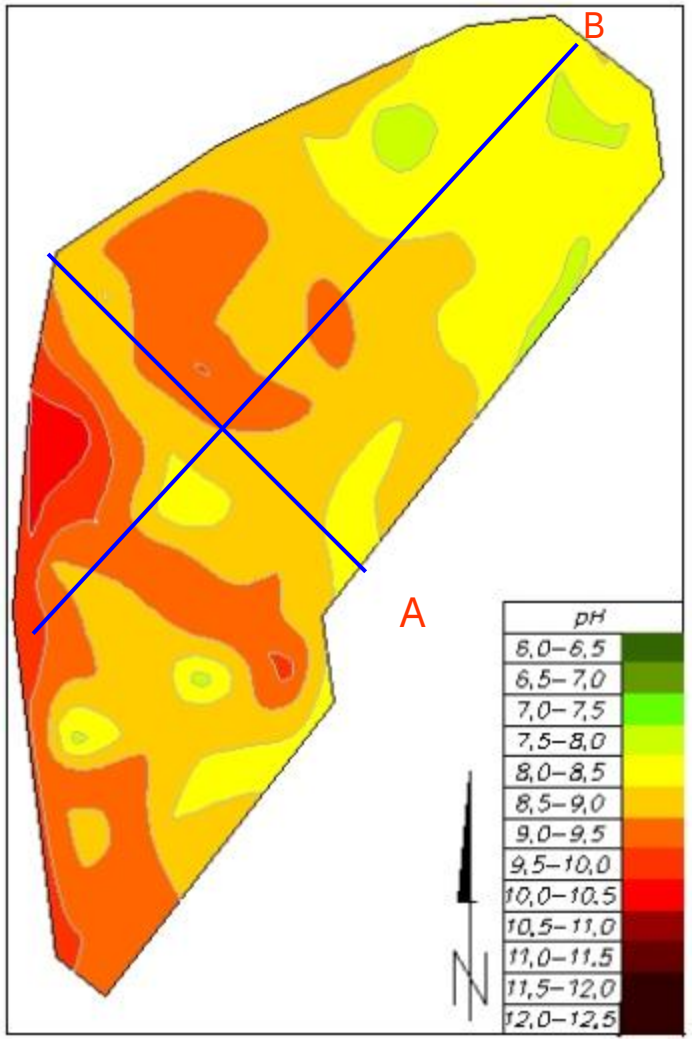
Sampling point – grid for EC and pH studies

Cross-section of the upper layer of combustion waste after sedimentation on disposal site

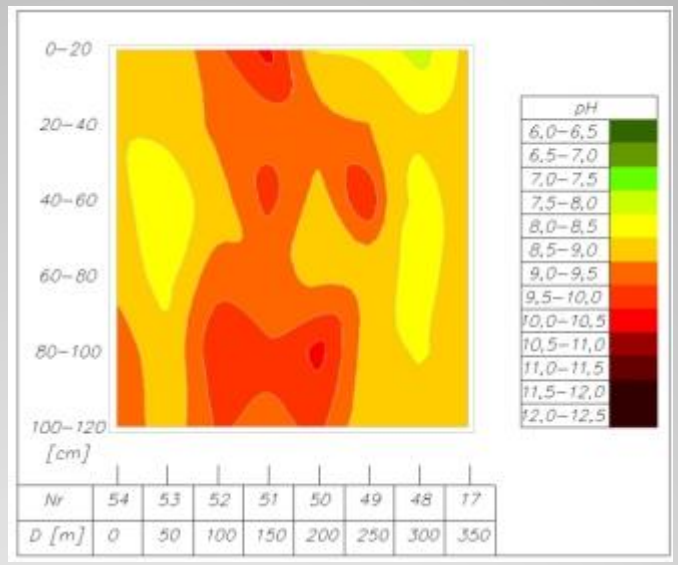
pH and EC values of combustion waste samples taken from layers up to a depth of 120 cm at the Lubień disposal site (5-6 years after the last deposit of the waste)

pH					
layer	N Number of samples	mean	minimum	maximum	coefficient of variation
0-20	100	8.68	7.72	11.79	9.43%
21-40	100	8.85	7.66	10.79	7.99%
41-60	100	8.81	7.62	12.37	8.18%
61-80	100	8.77	7.58	12.23	8.32%
81-100	98	8.69	6.33	10.28	7.76%
101-120	96	8.64	6.32	11.37	7.59%
EC µS cm-1					
0-20	100	873.22	105	1810	53%
21-40	100	971.91	182	1754	35%
41-60	100	1025.66	195	3780	43%
61-80	100	1030.03	122	3420	39%
81-100	98	954.296	228	2003	31%
100-120	96	983.135	186	1673	29%

SPATIAL DIFFERENTIATION OF pH (mean values for 6 layers up to 120 cm deep)

