Pyrolysis Technology: Environmentally friendly solution to nutrient management in the Chesapeake Bay

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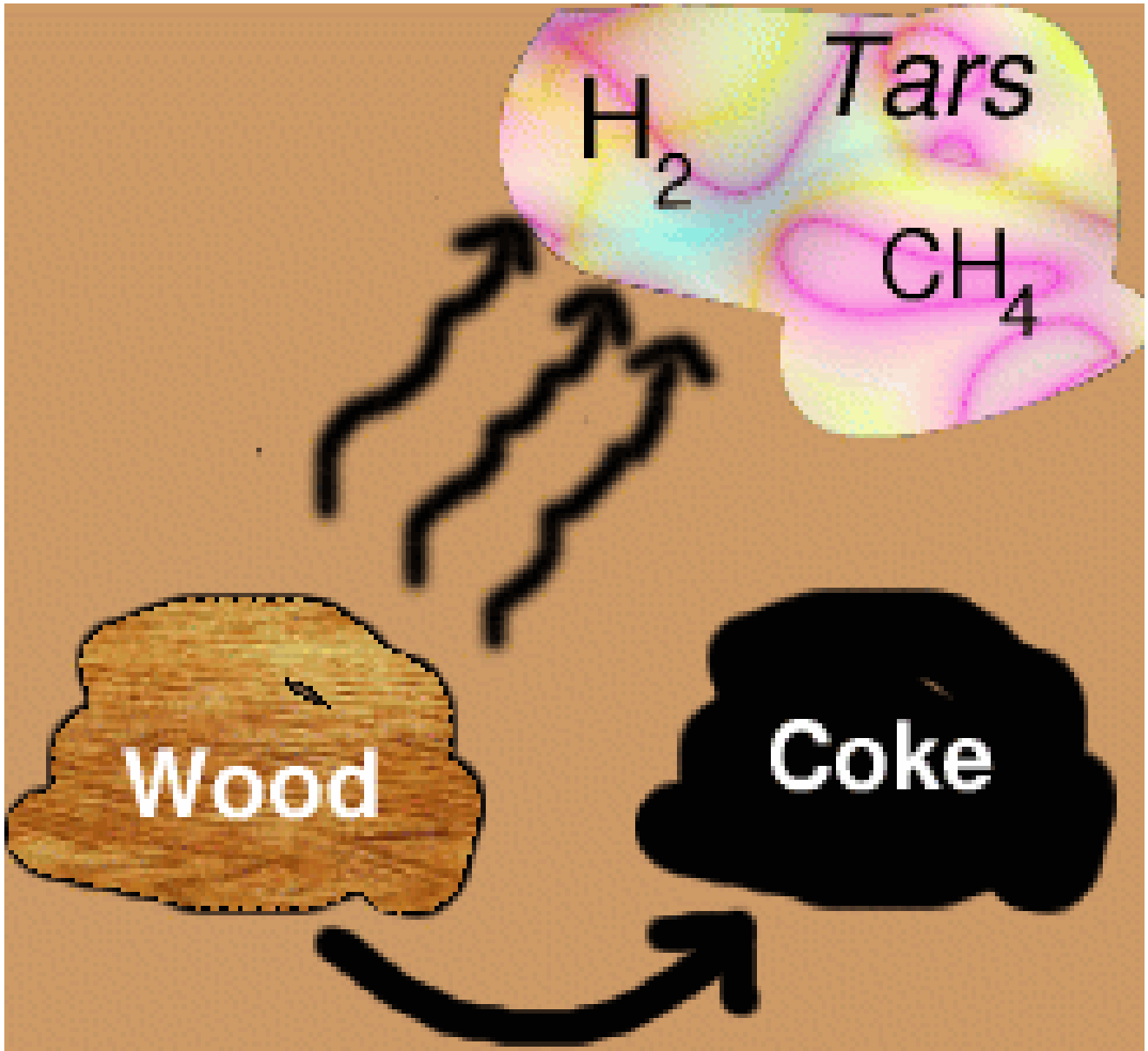
Reasons for Pyrolysis of Poultry Litter

- Traditionally, poultry litter is disposed by land application and used as cattle feed
- Disposal of poultry litter in the U.S. poultry industry is becoming a major challenge because of :
  - Excess nutrient in the soil due to land application
  - Contamination of drinking water
  - Eutrophication of surface waters
  - Ammonia emission from poultry houses
  - Soil acidification through nitrification and leaching
  - Biosecurity concerns

Feedstock analysis (dry basis)

Sample	C (%)	H (%)	N (%)	S (%)	Cl (%)	Ash (%)	HHV (MJ/kg)
Chicken bedding	47.24	5.94	**<0.5**	<0.2	82 ppm	**1.36**	19.25
Broiler litter-1	34.05	4.42	**2.89**	0.63	0.74	**15.33**	15.47
Broiler litter-2	36.84	5.00	**3.94**	1.02	1.14	**16.05**	15.65
Broiler litter-3	35.33	5.40	**4.10**	0.70	n/a	**21.17**	14.37
Starter turkey litter	43.65	5.71	**2.57**	0.36	0.20	**5.42**	18.47

