Waste Not:

Wood Ash

Dan Hettinger, Living Web Farms Biochar

Internet: “All you have to do is cover them in ash and put them in a cool, dark location”

Wood Ash:

Inorganic, mineral residue left behind after the complete combustion of wood

Composition depends on multiple factors:

- Species, Age, Soil and Weather conditions
- Section of wood: Limbs? Heartwood? Bark?
- Temperature of combustion
- Conditions between combustion and use/analysis

Organic residues may be present in the form of char or complex carbon molecules. Though char may be present, Wood Ash is NOT Biochar

Handling and Storage

Use ash rake to separate coals and shovel to remove ash.

Store in metal bucket w/ lid until completely cool.

Tip: Don’t put very hot coals in a galvanized pail

For stronger alkali, keep stored in airtight container

For potash recovery, do not quench ashes with water

Fresh ashes can be caustic, but don’t be afraid.

Wear gloves if sensitive and wash hands well.

Potent respiratory irritant. Protect eyes and membranes.

Ash Water, Potash and Lime are more potent. Protect yourself.

What's in it? NCDA Nutrient Analysis

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY20-W000299

Diagnostic

Waste Report

Links to Helpful Information

Client: Daniel Hettinger
[redacted]
Weaverville, NC 28787
Buncombe County

Advisor:

Sampled: 06/25/2019
Received: 07/08/2019
Completed: 08/20/2019

Farm: Living Web Farms

PALS #: 500142

PALS #:

Sample Information

ID: 1
Code: CSW
Description: Wood Ash
Grower Comments: Dry Stove Ash

Nutrient Measurements are given in units of parts per million (ppm), unless utherwise specifed.

Nitrogen (N)	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
Total N: 538	6450	47000	268000	11800	2980	1370	3800	201	133	227	-
Inorganic:											
NH_4-N											
NO_3-N											

Other Results

C	Al	Na	Cl
87500	3630	652	-

SS (10^{-5} S/cm)	EC (mS/cm)	pH (Unitless)	BD (lb/yd³)	CCE (%)	ALE (tons)	C:N (Unitless)	DM (%)
3960	39.60	13.30	-	88.3	1.04	163 : 1	97.6

Estimate of Nutrients Available for First Year (lb/ton)

Application Method:	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
Broadcast	1.05	28.8	110	524	23.0	5.83	2.67	7.42	0.39	0.26	0.44	-

Other Results (lb/ton)

Al	Na	Cl
7.09	1.27	-

Heavy Metals are given in units of parts per million (ppm).

As	Cd	Cr	Ni	Pb	Se
-	0.46	-	10.7	7.51	-

Heavy Metals Estimate of Availability (lb/ton)

Application Method:	As	Cd	Cr	Ni	Pb	Se
Broadcast	-	0.00	-	0.02	0.02	-

Wood Ash Composition

All variables, all the time!

Wood is typically <1% ash. Bark yields more ash.

Hardwoods typically contain more potassium than softwoods

Typ.: 25-40% Calcium, 5-10% Potassium, 1% Phosphorus

Range of micronutrients: Mg, Mn, Zn, Fe, S

Predominantly Insoluble or slightly soluble metals and silica.

Soluble Alkali in the form of Mostly Potassium and Calcium Carbonates and possibly hydroxides.

Non alkali soluble salts may be present: Chlorides and Sulfates

Soluble compounds can be leached into **“Ash Water”**

USGS Geochemical Survey: Buncombe County, NC

Element	Symbol	Mean	Std. dev.	Minimum	Maximum
Aluminum	Al (wt%)	5.722	0.716	3.835	7.099
Arsenic	As (ppm)	0.757	0.189	0.305	1.686
Calcium	Ca (wt%)	0.959	0.466	0.251	2.260
Copper	Cu (ppm)	14.528	3.470	6.981	22.735
Iron	Fe (wt%)	3.543	0.551	1.717	5.072
Mercury	Hg (ppm)	0.033	0.008	0.010	0.058
Magnesium	Mg (wt%)	0.585	0.148	0.270	0.846
Manganese	Mn (ppm)	795.239	155.257	416.342	1441.060
Sodium	Na (wt%)	0.723	0.251	0.335	1.455
Phosphorus	P (wt%)	0.044	0.012	0.017	0.080
Lead	Pb (ppm)	23.902	5.239	13.064	37.994
Selenium	Se (ppm)	0.117	0.022	0.100	0.194
Titanium	Ti (wt%)	0.788	0.155	0.393	1.100
Zinc	Zn (ppm)	66.143	10.575	37.123	96.772

https://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

Ash Water

Sodium Hydroxide (NaOH) and Sometimes KOH) sold in stores as Lye. Many online sources refer to leached wood ash water as Lye.