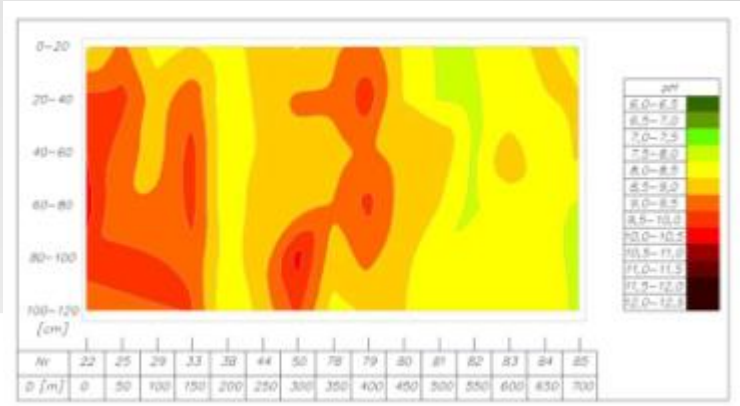


Spatial differentation of pH_{H2O} (up to 120 cm



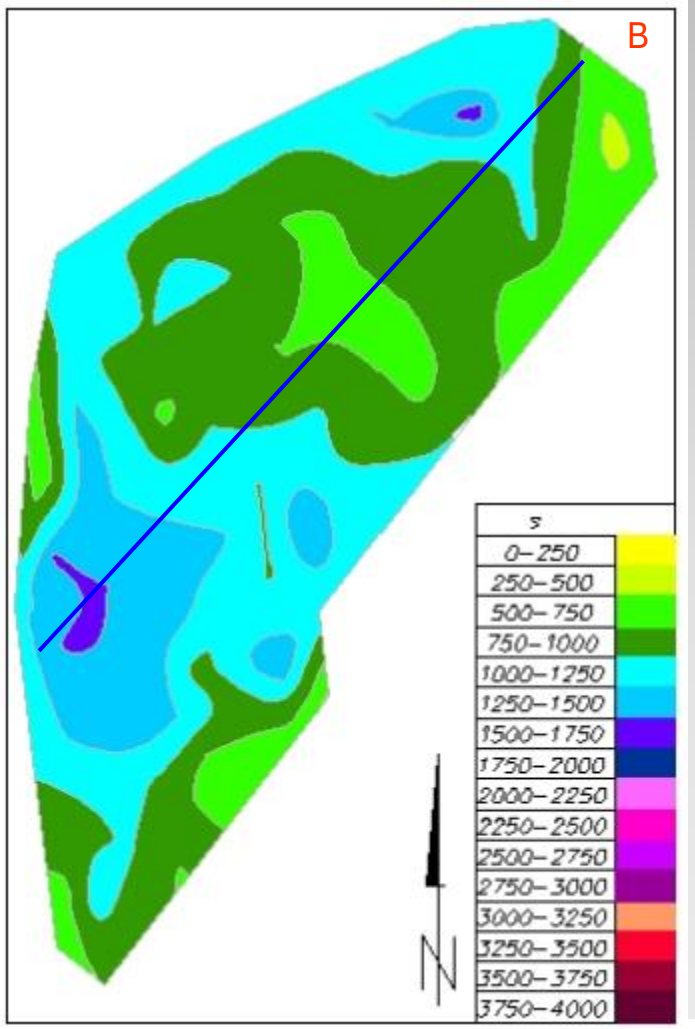
Transect A

Cross section showing the pH of H2O
for six layers along the designated transects

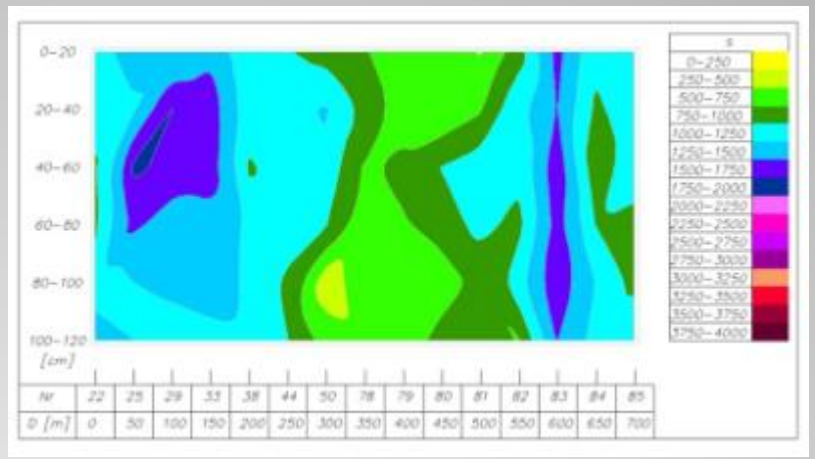


Transect B

SURFACE VARIABILITY OF EC FOR SIX LAYERS (average for 0 - 120 cm)



Transekt B



Cross section showing EC distribution for six layers along the designated transect B

Spatial diversity of EC (mean values for 6 layers up to 0-120 cm depth)

Degree of difficulties for biological reclamation (EC and pH summary)