Schematic depiction of Biomass pyrolysis

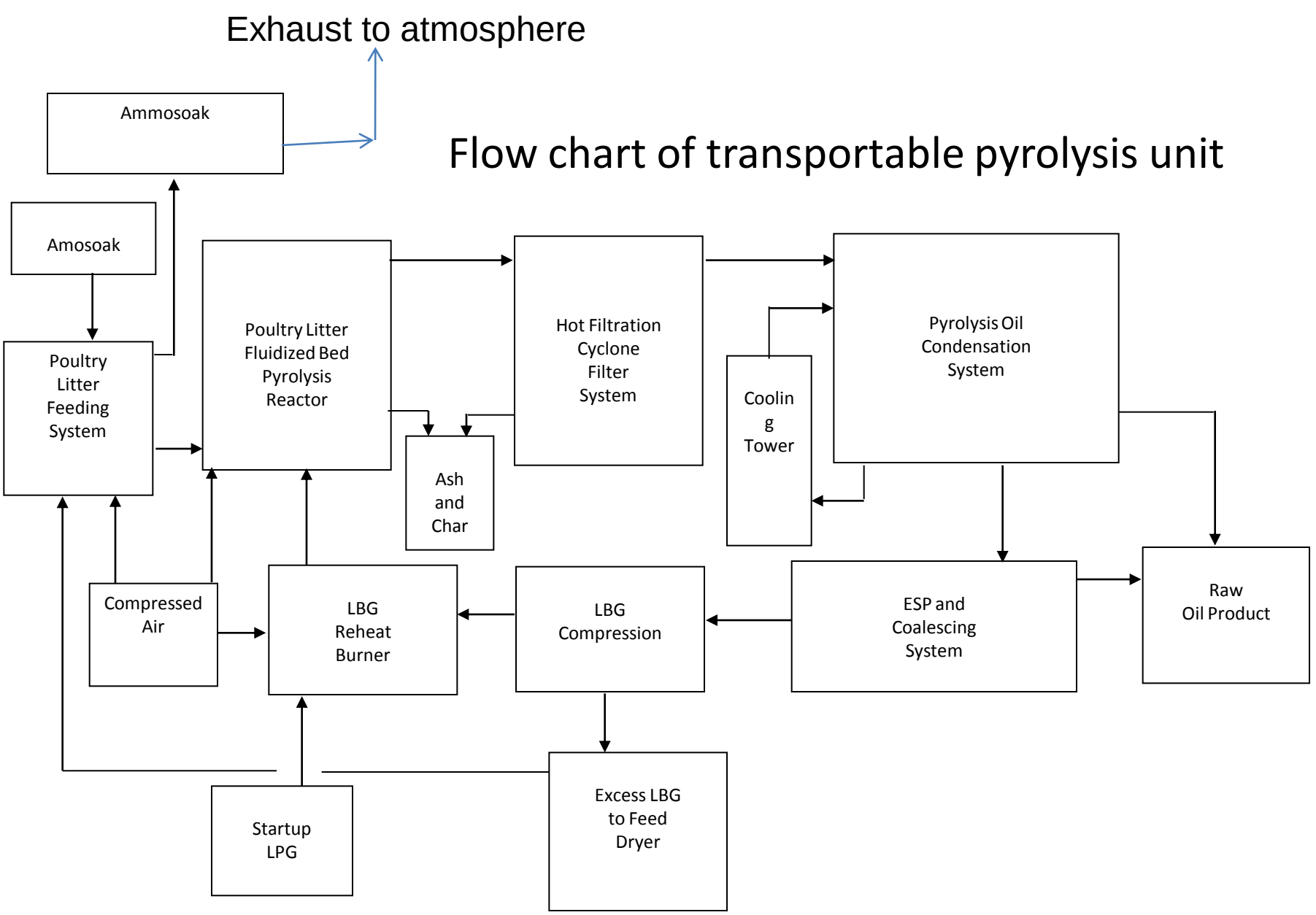


Fast pyrolysis

- Vapor residence time $1<t<5$ seconds
- Pyrolysis temperature $400 \leq T \leq 600\ ^{o}C$
- Products—liquid, solid, gases
- Liquid yield 60 to 70 wt%
- Gas yield 10 to 20 wt%
- Solid yield 10 to 40 wt%

Demonstration Unit

- Funding from the National Fish and Wildlife Foundation and Farm Pilot Projects Coordination was used to build a transportable pyrolysis unit to convert poultry litter into biooil and biochar (slow-release fertilizer) in the Shenandoah Valley.
- Pyrolysis demonstration is in progress.
- The demonstration unit is on the farm of Mr Oren Heatwole, Poultry Specialties Inc, Dayton, VA.


Exhaust to atmosphere
Ammosoak
Flow chart of transportable pyrolysis unit
Amosoak
Poultry Litter Feeding System
Poultry Litter Fluidized Bed Pyrolysis Reactor
Hot Filtration Cyclone Filter System
Pyrolysis Oil Condensation System
Coolin g Tower
Ash and Char
Compressed Air
LBG Reheat Burner
LBG Compression
ESP and Coalescing System
Raw Oil Product
Startup LPG
Excess LBG to Feed Dryer

