International Journal of
Environmental Sciences & Natural Resources
ISSN: 2572-1119

Juniper Publishers
key to the Researchers

Case Study
Volume 22 Issue 5 - December 2019
DOI: 10.19080/IJESNR.2019.22.556097

Int J Environ Sci Nat Res


# Evaluation of Phyto-ashes for Agri-environmental Goals - A Novel Approach

**Jean Diatta***

*Department of Agricultural Chemistry and Environmental Biogeochemistry, University of Life Sciences, Poland*

**Submission:** November 25, 2019; **Published:** December 02, 2019

***Corresponding author:** Jean Diatta, Department of Agricultural Chemistry and Environmental Biogeochemistry, University of Life Sciences, Poznan, Poland

**Summary**

The concept of the current research was based on the readaptation of the acid neutralising capacity (ANC) for agri-environmental use of phyto-ashes. For this purpose, 9 phyto-ashes from birch (*Betula*), oak (*Quercus*), red oak (*Quercus rubra*), hornbeam (*Carpinus*), pine (*Pinus sylvestris)*, poplar (*Populus*), maple (*Acer*), wheat straw (*Triticum aestivum*) and oilseed rape straw (*Brassica napus*) have been tested for their pH as well as Ca, Mg, K, Na and $SiO_2$. A novel approach was suggested for using the $CaO/SiO_2$ ratio in the evaluation of the geo-structural potential (flocculation effect) of phyto-ashes to soil medium.

**Keywords:** Phyto-ash; Acid neutralising capacity (ANC); Geochemistry, $CaO/SiO_2$ ratio

## Information

Burning plant biomass is a process accompanying human kind since the early beginning. The residues, i.e., phyto-ashes have been used as potash component or soil improvers, hence they are probably the earliest ever known mineral fertilizers in the human history. The industrial recovery of energy (bioenergy or green energies) by incinerating plant biomass generates huge amounts of phyto-ashes which are recycled for various purposes [1]. Their application as liming materials as well as fertilizers was desisted at the eve of the 20th century, due to the emergence of alternative products like lime and muriate of potash, [2]. With the progressive exhaustion of phosphate and potassium reserves phyto-ashes should be a valuable renewable resource agri-environmental goals [3,4] including, silviculture too. Degraded soils are particularly concerned.

One of the key parameters taking into consideration when applying phyto-ashes for agri-environmental goals is the reactivity expressed both by high alkalinity (reactivity) and the concentrations of basic metals (Ca, Mg, K and Na). This parameter (acid neutralizing capacity-ANC) may be determined by laboratory titration, but also evaluated empirically by the relationship outlined by MDDEP [5]: ANC (%) = (%Ca·2.5) + (%K·1.2) + (%Mg·4.2). The lack of sodium (Na) implies that the relationship is applicable for much more homogenic plant biomass, like wood. Other phyto-ashes with appreciable levels of Na, may exhibit distinct ANC.

The concept of the current research was based on the readaptation of the empirical ANC [5]. For this purpose, nine phyto-ashes from birch (Betula), oak (*Quercus*), red oak (*Quercus rubra*), hornbeam (*Carpinus*), pine (*Pinus sylvestris*), poplar (*Populus*), maple (*Acer*), wheat straw (*Triticum aestivum*) and oilseed rape straw (*Brassica napus*) have been tested for their pH and chemical composition (Ca, Mg, K, Na and $SiO_2$). A novel approach has been elaborated for evaluating the geo-structural potential of phyto-ashes to soil medium.

## Materials and Methods

Phyto-ash samples originated from the incineration at 600°C for 4 hours in a muffle furnace [6] of 7 wood parts with barks and 2 straws of crop plants. The recovered ashes are listed as below:

a) 7 wood ashes from birch (*Betula*), oak (*Quercus*), red oak (*Quercus rubra*), horbeam (*Carpinus*), pine (*Pinus sylvestris*), poplar (*Populus*), maple (*Acer*).

b) 2 crop plant ashes: wheat (*Triticum aestivum*), oilseed rape (*Brassica napus*).