- Variability of pH and EC on combustion waste disposal site is significant;
- The highest difficulties for biological stabilization will bo on the part of disposal site with **pH > 9.5** and EC **> 1.5 mS/cm – 5 %** of surface;
- **pH H_2O** from **8.5 to 9.5** (**65 %** of surface) - biological stabilization slightly easier and possible**;**
- **pH H_2O <** 8.5 on **30 %** surface - biological stabilization possible and effective **%**.
- **Special attention** has to be payed for the difficulties with **compaction** of the top layer (air-water properties)

Other examples of revegetation - trees introducing on combustion waste disposal site

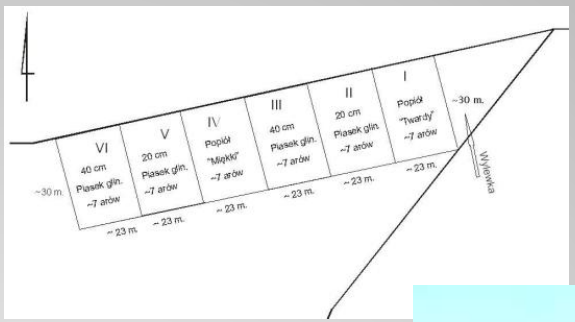
Results of research on the growth of pine and several accompanying tree species introduced in 1995 on the "Lubień" CWDS

DESCRIPTION OF EXPERIMENT

variants with TOPSOILING - thicknesses of 20 and 40 cm,

without TOPSOIL (control plots on ash)

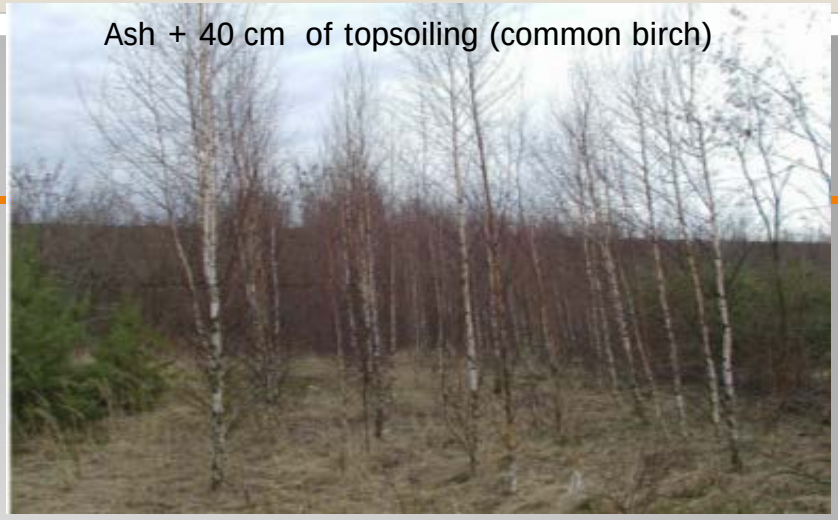
used tree species: Scots pine, common birch, black locust, and red oak.



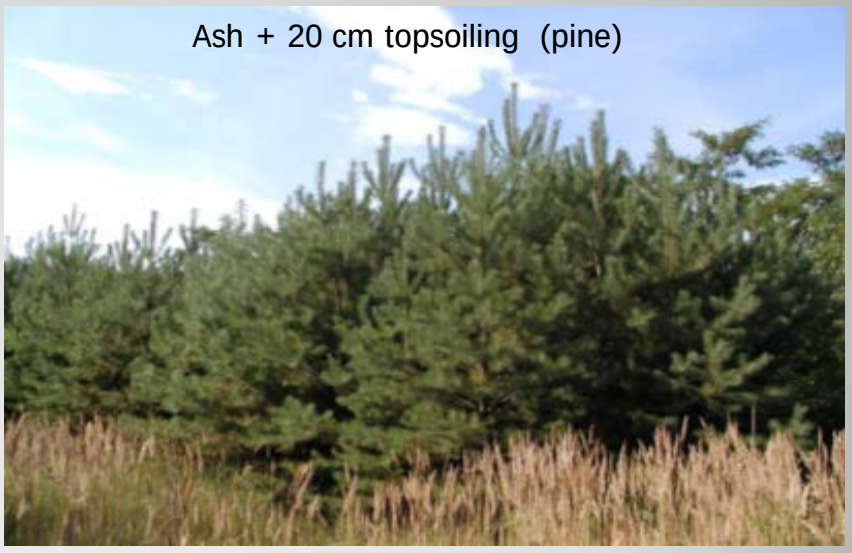
Selected properties of technogenic soil substrates