Ash Water is not Lye! Ash Water is mostly a solution of Potassium (Potash) and Sodium Carbonates (washing soda)

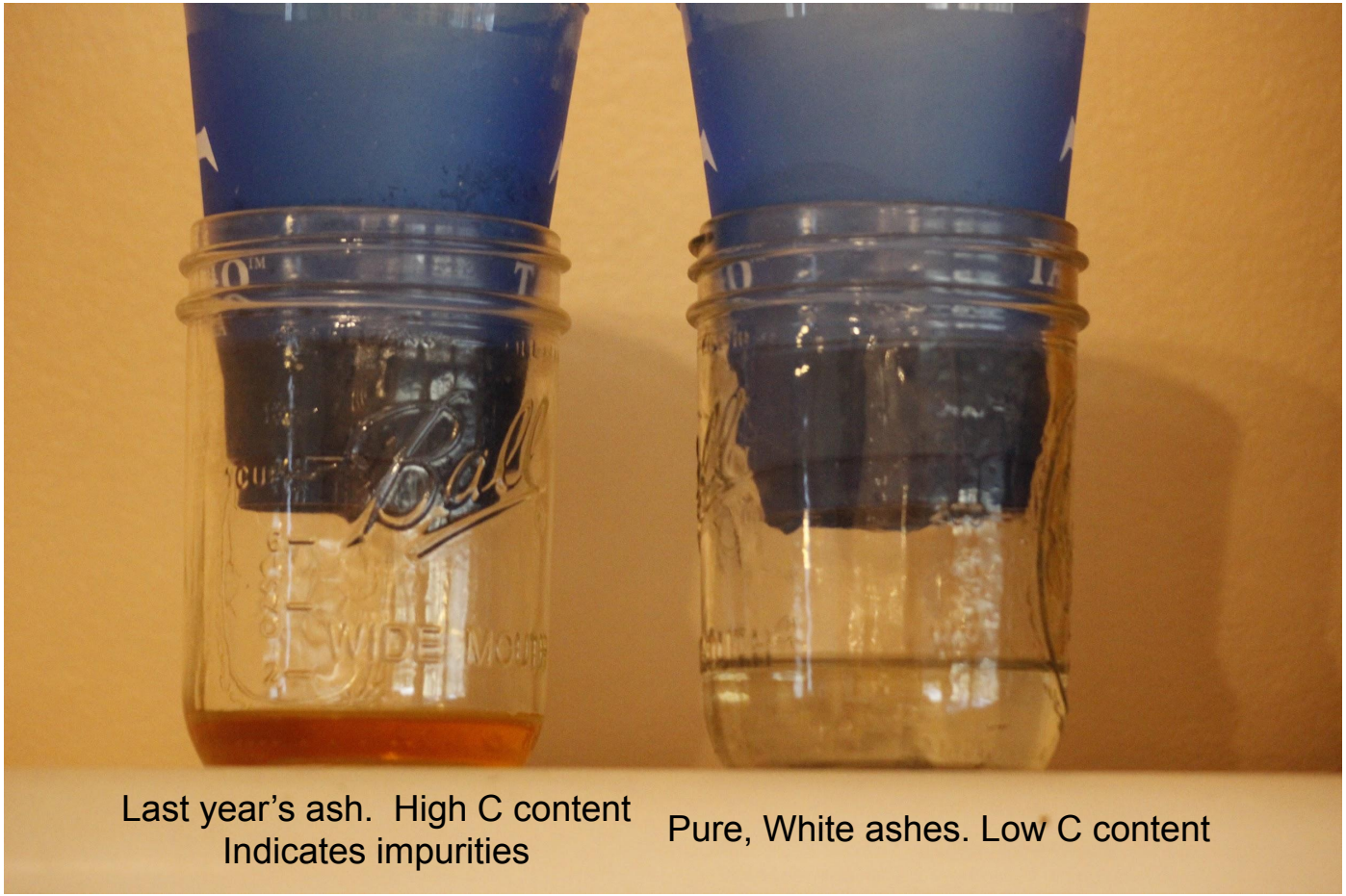
Some non-alkali salts may also be present. Possible some hydroxides are present with ashes from hot fires.

