# Managing phosphorus cycling in agriculture

## Biochars from digested fattening pig slurry

*Dried cake of digested fattening pig slurry and biochars obtained at 300 degrees Celsius during 30, 45 or 90 minutes (top down)*

### Introduction

All over the World the interest for pyrolysis of biomass increases. This interest arises from the production of:

1) energy from renewable biomass;
2) base material for the chemical industry in substitution for petroleum;
3) biochar with soil amending properties.

In addition, pyrolysis of biomass can contribute to a reduction of emissions of greenhouse gasses.

Pyrolysis is thermo-chemical decomposition of biomass (organic matter) in a nearly oxygen depleted environment. Pyrolysis comes from the Greek-derived elements pyr (fire) and lysis (separating). Pyrolysis of biomass results in three products:

4) syngas, a mixture of methane ($CH_4$) and carbon monoxide (or carbonous oxide, CO);
5) oil, a mixture of condensates of volatile components (benzene, toluene, styrene etc.) and
6) char or biochar; a charcoal

The type of biomass (feedstock), temperature, oxygen tension and length of the pyrolysis process.

Since way back pyrolysis has been used for the production of charcoal. The focus on a bio-based economy and the necessity to reuse wastes and byproducts has renewed the interest in pyrolysis. This has raised questions regarding the technical opportunities and economical perspectives and practical values of biochars for agricultural use.

Pyrolysis can be applied on almost all types of biomass. Animal manures are potentially feeding stocks. In particular the dried fraction of the solid cake which remains after separation of slurry is suitable for pyrolysis. Part of the organic matter (and nitrogen and sulphur) from animal slurry is converted to syngas, pyrolysis oil and char. Minerals from the solid cake are almost exclusively recovered in the char. Whether pyrolysis of animal slurry produces an agronomical acceptable biochar is not yet known.

This factsheet examines the agricultural value of biochars made from the thick cake of digested fattening pig slurry. The agricultural value of biochars is determined by the stability of the organic matter of the biochar, the availability of phosphorus and other nutrients for the crop.

Pyrolysis requires energy. The drier the thick cake, the higher the energetic return is of the products of pyrolysis. In our research we therefore used the dried thick fraction of digested fattening pig slurry.

### Method

Our research has five phases:

1. *Optimization of the pyrolysis process to produce an agronomic acceptable biochar*
2. *Determination of the nitrogen and carbon releasing properties of different types of biochar.*
3. *Determination of the phosphorus availability of selected biochars*
4. *Determination of the inorganic and organic contaminants and the environmental consequences of agronomic use of a biochar.*
5. *Synthesis and evaluation*

This factsheet presents results of the 1st and 2nd phase.

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## Results

Energy Research Centre of the Netherlands (ECN) has pyrolised dried thick cake of fattening pig slurry at temperatures ranging from 300 to 700 degrees Celsius during 30, 45 or 90 minutes at oxygen contents of 0% or 1%. By increasing the temperature the yield of biochar decreases. The effects of 45 minutes of pyrolysis or 1% $O_2$ addition compared to 30 minutes of pyrolysis and 0% $O_2$ addition are marginal. Pyrolysis yields about 65% biochar.

*Table 1. Relative yield of biochar from pyrolysis of dried thick cake of fattening pig slurry (feedstock)*

| Temperature, °C | without $O_2$ | | with 1% $O_2$ | |
|---|---|---|---|---|
| | 30 minutes | 45 minutes | 30 minutes | 45 minutes |
| 300 | 63 | 61 | 74 | 62 |
| 400 | 68 | 73 | nb | nb |
| 500 | 56 | 62 | 71 | 67 |
| 600 | 61 | 48 | nd | nd |
| 700 | 50 | 55 | 41 | 51 |

*nd: not determined*

Temperature and duration of the pyrolysis process do effect hot water extractable carbon (HWC) and anaerobically mineralisable nitrogen (Nmin). An increase of the temperature leads to a decline of HWC (figure 1). Nmin decreases with a temperature increase to 400 degrees Celsius. A further increase of the temperature leads to an increase of Nmin (figure 2). The C/N ratio at temperatures from 300 to 700 degrees Celsius increases from 20 to 48.

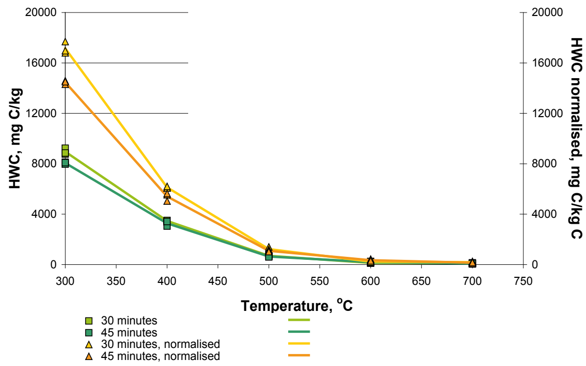


*Figure 1. Hot water extractable carbon (HWC) per product (left Y-axis) and HWC relative to the total carbon content (right Y-axis) of biochars produced at different temperatures and duration of pyrolysis.*

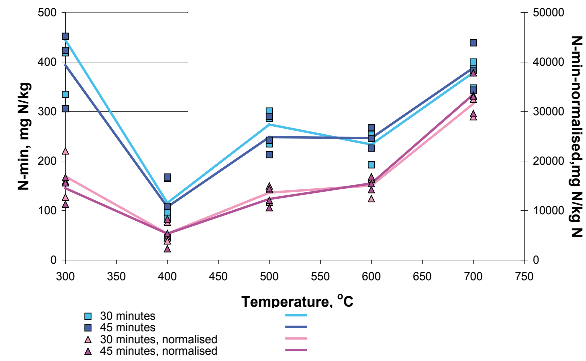


*Figure 2. Anaerobically mineralized nitrogen (Nmin) per product (left Y-axis) and Nmin relative to the total nitrogen content (right Y-axis) of biochars produced at different temperatures and duration of pyrolysis.*

## Conclusions & future research

Temperature of pyrolysis determines the yield of biochar (table 1) and the release rate of HWC en Nmin (respectively figure 1 and 2). An increase of the temperature lowers the yield of biochar and HWC. The availability of nitrogen is at its lowest level at a pyrolysis temperature of 400 degrees Celsius but the release rate increase at higher temperatures. The agronomic interpretation of the C/N ratio of bichars differs from that of manures. At relatively high C/N ratio of 48 biochar still releases Nmin.

Currently the phosphorus availability and the environmental quality of biochars are studied by means of an incubation experiment.

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