CHANGES IN pH AND BASIC CATIONS IN RUNOFF WATER COLLECTED IN A FOREST PLOT TREATED WITH WOOD ASH

F. Quiroga-Lago, A. Núñez-Delgado
Dept. of Soil Science and Agricultural Chemistry. Escuela Politécnica Superior. Campus de Lugo, 27002. University of Santiago de Compostela, Spain

ABSTRACT

The wood processing industry commonly makes use of felling remains (bark, leaves, fruit, etc.) to produce energy, by burning the remains in bioenergy plants designed for this purpose. The process generates huge amounts of wood ash, which is continuously disposed of in landfill sites. The residue possesses some potentially useful characteristics, such as a high pH and high concentrations of some essential nutrients for plants, which make feasible its use on agricultural and forest land as a liming and fertilizing agent. However, it is important to assess any possible environmental risks associated with use of this waste product. In the present study we investigated temporal variations in pH and basic cations in runoff water collected in an experimental plot, located on a gently sloping forest hill site, before and after application of wood ash. Comparison of the results for the control and the treated areas allowed us to assess the effect of wood ash on runoff water quality. However, the results suggest that the risks associated with the applied amendment are minimal.
Keywords: *Wood ash, forest plots, runoff, water quality.*

INTRODUCTION

Wood ash is generated as a waste product during the combustion of felling remains (bark, leaves, fruits, etc), carried out in timber processing plants to obtain energy.

It is clear from previous reports that biomass combustion is increasingly carried out in developed countries (Someshwar, 1996; Arvidsson et al., 2002).

The main disadvatage associated with the burning of biomass to obtain energy is the huge amounts of ash produced every year. It is estimated that biomass combustion generate 4.6 million tons of ash every year in USA (Someshwar, 1996). According to other reports the situation in the EU is very similar (Clarholm, 1994; Korpilahti et al., 1998).

It is well known that wood ash possesses certain characteristics – such as a high pH, high concentrations of some nutrients essential to plant growth, and usually low concentrations of heavy metals and other hazardous components – which make this residue potentially useful as an amendment and fertilizer for agricultural and forest soils (Demeyer et al., 2001).

However, prior to applying wood ash on agricultural land, possible environmental risks must first be determined. In the present study, we investigated the effect of wood ash on runoff water with which it comes into contact. For this we established an experimental forest plot situated on a gently sloping hillside. Wood ash was spread on part of the plot at a rate of 60 Mg ha^{-1}. Values of pH and nutrient concentrations in the control zone (without treatment) and in the treated area were compared before and after ash application, in order to determine the effect of wood ash on runoff water quality.

MATERIAL AND METHODS

The plot was established on a gently sloping hillside (average slope 7.8 %) situated in the municipality of Baralla (Lugo, NW Spain).

Soil characteristics were determined according to standard procedures (Tan, 1996) and were typical of soils developed in the area, i.e. sandy-loam texture, low pH value and low cation exchange capacity.

- The experimental plot is 25 m long – in the direction of the slope – and 6 m wide. Galvanised iron plates of 120 x 15 cm were placed along the sides of the plots to prevent surface fluxes entering the study area. Channels were dug at the upper limit of the plot for drainage, to deviate surface runoff from above.

The surface of the plot includes two furrows in which where trees (*Pseudotsuga menziensii*) were planted four years ago - within an area of 3 x 4 m - and three flat areas (see Figure 1).