The chemical composition, i.e. the content of Ca, Mg, K, Na and SiO2 was determined by the XRD spectrometry fluorescence method additionally with the minerology by using the diffractometer D8 Discover (Bruker), with the ray CuKα, Ni filter and Lynxeye detector. Next phyto-ashes were analysed for pH in aqueous (double distilled water) suspension at the ratio as 1 to 2.5 (10g / 25ml $H_2O$). The slurries were shaken for 1h on a rotatory shaker, after they were left to equilibrate for 1 hour before pH measurements by using a pH-meter (Elmetron CX 701).

## Data and Comments

The chemical composition of phyto-ashes (Table 1) revealed, that pH is highly alkaline ($pH_{H2O}$: 11.5 - 13.6), but slightly less for phyto-ashes obtained from crop plants. One of the parameter which deserves attention is the content of $SiO_2$. The relationship of CaO to this compound generated the following equation: $\%SiO_2 = 470.4 \cdot (\%CaO)^{-1.15}$ $R^2 = 0.809$; n = 9. Such relationship assumes, that $SiO_2$ may be a key factor, significantly regulating the chemical behavior of CaO, expressed among others by the acid neutralizing capacity (ANC) parameter [5].

**Table 1:** Reaction, content of alkaline elements and silicon oxide of chalk lime and investigated phytoashes.

| Material / Phytoash | $pH_{H2O}$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SiO_2$ |
|---|---|---|---|---|---|---|
| | | % | | | | |
| Chalk lime ($CaCO_3$) | 8.2 | 43.4 | 5.81 | 0.04 | 0 | |
| Birch (*Betula*) | 13.2 | 35 | 4.35 | 7.36 | 0.87 | 7.81 |
| Oak (*Quercus*) | 12.9 | 36.4 | 1.4 | 8.07 | 0.87 | 7.13 |
| Red Oak (*Quercus rubra*) | 13.4 | 32.9 | 1.56 | 9.13 | 1.05 | 13.36 |
| Horbeam (*Carpinus*) | 13.6 | 39.5 | 4.72 | 8.36 | 0.81 | 6.74 |
| Pine (*Pinus sylvestris*) | 13.4 | 38.4 | 3.28 | 5.49 | 1.02 | 8.46 |
| Poplar (*Populus*) | 13.6 | 26.5 | 4.55 | 30.7 | 0.69 | 4.57 |
| Maple (*Acer*) | 13.2 | 45.1 | 2.36 | 5.93 | 0.67 | 5.96 |
| Wheat straw (*Triticum aestivum*) | 11.5 | 7.45 | 2.48 | 9.4 | 0.91 | 58.3 |
| Oilseed rape straw (*Brassica napus)* | 12.6 | 10 | 2.4 | 21.7 | 0.52 | 29.3 |

According to Hébert et Breton [3], divalent alkaline elements (Ca, Mg) exhibit a flocculating potential once in the soil medium, whereas monovalent elements (K and Na), the dispersing effect. Therefore, their ratio should be indicative of any soil structure forming or not. On this basis, a concept was developed, where phyto-ash $SiO_2$, also as a prevailing soil constituent has been considered, resulting in $CaO/SiO_2$ ratio (Table 2).

**Table 2:** Reaction, content of alkaline elements and silicon oxide of chalk lime and investigated phytoashes.

| Material/Phytoash | ANC[a] | Geo-Struct[b] | Ratio[d] |
|---|---|---|---|
| | % | %(Ca+Mg) / %(K+Na) | $CaO / SiO_2$ |
| Chalk lime ($CaCO_3$) | 100 | 1050 | |
| Birch (*Betula*) | 81 | 4.09 | 4.48 |
| Oak (*Quercus*) | 103 | 5.06 | 5.1 |
| Red Oak (*Quercus rubra*) | 78 | 3.22 | 2.46 |
| Horbeam (*Carpinus*) | 91 | 3.67 | 5.86 |
| Pine (*Pinus sylvestris*) | 83 | 5.55 | 4.54 |
| Poplar (*Populus*) | 90 | 0.84 | 5.81 |
| Maple (*Acer*) | 93 | 6.27 | 7.56 |
| Wheat straw (*Triticum aestivum*) | 29 | 0.81 | 0.13 |
| Oilseed rape straw (*Brassica napus*) | 46 | 0.47 | 0.34 |
| **Threshold value** | - | 2.5[c] | 1.0[e] |

