# Solute and water fluxes in andisol fertilized with pig manure: soil columns experimentation

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## Introduction

Waste production is dramatically increasing in Réunion island and valorisation becomes an important scientific, technologic and economic challenge for the future. Among different recycling techniques, spreading is suitable for many wastes (especially for organic wastes) and permits to enhance soil fertility and to use soil purification power. In contrast, with the rich literature found for temperate conditions, few studies tackle risk estimation and management of waste spreading under tropical conditions with specific climatic and agro-pedologic features. This work aims at studying the physical and chemical transformations and the solutes transfer related to pig manure spreading on a volcanic andisol of Réunion island.

## Materials and methods

The experimental layout was based on three columns of disturbed soil (C1, C2 and C3) of one meter height and forty centimetres diameter (figure 1). Spreading was carried out on C1 and C2 whereas C3 was used as the reference. Columns were kept at 25°C and supplied with calibrated amounts of water corresponding to measured rainfall. Each soil layer (0-20, 20-40 and 40-100 cm) was equipped with a TDR probe to follow water regime and a pH electrode and redox electrode to monitorate chemical properties. A limnigraph stored the water flow at the outler of the columns. All these sensors were connected to a datalogger operating at a ten minutes time step. Micro-samplers were inserted at the same levels and at 7.5 cm to analyze the changes in soil solution chemical composition.

## Results and discussion

The chemical composition of the pig manure used in this study is reported in table 1. By comparing the two replications (C1 and C2) with reference column (C3), we observed several agronomical consequences of pig manure spreading:

*1/ Nitrification of the pig manure* (*i. e.* the conversion in the soil of ammonium into nitrate with the release of $H^+$ ions: $NH_4^+ + 2\ O_2 \rightarrow NO_3^- + 2\ H^+ + H_2O$). In the soil solution, at 7.5 cm depth, nitrate production was correlated with ammonium disparition. After one month and 500 mm of cumulated water amounts, nitrification was over and corresponding nitrate was leached. At 15 cm depth, we never observed ammonium from the pig manure and leaching of the nitrate, all coming from nitrification in the upper part of the soil, was completed after 750 mm of cumulated water amounts. Acidification of the soil solution was measured at 7.5 and 15 cm depth. At 15 cm depth, the acidification could not result from nitrification because no ammonium was observed at this depth. However, it may come from the leaching of $H^+$ ions from above.

*2/ Vertical transfer of major chemical elements*. We observed similar results for calcium, magnesium, sodium and nitrate: the maximum concentration of elution peak was measured after 600 mm of cumulated water amounts at 35 cm depth, and after 1200 mm of cumulated water amounts at the column outlet.

*3/ Saturation of soil exchange complex by potassium.* Conversely, potassium concentration in soil solution did not reveal the high concentration of the pig manure. A large part of potassium ions probably participated to the saturation of soil exchange complex.
*4/ Two kinds of pollution by trace metal elements.* Copper and zinc are two metals frequently observed with high concentrations in pig manure (due to the veterinary treatments). Each one had a specific behaviour in the soil. Copper was accumulated in topsoil layer and created a local pollution source whereas a deep transfer of zinc induced a risk of groundwater pollution.

**Conclusions**
The first objective of this study was to create an experimental device in order to evaluate the pollution risk related to agronomical valorization of organic wastes in Réunion andisol under tropical climatic conditions. We used representative conditions (waste, soil, water supply) and followed water fluxes and chemical composition of soil solution at different depths. Results permitted to quantify pollution transfer (especially nitrate and metal elements) through the soil without the perturbation of plant uptake. For the farmer, these results emphasized kinetics and depth influence of pig manure nitrogen impact (nitrification and transfer). The plant will be accounted for in a following step.

Table 1. Chemical composition (milimoles/l) of the pig manure used in the soil columns C1 and C2.

| Ca mM/l | Mg mM/l | K mM/l | Na mM/l | Al mM/l | Mn mM/l | P mM/l | Si mM/l | Cu mM/l | Zn mM/l | S mM/l | Cl mM/l | $NO_3^-$ mM/l | $NH_4^+$ mM/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.23 | 0.92 | 50.1 | 15.7 | 0.01 | 0.001 | 4.66 | 1.58 | 0.004 | 0.007 | 1.87 | 39.49 | 0 | 100.59 |

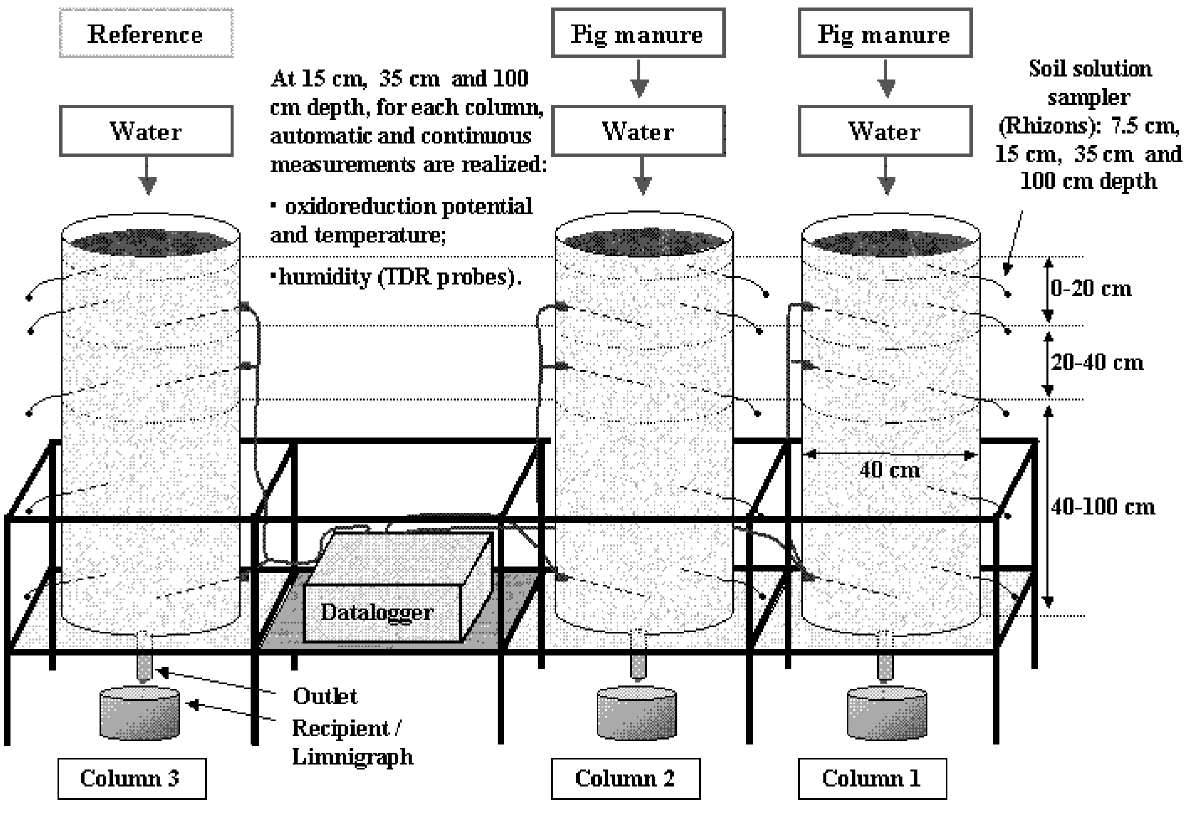


Figure 1. Soil columns experimentation.