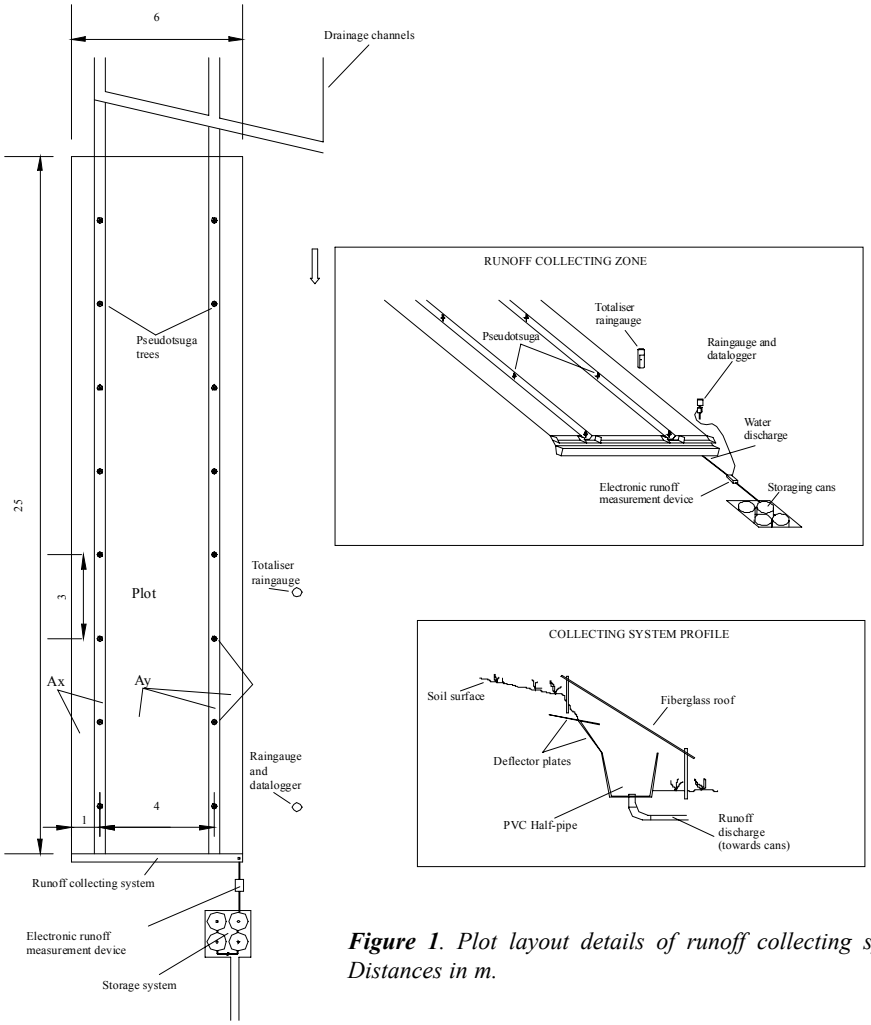

***Figure 1**. Plot layout details of runoff collecting system. Distances in m.*

A runoff collecting device, designed specifically for this study, was installed at the lower end of the plot. The device was constructed using PVC guttering and was situated a few cm below soil level, where runoff water flowed into plastic containers, aided by galvanised iron deflectors. The collecting device was covered by a small fiberglass panel to prevent direct rainfall entering the system.

The PVC pipe has two independent collecting parts associated with it, each of which received flow from two different zones of the plot: Ax and Ay (Ax includes the flat area and the furrow on the left, and Ay includes the wide central flat area, and the furrow and flat area on the right; see Figure 1). Each collecting part has an independent storage system.

Two rain gauges were situated beside the plot to register rainfall over the area. One of the gauges was connected to an electronic data-logger and registered rainfall continuously. The other gauge - a totaliser rain gauge - was periodically emptied and served to verify the reliability of the electronic gauge. The whole system was designed specifically for this kind of experiment (Quiroga et al*.,* 2002).

-Wood ash. The wood ash used in this study was obtained from Tablicia S.A., in Nadela (Lugo, NW Spain). Application of the ash on the plot was carried out, on February 25th 2002, at a rate of 60 Mg ha^{-1}. Application was carried out by hand and only in the zone Ax, leaving zone Ay without treatment as a control.

The wood ash used in the present study was alkaline (pH_{H2O} = 9.65) and contained high levels of basic cations, characteristics also described by other authors (Someshwar, 1996; Demeyer et al*.,* 2001). The concentrations of elements in the aqueous extract were: Ca= 96.33 mg Kg^{-1}; Mg= 32.04 mg Kg^{-1}; Na= 169.44 mg Kg^{-1}; K= 632.35. The contents of basic cations, especially K, were notably high. On the other hand, the concentrations of heavy metals were low (data not shown here). In terms of its chemical characteristics, the wood ash under study can be considered as potentially useful for agronomic purposes.