Study field (variant)	layer [cm]	pH		EC	Available nutrients [mg/100g]			Content in %				$CaCO_3$ win %
		w H_2O	w KCl	uS/cm	Mg	K_2O	P_2O_5	C	N	S	C/N	
I ash	0-20 cm	8.1	7.7	53	1.54	4.51	3.5	0.26	0.009	0.012	30.34	0.08
	40- 60 cm	7.8	7.7	**891**	10.91	3.25	0	3.00	0.026	0.023	113.67	8.72
II 20 cm top soil	0-20 cm	8.3	7.7	65	3.57	7.05	2.12	0.45	0.015	0.014	29.74	0.44
	40- 60 cm	8.1	7.7	217	**13.82**	4.88	0	**4.41**	0.039	0.021	114.22	**9.79**
III 40 cm top soil	0-20 cm	8.2	7.9	77	2.66	5.12	1.16	0.55	0.012	0.013	44.44	1.33
	40- 60 cm	8.1	7.6	171	9.44	3.67	0	2.95	0.024	0.019	121.82	2.38
IV ash	0-20 cm	8.1	7.7	102	7.13	2.11	0	3.57	0.030	0.020	119.50	4.18
	40- 60 cm	**8.4**	**8.2**	833	6.9	**25.9**	0	3.03	0.034	**0.027**	89.06	4.29
V 20 cm top soil	0-20 cm	7.8	7.1	37	1.65	5.06	3.68	0.27	0.022	0.011	11.98	0.05
	40- 60 cm	8.1	7.5	126	9.86	2.41	0	3.72	0.043	0.019	86.20	5.53
VI 40 cm top soil	0-20 cm	7.9	7.6	67	2.61	5.42	1.76	0.30	0.027	0.010	11.20	0.35
	40- 60 cm	7.9	7.7	686	7.63	6.2	0	3.69	**0.044**	0.020	83.65	5.74


Ash – no topsoiling
(pine introduced)


Ash + 40 cm of topsoiling (common birch)


Ash + 20 cm topsoiling (common birch)


Ash + 20 cm topsoiling (pine)

Some tips for revegetation

after 11 years of study with topsoiling and using of varied tree species

- Afforestation of combustion waste disposal site without topsoiling is promissing
- Best growth: black locust, pine and birch
- The high adaptability of the pine was observed, and pine could be the main species in the afforestation and birch as an admixture;

Photo by M. Pietrzykowski 2015

EXPERIMENT WITH Alders introduction (*Alnus spp.*)
on „Lubień" combustion disposal site

Experiment design

• Preliminary using of sewage sludge (biosolids 4 tons /ha + grasses 250 kg/ha)

• 36 plots (6m x 13 m each)

• 3 Alder species (*A. viridis. A. incana. A. glutinosa)*

• plantting to holes *(*40×40×40 cm - 1.2 × 1.3 m spacing, 50 seedlings on each plot)

• 2 variants with substrate addition (3 dm^3 substrate per hole):

- **CW + L** (combustion waste + lignite culm with pH 5.6);
- **CW+AS** (combustion waste + acidcic - pH 3.7, miocene sand)
- **C** - control plots, only combustion waste

Experiment arrangement – spring 2006

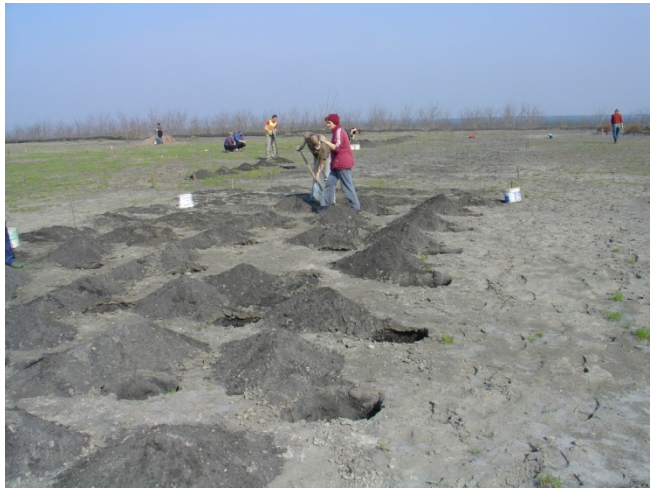


Photo by Krzaklewski W. 2006
used with permission

Late spring 2006

Summer 2008

Summer 2009

Summer 2017 – black alder

Spring 2015

Summer 2015

Survival rate, growth and C and N accumulation in soil and litter layer

Tree measurements

• 2012 and 2016: survival and growth (height, D0 and DBH), green alder only D0 and survival rate)

Soil study

• fall 2016 - the mass of litter layer and sampling for C and N analysis;

• spring 2016 and 2017 – sampling (0-5 cm; 5-40 cm) and basic soil parameters

Coarse roots study (morphology and biomass)

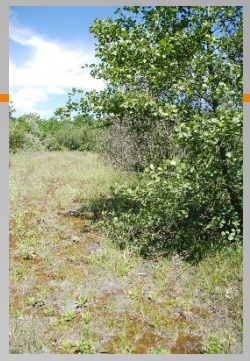
• coarse roots after 5 years - extraction and morphology description, weighting) C and N content determination

Fine roots study (biomass and yearly growth)

• spring 2016 - instalation of fine roots microryzotrons (PCV cylinders 50 mm x 300 mm, grid 2 mm);

• fall 2016 extraction, washing, weighting, C and N determination)