Sourced by slowly leaching water through ashes.

Boiled down and purified: Source of pure **Potash** (more on this later)

Solubility increases with hot water, good mixing.

Many sources suggest filtering with straw. I found this unnecessary.



Last year's ash. High C content
Indicates impurities

Pure, White ashes. Low C content

There’s more there than just simple salts
Mystery Green Stuff: Suspension of Carbonate Green Rust?

Homestead Applications for Wood Ash

Poultry Housing - Don’t bother screening char and apply on coop floor. Ash will sanitize and char will adsorb smells and ammonia gases.

Use fresh, screened ash for feather dusting.

Ice Melt - Potassium and Calcium Carbonate salts likely more environmentally safe than conventional chloride salts.

Garden

Cooking

Food Preservation

Soapmaking

Cooking: Nixtamalization

Treatment of dried field corn (dent corn) with alkali water solution

Traditional methods of heating whole kernels in alkali water, followed by extended soak are shown to significantly reduce **aflatoxins** - carcinogenic molds from improperly stored staple foods

Modifies proteins for more gel like consistency - ground meal now able to form dough. Used fresh for dough (Tamales!!!) or dried as **Masa**.

Increases availability of **niacin** (vitamin b3), balanced proteins and increased absorption of minerals, especially calcium.

Smells great! Richer Flavor, Easier to grind, helps soften pericarp for easy removal

Bloody butcher dent corn

Nixtamal with Lime

Common Recipe:

1 tbs Calcium Hydroxide (Cal, Slaked Lime, Pickling Lime) per 1 cup dried dent corn

Bring to near boil and soak for at least 12 hours. Rinse and rinse and repeat until no longer slippery.

Remove pericarp as best as possible.

Hominy as whole kernel, or grind for Masa as dough

Great DIY instructional video from FlavorLab channel

Images: wikipedia commons

Nixtamalization with Wood Ash

Little scientific data available.

Exact processes vary culturally.

Presumably more micronutrient dense, less calcium dense compared to lime treatments

Given variables, can be challenging to hit alkalinity range

I had success with 2 parts corn to 1 part old, sifted ash. Color change, great flavor, intact but removable pericarp.

Use much less ash if fresh. 1 day old ashes at ¾ cup to 2 cups seemed too strong. Experienced color change, yet slightly bitter, too earthy flavor, mushy pericarp after 2 hours before adequate texture change.

Alkalinity

Ionic compounds have atoms bonded via electrical charge

All ionic compounds can **ionize**: break apart into **+ cations** and **- anions.**

Wood Ashes contain salts (soluble, ionic compounds) of the Alkali Metals (Na and K) and Alkali Earth Metals (Ca)

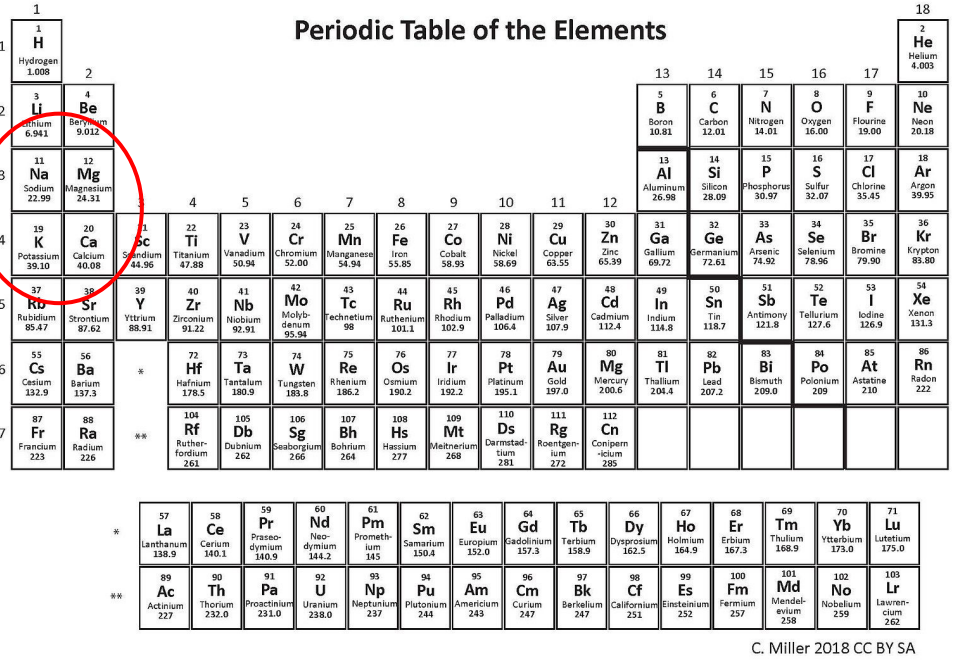
Water also can ionize into:

H+ (Hydrogen), and,

OH- (Hydroxide) ions.

If there are more H+ Ions, the solution is **Acidic**

If there are more OH- Ions, the solution is **Basic**.



Let's look at **Potassium Carbonate**: An **alkaline salt** sourced from wood ashes ionizes in water

Potassium Cation becomes a 'spectator ion' and carbonate anion is reactive

$$\mathbf{K_2CO_3(s) \text{-----> } 2\ K^+(aq) + CO_3^{2-}(aq)}$$

In Acid solutions, Carbonate Ion reacts with any H+ ions, forming **Bicarbonates**

$$\mathbf{CO_3^{2-}(aq) + H^+(aq) <\text{-----> } HCO_3^-(aq)}$$

In more Neutral solutions, Carbonate Ions will 'steal' H+ ions from water molecules, forming **Hydroxides**, making solution more Basic

$$\mathbf{CO_3^{2-}(aq) + H_2O(l) <\text{-----> } HCO_3^-(aq) + OH^-(aq)}$$

Determining pH

The measure of hydrogen ions in water solutions, quantified by **mols/L.**

Excess hydrogen ions indicates acidity.

Pure Water: H^+ concentration is **0.0000001 mols/L. pH = 7**

White Vinegar (Acetic Acid): .**0001 mols/L. pH = 4**

Potassium Carbonate (Potash): **.0000000001 mols/L. pH = 10**

Red Cabbage pH indicator

Compost and Garden

Long tradition of using ash in compost. See: **“Indore” Method**

Ash can be very useful for correcting overly acidic soils, valuable source of potassium and calcium.

Nearly all agree: Apply thin and test soil often.

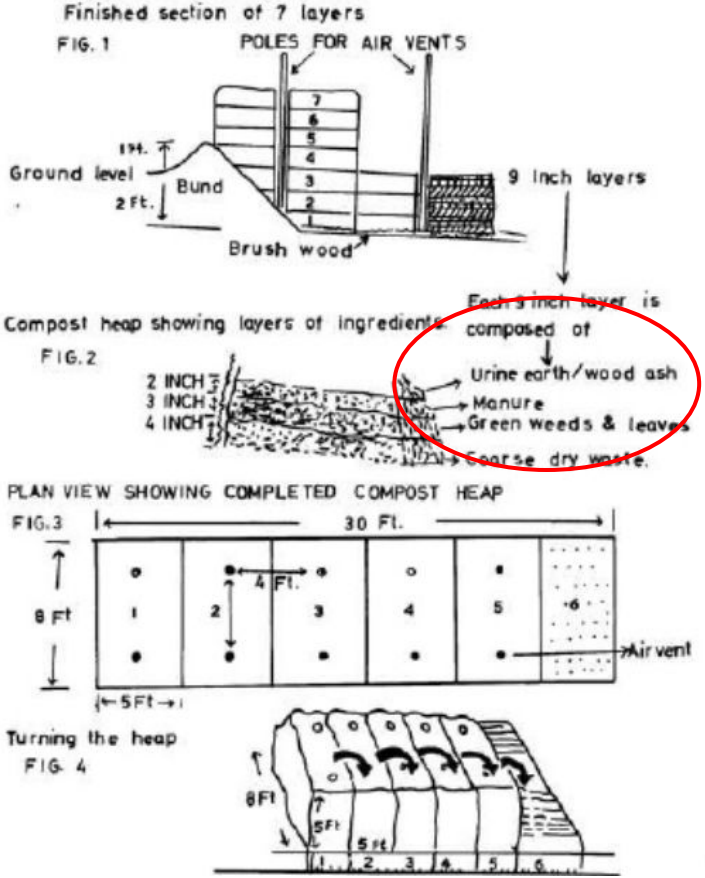
Common among Ag. Ext Agents: 5 lbs/ 100 sq ft. max

Avoid use around seedlings. Not to be used around acid loving plants!