[a]. Acid neutralising capacity; [b]. Geochemical structure potential [5]; [b]. calculated according to Hébert et Breton [3] and expression by the Author of the current paper; [c]. according to Hébert et Breton [3]; [d]. concept by the Author of the current paper; [e]. outcome from Figure 1.

A state-of-the-art graphical output (Figure 1) has been obtained for the pairs $CaO/SiO_2$ ratio *versus* CaO (%) and $SiO_2$ (%). The intersection of both curves represents the value, i.e., threshold value below, which the *geochemical structure potential* exerted by a given phyto-ash once incorporated to the soil is weak. In another words, the flocculation process leading to a good soil structure is less efficient.



How to cite this article: Jean Diatta. Evaluation of Phyto-ashes for Agri-environmental Goals - A Novel Approach. Int J Environ Sci Nat Res. 2019; 22(5): 556096. DOI: 10.19080/IJESNR.2019.22.556097

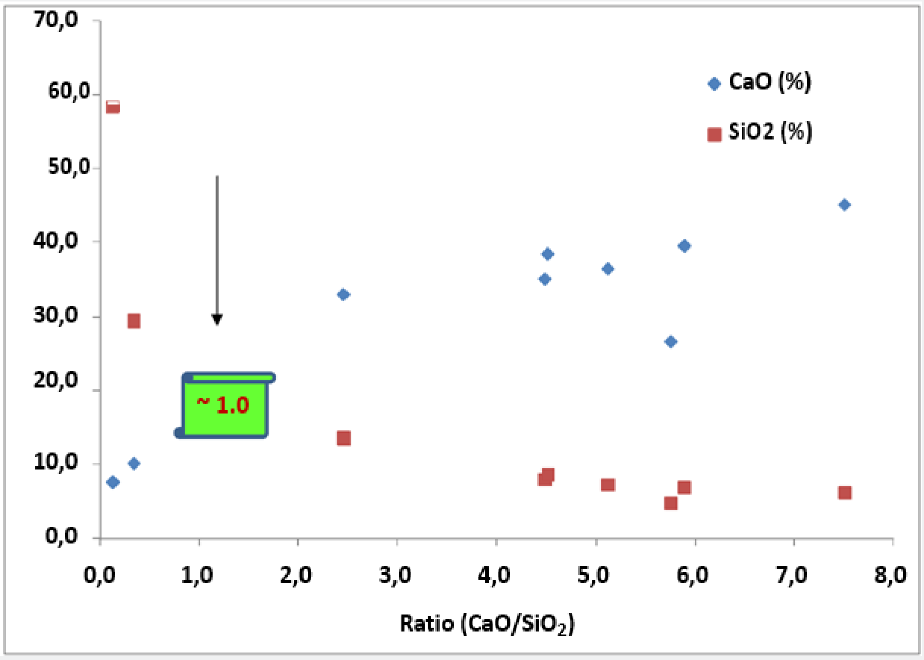


**Figure 1:** Relationship between $CaO/SiO_2$ ratio and CaO content of investigated phytoashes (more details, refer to Table 1 & 2).

The use of the % (Ca + Mg) / % (K + Na) parameter [5] with the 2.5 as threshold value (Table 2) discriminated 3 phyto-ashes: poplar, wheat and oilseed rape. In the case of the current (i.e. 1.0) value, only the 2 last ones were below this value.

This novel approach implies, that the $CaO/SiO_2$ ratio is a simple and reliable parameter in evaluating the potential capacity of any phyto-ash for flocculating soil colloids and hence, forming appreciable structure.