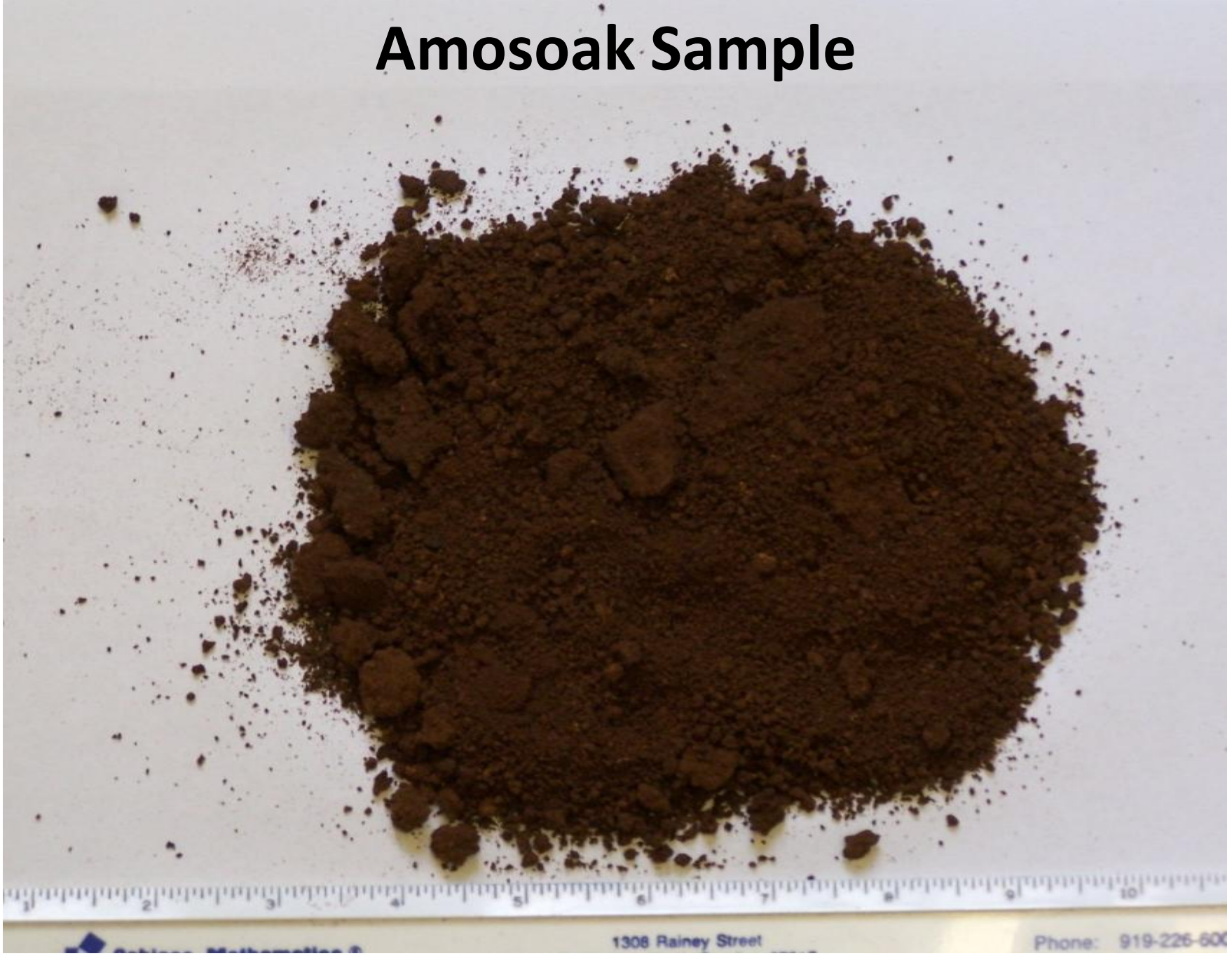


Figure 3 Pretreated corn cobs

Transportable pyrolysis unit

Poultry litter biooil

Products yield from fluidized bed reactor

Sample	Temperature, ℃	Yield, wt%		
		Oil	Gas	Char
Chicken bedding	500	63.3±11.3	n/a	12.7±
Broiler litter-1	500	45.7±2.9	13.6±5.7	40.6±6.2
Broiler litter-2	500	36.8±1.2	22.3±2.5	40.8±1.9
Broiler litter-3	500	43.5±5.1	23.6±6.4	32.9±3.7
Starter Turkey litter	500	50.2±1.6	21.7±1.9	21.7±1.9

Bio-oil properties

Sample	C (%)	H (%)	O (%)	**N (%)**	S (%)	Moit (%)	**pH**	Ash (%)	**HHV (MJ/kg**
Chicken bedding	55.25	6.54	37.58	**<0.5**	<0.05	5.3	**2.7**	<0.08	**22.64**
Broiler litter-1	63.24	7.22	23.89	**5.05**	0.46	4.6	**6.1**	<0.09	**28.25**
Broiler litter-2	64.06	8.14	22.27	**4.94**	0.41	4.6	**6.3**	<0.09	**28.0**
Broiler litter-3	62.84	8.31	20.72	**7.23**	<0.9	4.0	**6.3**	0.17	**29.57**
Starter turkey litter	64.90	8.44	20.31	**5.60**	0.4	3.7	**4.2**	0.10	**29.76**

Modified Furnace for Using Bio-Oil

Pyrolysis gas composition

Component	Concentration	Mass rate (lbs/h)
CO	1414 ppmdv	1.10
Filterable Particulates	0.0106 (g/dscf)	0.02
NOx (as NO_2)	19.2 ppmdv	0.02
NH_3	942.8 ppmdv	1.86
VOC (as propane)	5300 ppmdv	6.50
Phenol	8.73 ppmdv	2.53E-02
Formaldehyde	0.05 ppmdv	4.34E-05
HCl	3.65 ppmdv	0.004
H_2S	0.00 ppmdv	0.00
Naphthalene	1.29 ppmdv	5.06E-03