Results



- pH and EC,
- trace element content

in substrates under Alders species

[1]	pH_{H2O}	pH_{KCl}	EC	Zn	Cu	Cd	Pb	Cr
			$\mu S \cdot cm^{-1}$	$mg \cdot kg^{-1}$				
Green Alder	**7.94**	**7.86**	**526.37**	**47.24**	**22.34**	**1.26**	**16.67**	**17.08**
	(7.83-8.07)[2]	(7.79-7.93)	(460.50-597.00)	(44.60-50.30)	(18.63-28.15)	(1.05-1.55)	(14.13-19.93)	(14.68-18.95)
Grey alder	**7.95**	**7.89**	**474.2**	**43.04**	**18.70**	**0.86**	**17.05**	**19.37**
	(7.68-8.24)	(7.53-8.24)	(286.50-579.50)	(32.60-52.93)	(12.80-24.95)	(0.43-1.33)	(12.83-19.30)	(12.85-30.28)
Black alder	**8.00**	**7.88**	**534.06**	**47.81**	**21.66**	**1.08**	**18.97**	**18.58**
	(7.88-8.11)	(7.70-8.01)	(378.25-788.50)	(40.90-53.88)	(20.13-22.50)	(0.63-1.40)	(16.80-22.03)	(15.28-21.60)

1- tree species variant
2 – mean and range (n = 4)

Results

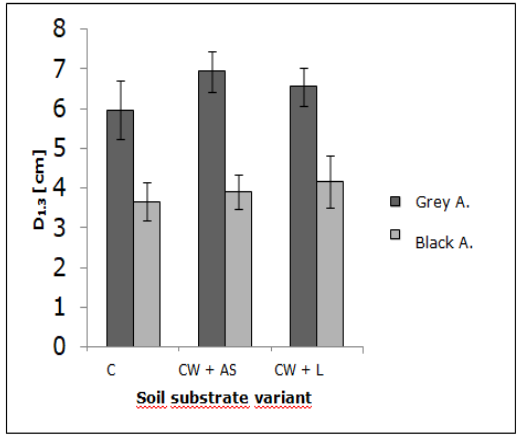
Trees survival and growth after 5 years

Species (alder)	Survival [%]	D0 [cm]	h [cm]
Green A.	72 ± 24[1]	n.d. [2]	74.37 ± 40.63
Grey A.	87 ± 4	4.26 ± 1.78	233.47 ± 70.17
Black A.	76 ± 11	5.17 ± 1.52	302.61 ± 80.14

Objaśnienia:
[1] – mean ± SD
[2] – green aldres - measurements of h and survival , because shrubs form

Cited by:
Krzaklewski W., Pietrzykowski M., Woś B. 2012. Ecological Engineering 49, 35-40.
Pietrzykowski M., Krzaklewski W., Woś B. 2015. Journal of Forestry Research 26(1): 131-136

Growth after 10 years



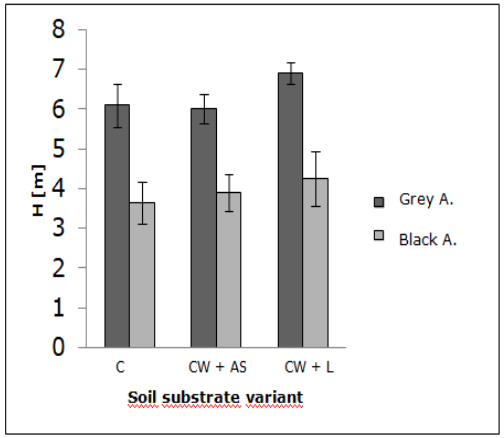
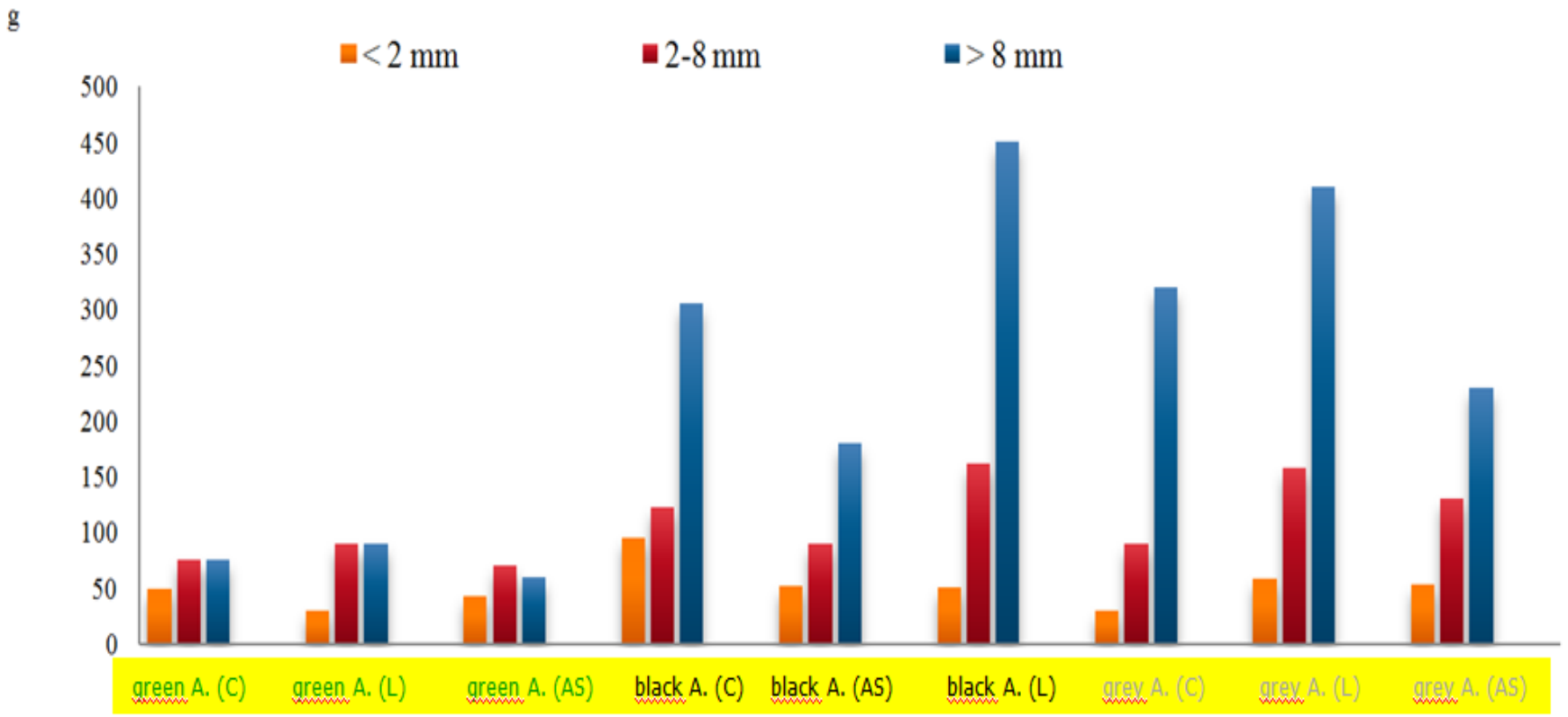