Hypothesis: Great application for carbon rich, brown, impure ashes.

Hypothesis: Ashes applied in compost and garden should be kept outside in open containers. Exposed to air, oxides present will eventually convert to carbonates and be ‘softer’ on the soil.

Fresh, white ashes are likely too harsh for worms in continuous backyard compost piles



The Waste Products of Agriculture. Sir Albert Howard, 1931

Wood Ash as a Liming Agent

Do not add wood ash to soils unless you know your soil pH!

Acidic soils can be neutralized through application of lime. Alkaline soils are much more difficult to adjust!

Higher pH leads to deficiencies in availability of iron, manganese other micronutrients

Smaller incremental doses and regular pH testing recommended.

Wood ashes usually contain a lot of potassium, some phosphorous. Very little nitrogen.

Alkaline ashes react with strong nitrogen fertilizers, wasting valuable nitrogen as ammonia gas.

My plan: Use wood ashes in compost and on small front lawn play area where lime is recommended by NCDA. I'll only use previously leached ashes, and apply along with soft rock phosphate as recommended.

NCDA Predictive Home & Garden Soil Report

Sample ID: FL026

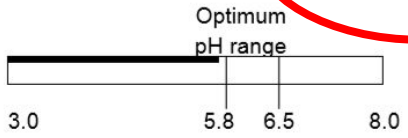
Lime History:

Daniel Hettinger

Crop 1- Lawn (not centip.)
Crop 2-

Test Results:

pH = 5.8



Lime Recommendations

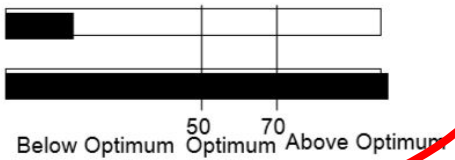
15.0 lb per 1,000 sq ft
0.0 lb per 1,000 sq ft

N-P-K Fertilizer Recommendations *

20 lbs per 1,000 sq ft 5-10-5 Group B

Phosphorus Index (P-I) =17

Potassium Index (K-I) =104



Additional Test Results:

Soil Class	HM%	W/V	CEC	Mn-I	Zn-I	Cu-I	S-I
Mineral	0.41	0.95 g/cm^3	8.6 meq/100 cm^3	538	157	138	40

**If you cannot find the fertilizer recommended here, choose one from the same Group (A, B, C or D) listed on the last page of this report.*
Note: This soil test does not measure nitrogen (N) levels. N fertilizer recommendations are based only on needs of the designated crop.

NCDA Diagnostic Waste Report: Rinsed Stove Ash

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY20-W000299

Daniel Hettinger **Sampled:** 06/25/2019 | **Received:** 07/08/2019 | **Completed:** 08/20/2019 Page 2 of 4

Sample Information
ID: 2
Code: CSW
Description: Wood Ash
Grower Comments: Rinsed Stove Ash

Nutrient Measurements are given in units of parts per million (ppm), unless utherwise specifed.

Nitrogen (N)	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
Total N: 500	8480	27900	286000	14200	1400	1810	4990	253	185	211	-
Inorganic:											
NH_4-N											
NO_3-N											

SS (10^{-5} S/cm)	EC (mS/cm)	pH (Unitless)	BD (lb/yd³)	CCE (%)	ALE (tons)	C:N (Unitless)	DM (%)
2370	23.70	10.10	-	86.5	1.07	201 : 1	97.2

Other Results

C	Al	Na	Cl
100000	4460	506	-

Estimate of Nutrients Available for First Year (lb/ton)

Application Method:	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
Broadcast	0.97	37.8	65.0	556	27.6	2.73	3.53	9.69	0.49	0.32	0.41	-

Other Results (lb/ton)

Al	Na	Cl
8.68	0.98	-

Soil Report: recommended liming rate 15 lbs 1000 ft2.