Emission Data

Compound	Emission (lbs/h) Burner off	Emissions (lbs/h) Burner on
H2S	0	0
SO2	0.04	0.06
CO	1.10	1.31
NOx	0.02	0.25
VOC (as propane)	**6.50**	**8.35**
Filterable Particulate	0.02	0.06
HCl	0.004	0.005
NH3	**1.86**	**2.06**
Phenol	0.0253	0.0146
Naphthalene	0.00506	0.00283
Formaldehyde	0.0000434	0.0000194

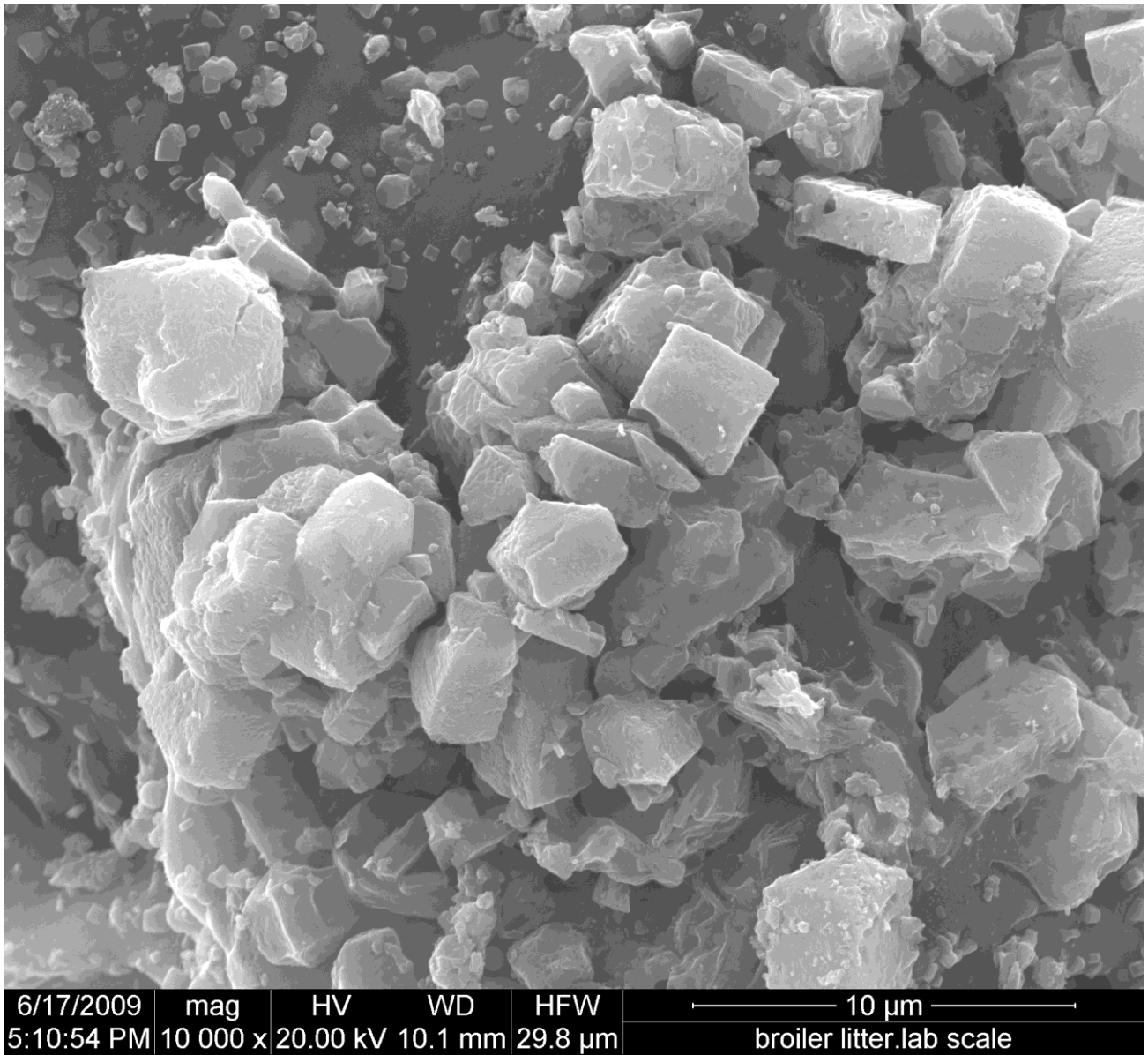
Broiler Litter Pyrolysis Char

Particle size distribution of pyrolysis chars

Mesh Size	Size (µm)	Char Mass fraction (%)	
		Poplar wood	Broiler litter
-18/+20	917	0.17	1.44
-20/+35	667	2.63	2.29
-35/+45	428	3.02	0.29
-45/+100	253	**61.89**	11.32
-100/+115	137	9.29	4.24
-115/+200	100	11.89	3.80
-200/+230	69	3.76	19.43
-230	32	7.28	**57.29**
Total		100	100