## Future Research Prospects

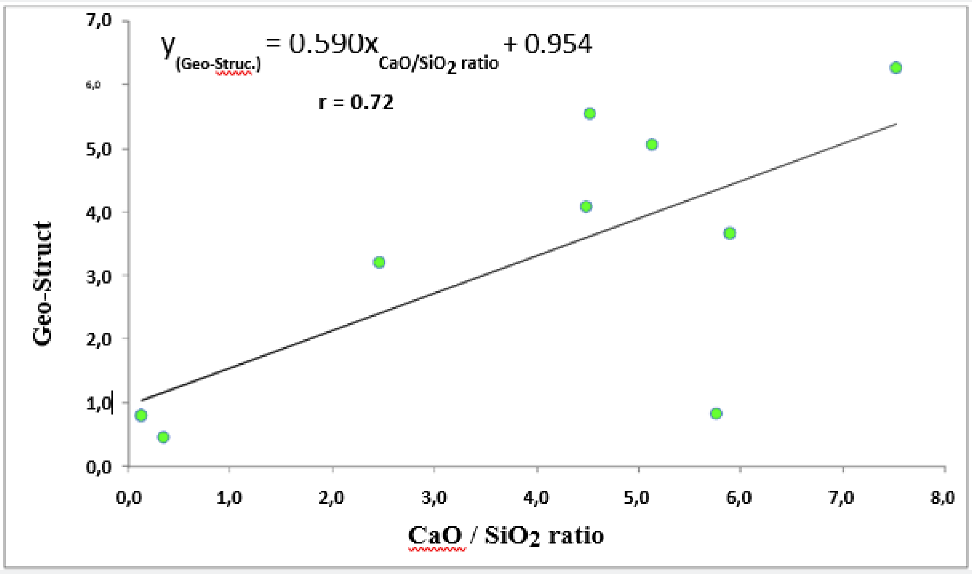


**Figure 2:** Relationship between $CaO/SiO_2$ ratio and CaO content of investigated phytoashes (more details, refer to Table 1 & 2).

Bioenergy recovering is currently a worldwide broad practice, since performing of renewable environmental resources – plant biomass. Its mineral composition derives from soil reserves, hence the urgent need for incorporating back these elements, in an appropriate way.

Relevant indices like $CaO/SiO_2$ ratio (Figure 2) are worth implementing broadly. The generated relationship with the coefficient of correlation (r = 0.72), supports the concept developed herein.



**How to cite this article:** Jean Diatta. Evaluation of Phyto-ashes for Agri-environmental Goals - A Novel Approach. Int J Environ Sci Nat Res. 2019; 22(5): 556096. DOI: 10.19080/IJESNR.2019.22.556097

## References


1. (2018) Circular Economy Package.
2. Maltas A, Sinaj S (2014) Wood ash: a new fertilizer for Swiss agriculture. Recherche Agronomique Suisse 5(6): 232-239.
3. Hébert M Breton B (2008) Agricultural recycling of wood ash in Quebec - state, impacts and good agro-environmental practices. Agrosolutions 19: 18-33.
4. Vassilev SV, Baxter D, Andersen L, Vassileva C (2013a) An overview of the composition and application of biomass ash. Part 2. Potential utilization, technological and ecological advantages and challenges. Fuel 105: 19-39.
5. MDDEP (2008) Guide sur la valorisation des matières résiduelles fertilisantes. Critères de réferences et normes réglementaires. Environnement Québec, p. 127.
6. Xiao R, Chen X, Wang F, Yu G (2011) The physicochemical properties of different biomass ashes at different ashing temperature. Renewable Energy 36(1): 244-249.








**How to cite this article:** Jean Diatta. Evaluation of Phyto-ashes for Agri-environmental Goals - A Novel Approach. Int J Environ Sci Nat Res. 2019; 22(5): 556096. DOI: 10.19080/IJESNR.2019.22.556097