ALE: Agricultural Lime Equivalent. Add 1.07 part rinsed ashes for every 1 part lime recommended

1500 ft2 lawn area. 1500/1000 = 1.5 15 lbs x 1.5 = 22.5 lbs lime recommended.
22.5 lbs lime x 1.07 = 24.075 lbs **DRY, previously rinsed** wood ash.

Note: **My single-rinsed ash is still 2.8% potassium**, applied to soils already exceeding recommended optimum potassium.

Sourcing Potash

Controlled soak for complete leaching

3 quarts of last years' ash in 2 gal HDPE bucket

Added 3 quarts distilled water, where after settling, water level was 1.5" above ash.

Drilled 5 1/16" holes. Drained overnight. Filled again to original fill level after each yield

First yield: 53 oz. 11.2 pH. 5.08 g/ 5ml

Second yield: 52 oz. 11.1 pH 5.00g/ 5ml

Third yield: 54 oz. 11.0 pH 5.00g/ 5ml

Controlled soak for complete leaching

Boiled off water from 1 quart sample of each yield to measure crude potash content

Yield #1 - 32 oz boiled down to 41 g crude potash.

Expected total potash from 53 oz: 41g x 1.65 = 67.65g

Yield #2 - 32 oz boiled down to 21.25g crude potash

Expected total potash from 52 oz: 21.25g x1.62 = 34.42g

Yield #3 - 32 oz boiled down to 11.94g crude potash

Expected total potash from 54 oz: 11.94 x 1.68 = 20.15g

Total expected yield after 3 soaks from 2.29 lbs (1038g) ash = **122.22g**

11.77% crude potash

Refined Potash

Add crude Potash to hot water until fully dissolved

Boil roughly half of the water off until chlorides precipitate

Decant carbonate rich solution

After cooling, sodium carbonate will precipitate. Boil down for pure potash.

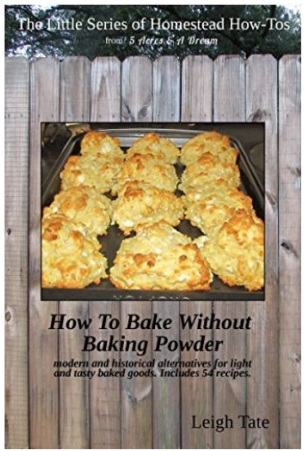
Purified, food grade potash is sometimes called Pearl Ash.

Traditionally used as a leavening agent in baking breads. Recipes in “How to Bake without Baking Powder” by Leigh Tate

Try ½ tsp baking powder to 1 tsp pearl ash

Substance	Solubility (grams/100 mL water)	
	Cold	Hot
potassium carbonate	147	331
calcium chloride	75	159
sodium chloride	36	39
potassium chloride	34	57
sodium carbonate	22	421
calcium carbonate	0.001	0.002

Source: Caveman Chemistry, A primitive Alkali: Potash



Potassium Carbonate (Potash) In solultion: Review

Potassium Cation becomes a ‘spectator ion’ and carbonate anion is reactive

$$K_2CO_3(s) \text{ -----> } 2\ K^+(aq) + CO_3^{2-}(aq)$$

In Acid solutions, Carbonate Ion reacts with any H+ ions, forming **Bicarbonates**

$$CO_3^{2-}(aq) + H^+(aq) \text{ <-----> } HCO_3^-(aq)$$

In more Neutral solutions, Carbonate Ions will ‘steal’ H+ ions from water molecules, forming **Hydroxides**, making solution more Basic

$$CO_3^{2-}(aq) + H_2O(l) \text{ <-----> } HCO_3^-(aq) + OH^-(aq)$$

In stronger acid solutions, Bicarbonates will bond with H+ and form **Carbonic Acid**