Broiler litter pyrolysis char

Broiler Litter char sample

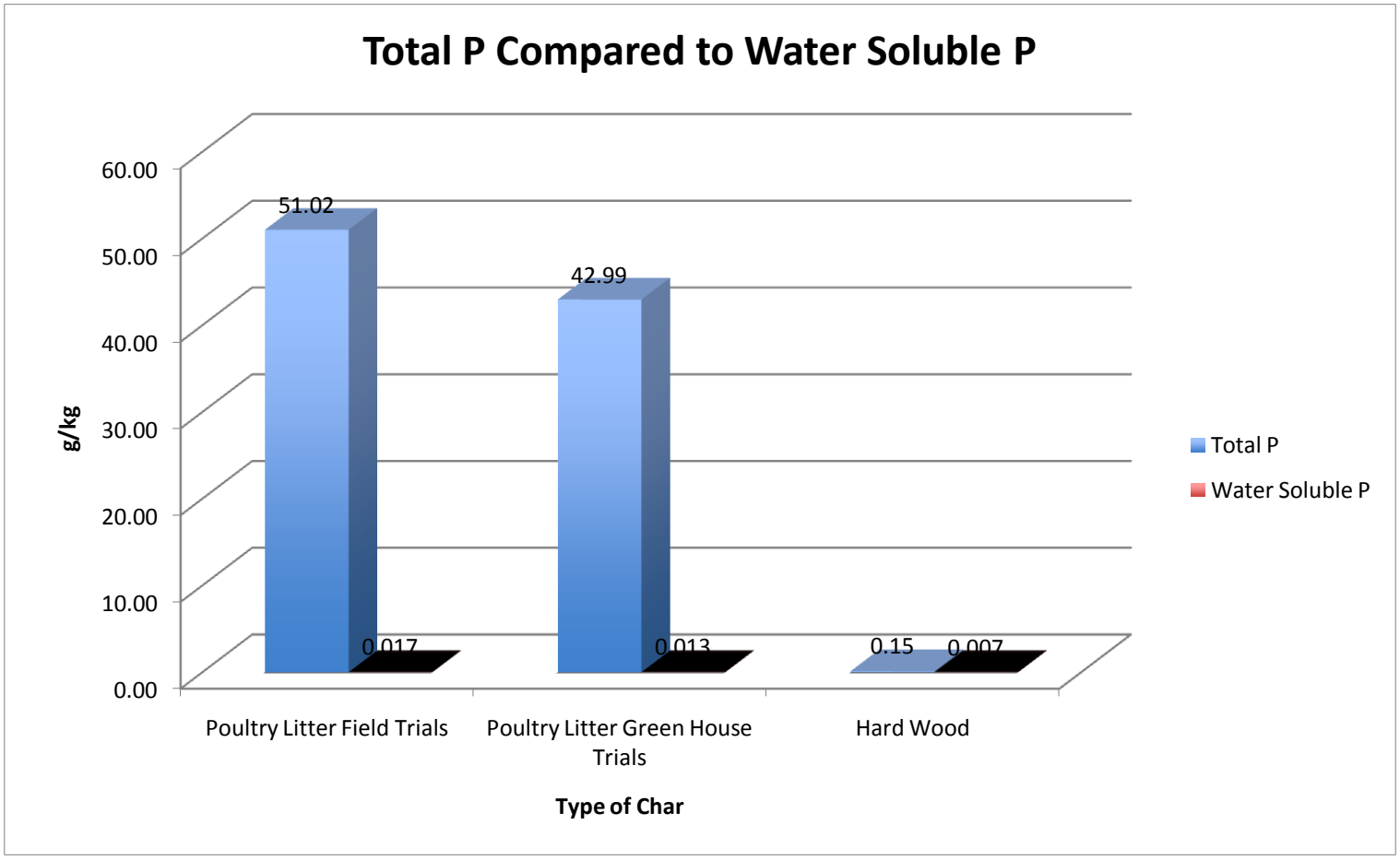


Nutrient Composition Broiler-3 char

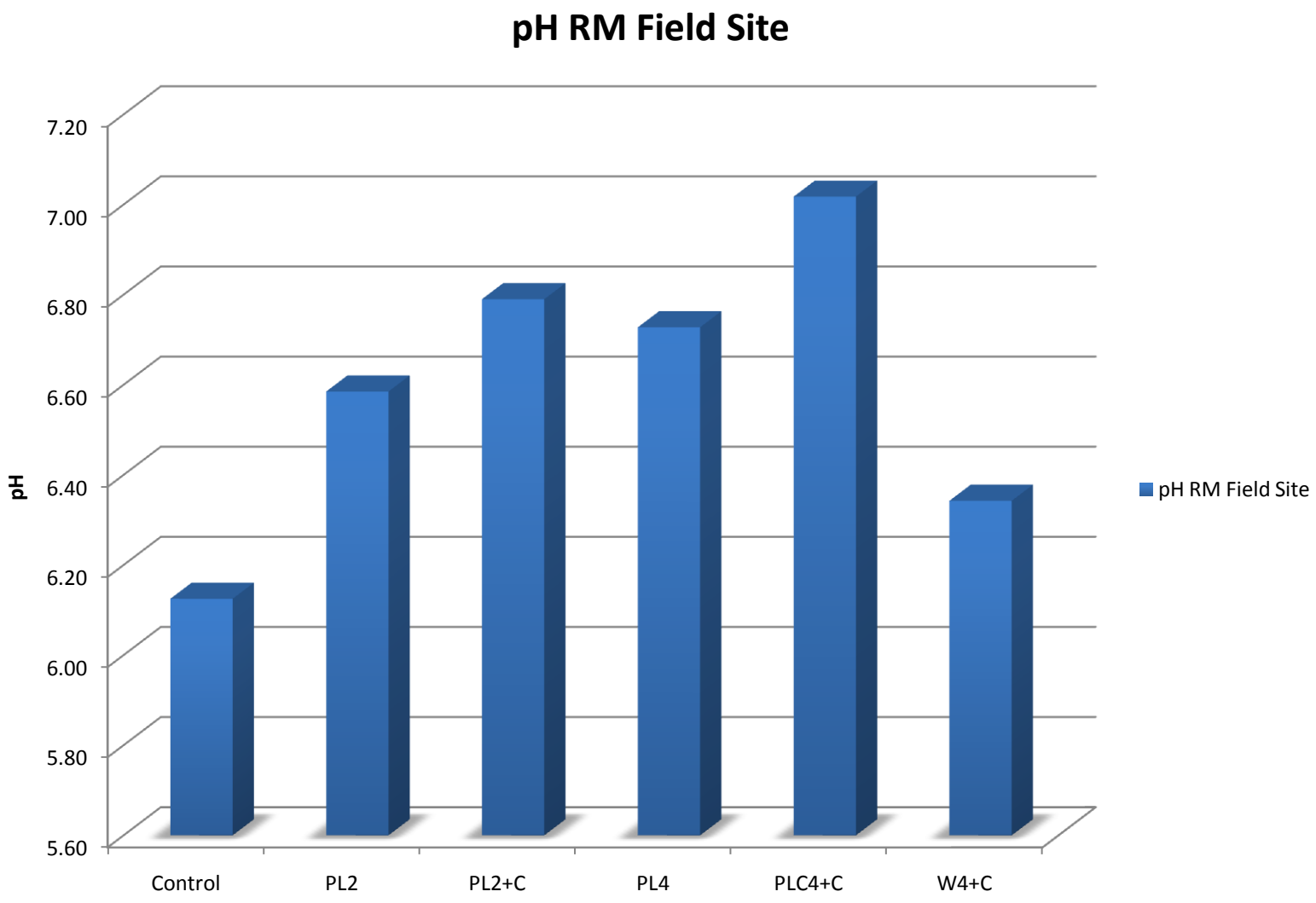
Element/Compound	Wt%
Total N	2.84
P_2O_5	2.68
K_2O	4.19
Ca	7.5
Mg	1.54
S	0.99
Al	0.54
B	0.01
Cu	0.11
Fe	0.54
Mn	0.12

Element	