Fig. 2. DBH (fig. 2a) and height (fig. 2b): C – control; CW + AS; CW + L

Cited by Pietrzykowski, M., Woś, B., Pająk, M. et al. Environ Sci Pollut Res (2018).

Coarse roots assesment



- **black alder the highest root biomass**

Krzaklewski W. Pietrzykowski M., Leńczuk D., Góral R. 2015. Episteme 26(1): 103 - 110

Fine roots - biomass growth and spatial variability

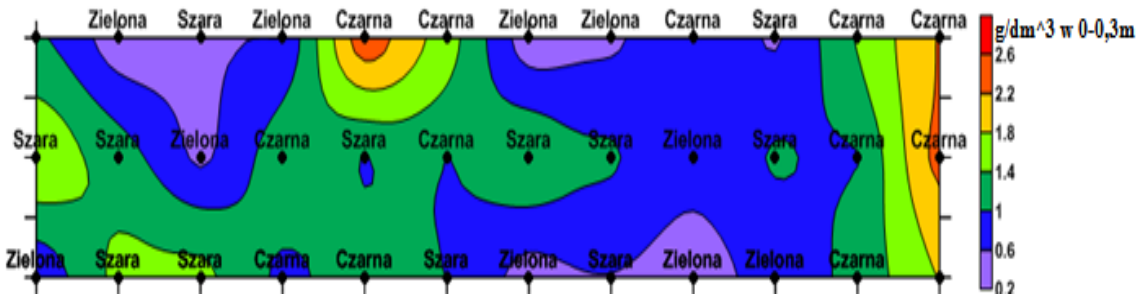


Fig . Spatial variability of fine roots growth (up to 0-30 cm) – study plots in total area

Photo – fine roots sampling and microrizothron

Litter mass and C and N accumulation

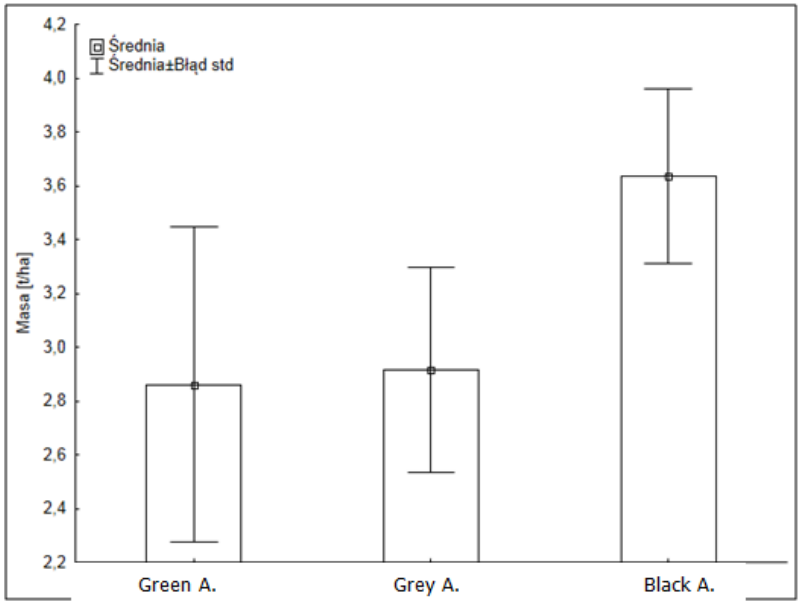


Fig. Litter dry mass (metric t/ha]