- Runoff water sampling and analysis. Runoff water samples were collected in the storage cans when rainfall generated runoff episodes. At each sampling time, the cans were shaken to homogenize the sample, which was then placed in suitably labelled polythene bottles (1500 cm^3).

Samples of the wood ash were homogenised and analysed for pH, Ca, Mg, Na and K, according to standard methods (Guitián and Carballas, 1976; Tan, 1996, APHA, 1998).

Runoff water samples were analysed for the same parameters as wood ash, following procedures described in APHA (1998). Samples were collected before and after application of the wood ash.

RESULTS AND DISCUSSION

The values of several parameters affecting runoff water quality were determined before and after application of wood ash, to assess the effect of the waste product on natural waters.

The pH of the runoff samples collected before and after the ash treatment in zone Ax differed substantially. The pH values before application of the ash varied between 5.67 and 5.97, while after the amendment they ranged between 6.17 and 6.45. The pH values in samples from zone Ay (without treatment) were always lower.

The variation in basic cations in runoff samples did not indicate large transfers of these elements from the wood ash to runoff water. There did not, therefore, appear to be a high risk of environmental degradation through nutrient loss. The variation in concentrations of Ca, Mg, Na and K in zone Ax and Ay before and after application of wood ash are shown in Figure 2. The results corresponding to Ca and Mg showed many similarities. The values tended to fall over time before ash application (with more oscillations in zone Ay). Cation leaching therefore appeared to have taken place prior to ash application. The effect of ash on Ca concentration was observed at the first two sampling dates after ash application, and reached concentrations of 1.72 mg l^{-1} in zone Ax**.**

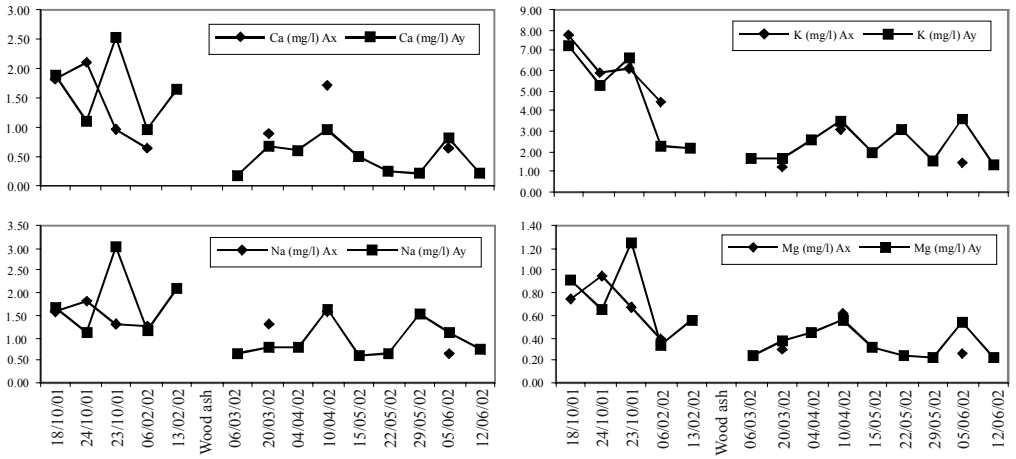

***Figure 2**. Temporal changes in basic cations in the experimental plot before and after application of wood ash.*

Wood ash had no clear effect on the concentrations of the other basic cations in runoff water; this is particularly surprising in the case of K, considering the high concentrations of soluble K of the wood ash.

It must be taken into account that only light precipitations were registered in the area during the study period, therefore heavy runoff events did not take place (data not shown). Therefore, greater dragging episodes from the treated zone are expected during heavier precipitation, as occurred during previous experiments carried out in the same plot (Martínez, 2001).

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