Na, (wt%)	2.05
Zn, (wt%)	0.1
Cd, mg/kg	1.0
Ni, mg/kg	40.0
Pb, mg/kg	37.0
As, mg/kg	42.5
Hg, mg/kg	DL
Se, mg/kg	1.9
Mo, mg/kg	16.0
Co, mg/kg	5.0

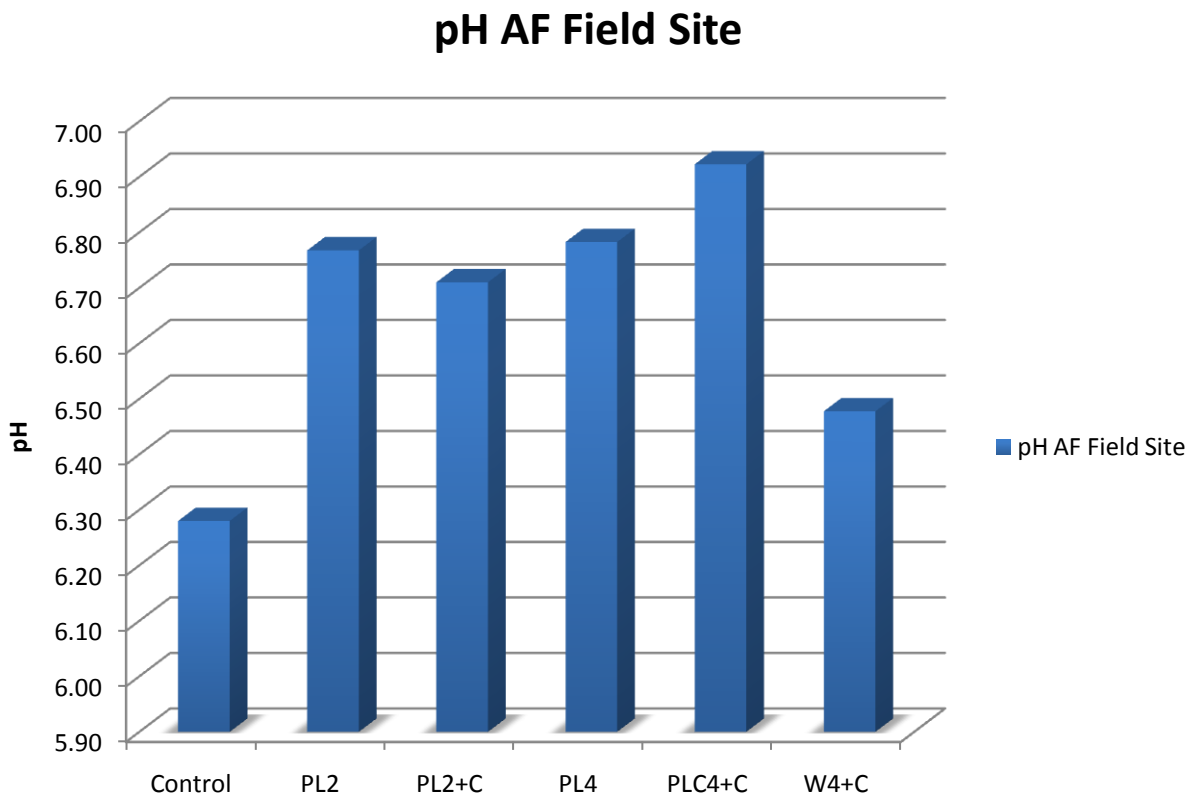
Pyrolysis char sample	pH
Broiler-1	9.6
Broiler-2	9.2
Broiler-3	9.7
Switchgrass	9.7
Poplar wood	7.9
Oak wood	6.6
Pine wood	7.1