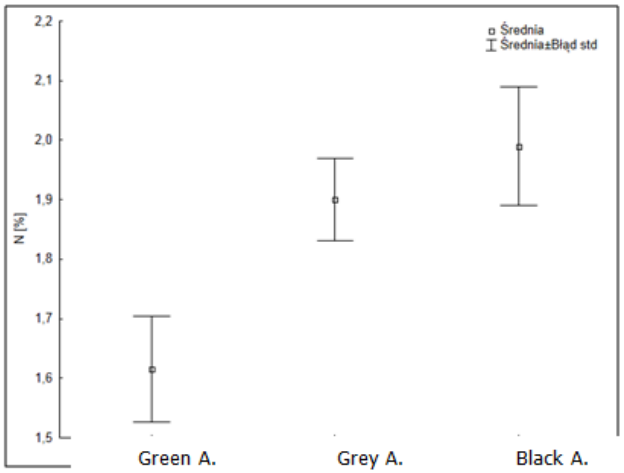


Fig. N (%) in litter

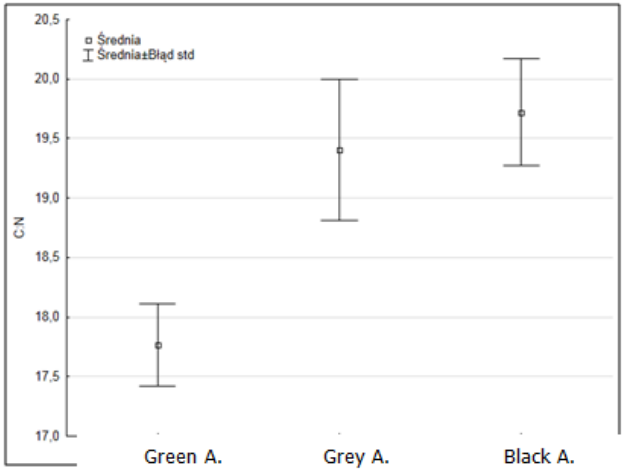


Fig. C – to - N ratio in litter

SOC and N t content in soil

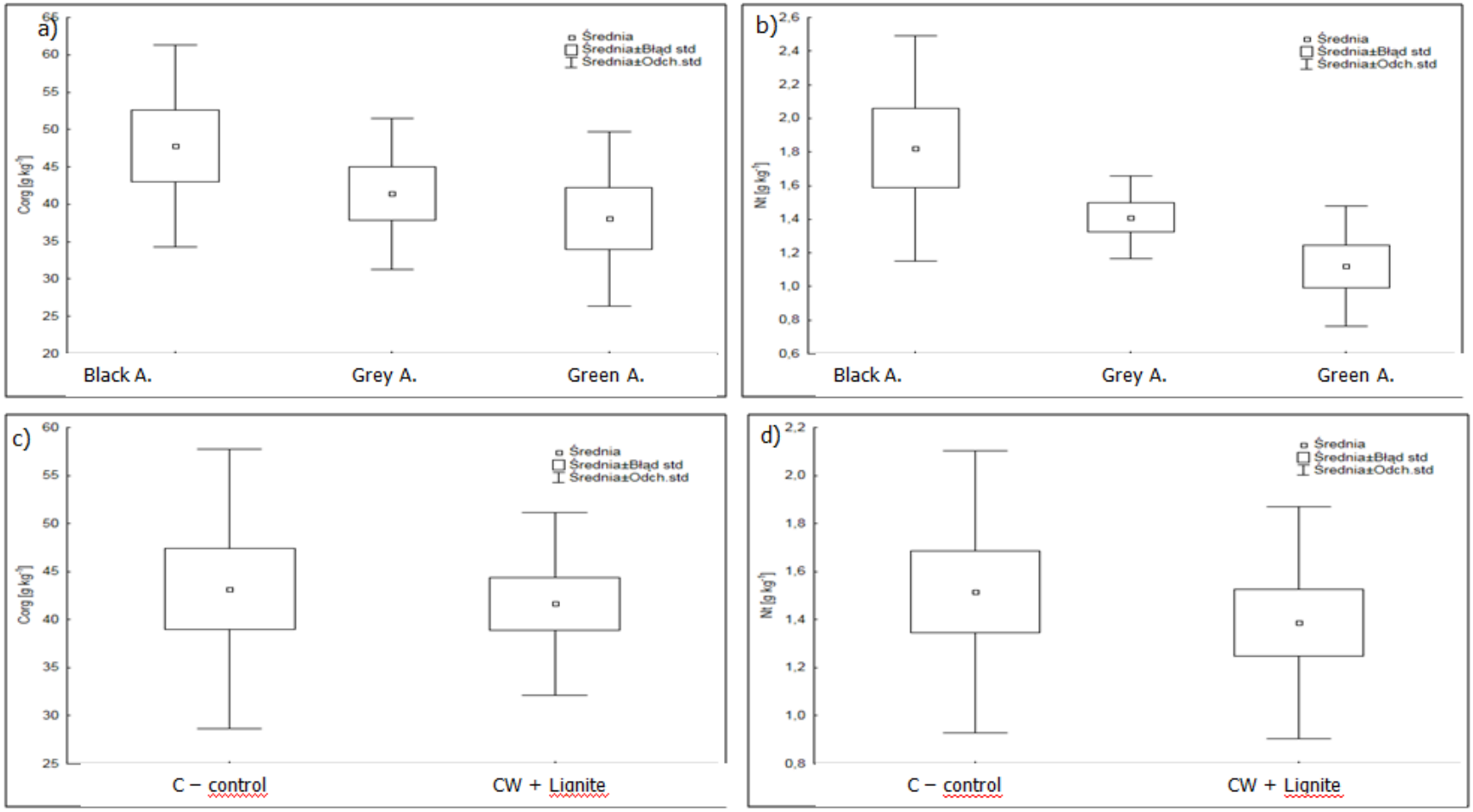
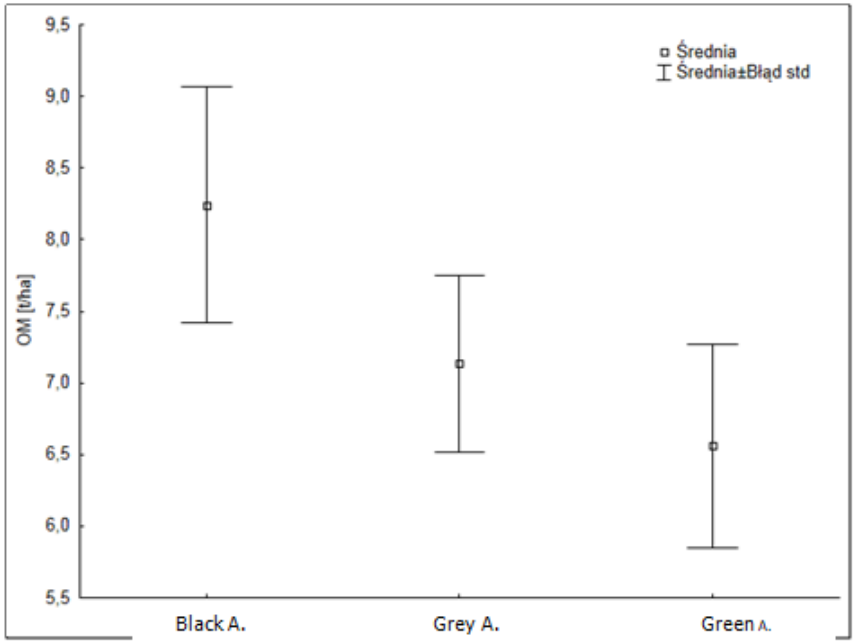


Fig. SOC content and N total (Nt) in uppermost soil aver (0-5 cm) depends on: a). b) trees species; c). d) soil substrate addition

Explanation: - As variant not included in assessment in 2016 because no effect in growth

SOM accumulation [metric t/ha] in uppermost soil layer



Carbon accumulation in total

(soil + litter + roots)

1	Litter	Soil (0-5 cm)	Coarse roots	Fine roots	Total
	C [t/ha]				
Green A.	0.76	32.4	1.0	0.7	34.9
Grey A.	1.15	35.2	3.6	1.5	41.5
Black A.	1.31	40.6	3.3	2.0	47.2
N = 4					

N accumulation in total (soil + litter + roots)

1	Litter	Soil (0-5 cm)	Coarse roots	Fine roots	Total
	N [kg/ha]				
Green alder	43.2	952.1	20.9	15.8	1032
Grey alder	59.5	1199.3	86.2	40.6	1386
Black alder	68.2	1549.2	83.3	54.5	1755

SUMMARY AND CONCLUSIONS

- Results shown utility of alders for biostabilization and revegetation of combustion wastes

- the highest growth and the biggest survival was noted for black alder

- litter C-N ratio from 18 to 20, the highest N content under black alder

- effect of litter accumulation under alders: from 2.9 to 3.6 t/ha

- initial organic layer development - SOM accumulation (0-5 cm) from 55.8 t/ha (under green A.) to 60.7 t/ha (grey A.) and 70.0 t/ha (black alder)

- No significant effect of substrate addition on SOC and N accumulation

THANK YOU FOR YOUR ATTENTION !

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Acknowledgement
Study Financed by National Science Centre POLAND .Grant No. 2015/17/B/ST10/02712
Author is **Fulbright Scholar** in 2013-2014, Advanced Senior Grant and
Laureate of **CULTURA PRIZE 2015 Alfred Toepfer Foundation Award**