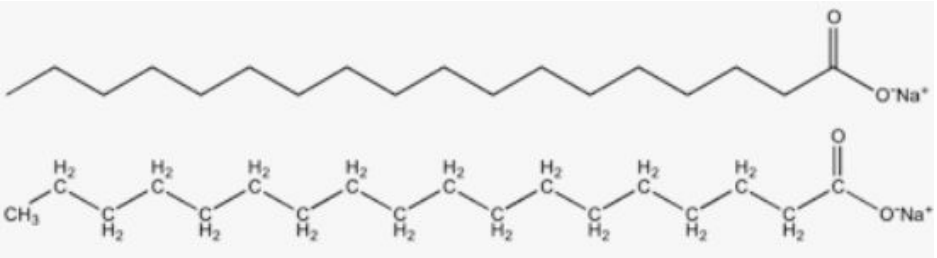
$$HCO_3^-(aq) + H^+(aq) \text{ <-----> } H_2CO_3(aq)$$

Carbonic acid can decompose into **Carbon Dioxide and Water (**Heat Activated: Bread Rising!)

$$H_2CO_3(aq) \text{ <-----> } H_2O(l) + CO_2(g)$$

Soapmaking

Saponification



Sodium Stearate - Sodium soap of common Fatty acid in beef tallow, or cocoa butter

Hydrolysis of Triglyceride fatty acids...

...with a strong base to form a salt - Soap!

Soap: A polar (water soluble) salt with a long non-polar (oil soluble) fatty acid tail

Saturated fats - Tallow, Butter, Lard generally yield harder soaps.

Unsaturated fats - Oils yield comparatively soft soaps.

Sodium Hydroxide - Commonly used alkali for hard handcrafted soaps

Potassium Hydroxide - Common alkali used in liquid soaps.

Suitable Wood Ash Soap possible, but expect major variability compared to handcrafted soaps.

“Grandpappy’s” Wood Ash Soap

Boil ‘average’ wood ash water at 1 gallon down to ⅜ cup.

¾ cup concentrated ash water to 2 cups warm fat.

Full process at: https://grandpappy.org/hsksoap.htm

First attempt: Lamb Tallow and Last year’s ash water at 1.24g/ml concentration

I experienced inadequate saponification and impossible mixing prior to ‘trace’ with this method. Determined a function of not enough water / too concentrated ash water

Second attempt: Lamb Tallow and Olive oil blend, ash water at 1.1g/ml concentration

Long process: I experienced very slow to trace, excess oil. Added ⅝ cup additional ash water. Additional ¼ cup water (after boiling on accident). Added 2 tsp salt for harder soap.

Testing Ash Water Strength

Egg test - Ready for soap when “a fresh egg floats to a quarter sized area above the surface”

Feather Test - Strong enough when “a feather dissolves to heated lye” “too strong if the quill dissolves”

Density Test - More precise approach to Egg Test.

A measure of specific gravity, expressed as grams/ml

pH - could be helpful to indicate presence of hydroxides and alkalinity of finished soap. Soap over 8.5 ph may be too alkaline and unsuitable for washing hands and body

Egg floating test

Attempted Titration of Wood Ash “Lye”

Pure Potassium Hydroxide (KOH) is very hygroscopic and will change weight if left in open air.

Had success w/ titration of older KOH concentration for liquid soaps, where complete saponification is preferred using method described in *Scientific Soapmaking* by Kevin M. Dunn.

Determined Old KOH was roughly 10% less potent than pure KOH.

Substituted potash for KOH in same titration process, determined my impure potash was roughly ⅔ potency of old KOH. Not sure if this is accurate. Maybe a real chemist can help?

Since then, came across Beyond Benign: a nonprofit for supporting green chemistry education. Labs available for K-12, Higher Ed and Professional Development.

Liquid Soap

Continued Exploration

- Refinement of Potash for food applications
- Applications in Building Materials as portion of cement, DIY refractory bricks
- Easy at home DIY alkalinity tests for contrasting recipes for soap, food prep
  - https://www.beyondbenign.org/lessons/wood-ash-titration/
- Homestead calcium processes for quicklime

Special Thanks to helpful references:

Kevin M. Dunn: *Caveman Chemistry* and *Scientific Soapmaking*

Leigh Tate: *How to Bake without Baking Powder*, 5 Acres and a Dream Blog

Homestead Laboratory Blog

Give it back to the Earth!

If this is all too much...

Store ashes until **Fully Extinguished!**

Lightly quench if necessary, but retain potassium nutrients

Do not start a forest fire!!!

Cast thinly on forest floor, not directly on green leaves, and away from waterways.