Total P Compared to Water Soluble P
60.00
50.00
40.00
30.00
20.00
10.00
0.00
g/kg
51.02
0.017
42.99
0.013
0.15
0.007
Poultry Litter Field Trials
Poultry Litter Green House Trials
Hard Wood
Type of Char
Total P
Water Soluble P

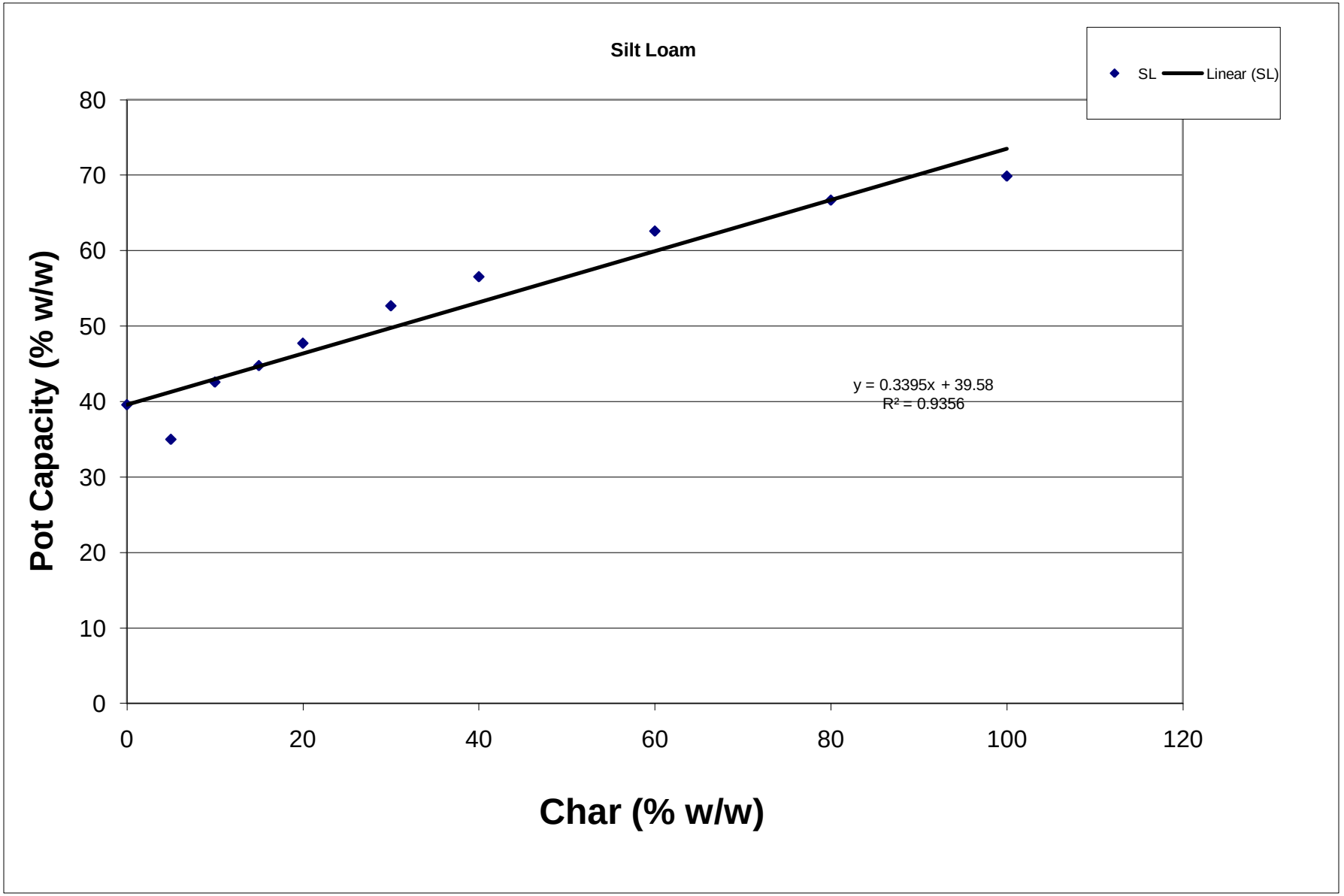
Effect of char on soil pH



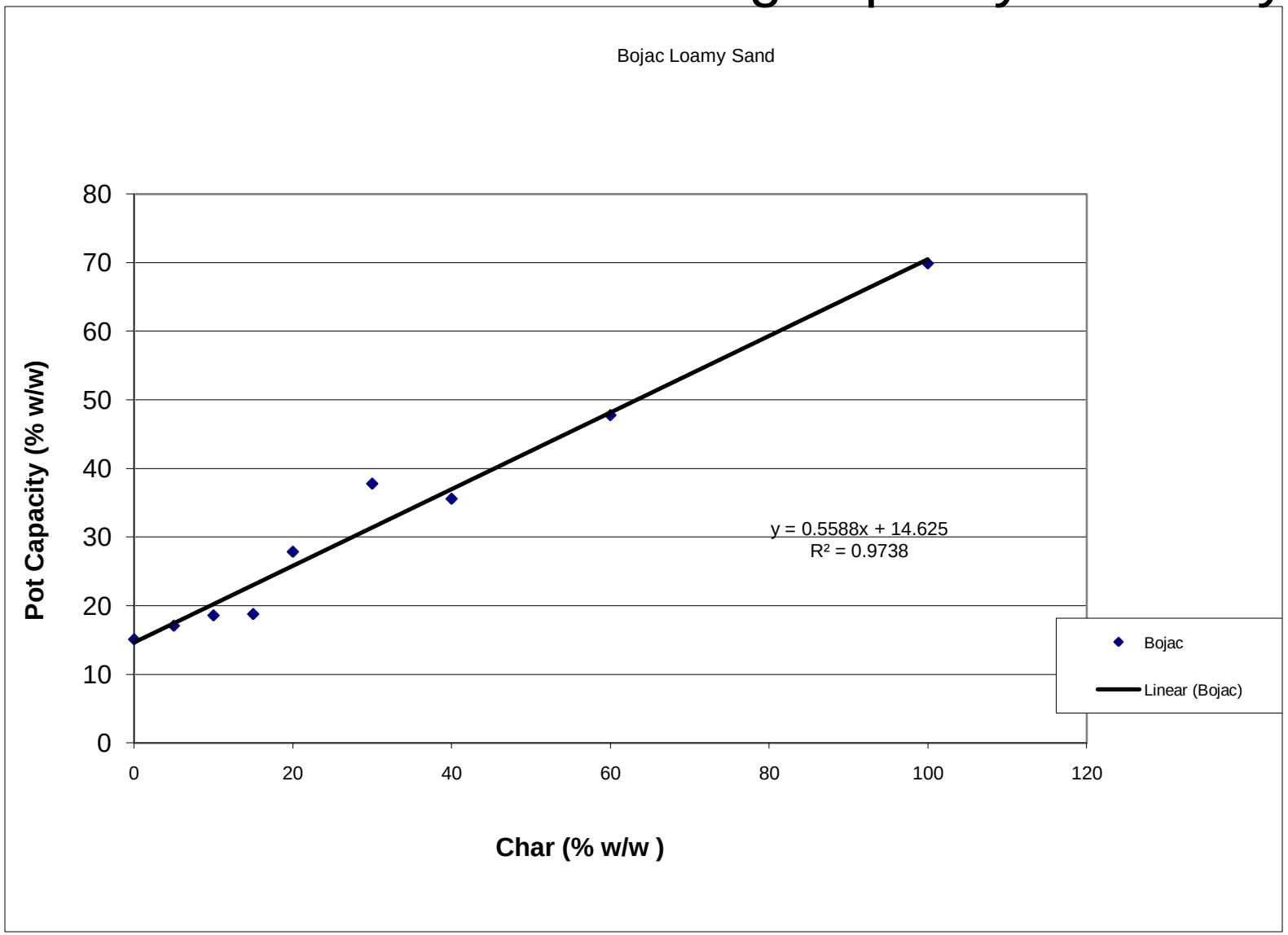
Effect of char on soil pH



Effect of char on moisture holding capacity of loam soil



Effect of char on moisture holding capacity of sandy soil



Commercialization Potential

- BioEnergy Planet Inc. was formed to commercialize technology
- Received funding from NRCS to build pre-commercialization unit
- Fertilizer companies evaluating the biochar for fertilizer ingredient (1000 tons per year)

Commercialization Potential

- Small scale cluster model– several 10 tons per day pyrolysis units serving about 20 small farms in the Shenandoah Valley.
- Large scale unit for large production areas such as the Del Marva Penninsula

Conclusions

- Poultry litter can be successfully pyrolyzed into biooils but have low oil yields and high char yields
- We can produce bio-oils on a demonstration scale
- Biooils have high energy content, high pH, but are very viscous
- Non-fuel applications of biooil needs to be developed
- Pyrolysis char release much less nutrients compared to raw materials
- Evidence from greenhouse studies indicates that the nutrients from biochar are available to plants
- Nutrients take longer than typical growing seasons to be released

Acknowledgement

- We greatly appreciate the contribution of Virginia Poultry Federation, Chesapeake Bay Foundation and Shenandoah RC & Council for their foresight and initial funding support.
- Farm Pilot Projects Coordination Inc (FPPC) for funding support
- National Fish and Wildlife Federation for Scale-up funding support
- Blue Moon Fund Program for funding support
- Mr Robert Clark for initiating the project, collecting samples and getting the growers in the Valley involved in the project
- Waste Solutions Forum for promoting the project

Litter Powered!!!

Thank you

- Questions?