Gaseous emissions from biological aerobic treatment (using an intermittent aeration) were compared with traditional manure management (based on 6 months storage before spreading). Using farm measurements and modelled estimations of slurry volume, flow rates and composition, annual emissions were estimated for four slurry management schemes (three involving biological treatment with the fourth based on traditional storage/spreading) for a farrowing-fattening farm with 200 sows. The results show a large decrease of the greenhouse gases (methane and nitrous oxide) and ammonia (NH₃) when a biological treatment is compared to using storage alone. The reduction was 30–52% for NH₃ when the biological plant included mechanical separation and was 68% when there was no separation. Greenhouse gases (CH₄ and N₂O) were reduced by about 55% whatever the composition of the biological treatment plant.

1. Introduction

Intensification and concentration of French pig production in Brittany over the last 30 years has led to public concern over the resulting environmental impacts from this agricultural sector on water and air pollution. At the moment, regulatory requirements mainly focus on the appropriate management of manure to reduce water pollution. Under the EC Nitrate Directive, most of Brittany has been classified as a nitrate vulnerable zone (NVZ) (Agence de l’Eau Loire Bretagne, 2004) where the average annual nitrogen disposal from animal waste must not exceed 170 kg[N] ha⁻¹ year⁻¹. In order to achieve this level, about 300 farms in the region have opted for a pig slurry treatment. Eighty percent of the treatment schemes are based on biological treatment using intermittent aeration.

Treatment schemes processed 1.3 million tonnes of pig slurry in 2003 (Levasseur & Lemaire, 2003). They led to the production of a solid (biological sludge) and a liquid (super-natant) which were used on the farm by land spreading and irrigating, respectively. According to a survey of the principal manufacturers of biological aerobic treatments (Beline et al., 2004), there were four major types of farm-scale aeration systems achieving a reduction of 60–70% of the total nitrogen in the raw slurry. These treatments may include mechanical separation devices (especially, decanter centrifuge or compaction screw) and a sedimentation tank for the aerated slurry. A study of these treatment systems enabled an assessment of their performance both in terms of nutrient removal (i.e. N, P, Cu and Zn) and of main characteristics of the treatment by-products (Beline et al., 2004).

Biological aerobic treatment can induce a nitrification and de-nitrification processes, which transforms the ammoniacal nitrogen in the raw slurry to gaseous products, mostly di-nitrogen gas (N₂) (Burton et al., 1993; Beline et al., 1998).
Nevertheless, poorly controlled aeration processes can also produce polluting gases including nitrous oxide (N$_2$O) and ammonia (NH$_3$). The storage of the treatment by-products (aerated whole slurry or the solid separated fraction, settled sludge and supernatant) can be a separate source of atmospheric pollution. Indeed, manure management in general can lead to emissions of NH$_3$, CH$_4$, N$_2$O and CO$_2$ (De Bode, 1990; Husted, 1994; Sommer et al., 1991). The extent of such emissions depends on various parameters such as volume and composition of manure, type and duration of manure storage and weather conditions (temperature, wind velocity and humidity). For raw slurry storage, the available data gives a range of ammonia emissions between 1.8 and 12.0 g of ammonia (as nitrogen) per m$^2$ of surface area per day (De Bode, 1990; Sommer et al., 1993; Loyon et al., 2004). For carbonaceous emissions (i.e. CH$_4$ and CO$_2$), reported data give emissions between 0.4 and 70 g[C] m$^{-3}$ d$^{-1}$ (Husted, 1994; Zeeman, 1994; Safley & Westerman, 1988; Martinez et al., 1999; Loyon et al., 2004). During the storage of manure under anaerobic conditions the emissions of N$_2$O are very low or insignificant (Osada et al., 1998; Phillips et al., 1997). For biological treatment using intermittent aeration, published data relates principally to the batch reactor. Ammonia emissions depend on the hydraulic residence time and can be very low (Evans et al., 1986; Burton, 1992; Beline et al., 1998). Nitrous oxide emissions from intermittent aeration systems typically represent 2–3% of total nitrogen (Osada et al., 1995; Beline & Martinez, 2002; Melse & Verdoes, 2005) although other studies indicate higher N$_2$O emissions, between 10% and 20% of the total nitrogen (Burton et al., 1993; Willers et al., 1996).

The purpose of this study was to assess the total gaseous environmental impact of biological treatment systems at the farm. This is compared to the traditional manure management system based on storage before spreading.

2. Materials and methods

2.1. Farm measurement of gaseous emissions

In Brittany Beline et al. (2004) identified four major designs for biological aerobic treatment units. They all include a raw slurry reception pit, a reactor with intermittent aeration and a tank for the storage of aerated slurry which is then spread on cropland near the farm. The four design concepts differ by aeration regime, by the optional use of raw slurry separation (e.g. press auger, compacting screw or centrifuge) and the optional inclusion of a decanting stage after aerated slurry. To represent this, farm measurements of emissions were taken from six scenarios on different commercial pig farms between September 2002 and August 2004: (1) a raw slurry reception pit, (2) an intermittent aeration reactor, (3) a solid separated fraction storage, (4) an aerated slurry separation decanter (5) a decanted sludge storage and (6) a supernatant storage. In order to evaluate and compare the environmental impact of different biological aerobic treatment schemes, we also measured the gaseous emissions from: (i) an unstirred raw slurry reception pit before spreading, (ii) from aeration vessels using two other means of intermittent aeration, and (iii) from stored separated solids produced by an alternative separator. The characteristics of the effluent at each of the measurement locations are listed in Table 1.

Gaseous emissions of NH$_3$, N$_2$O, CH$_4$, and CO$_2$ were measured from each of the liquid fractions described above using the dynamic chamber technique described by Peu et al. (1999). This technique consisted of a floating rectangular polyvinyl chloride (PVC) open bottom chamber (height 0.4 m, width 0.4 m and length 0.6 m) placed on the liquid surface. Emitted gases were withdrawn from the chamber by clean air delivered by a pump at a flow of 1.5 m$^3$ h$^{-1}$. Gaseous emissions from the storage of the solid separated fractions were measured by enclosing a cone-shaped heap in a large polyethylene structure during all the period of storage. The store was 8 × 8 m and 4.5 m tall with a capacity of 150 m$^3$. The gaseous emissions from the heap were determined by drawing the store by a current of air (2000 m$^3$ h$^{-1}$) over the enclosed heap.

The concentration of N$_2$O, CH$_4$, and CO$_2$ of the inlet and exhaust air of the heap and of the dynamic chamber were analysed continuously either by infrared detection (URAS 14 and 10) or by gas chromatography coupled with a Flame Ionisation Detector/Electron Captor Detector (Varian star 3800). Ammonia concentration was determined by continuously passing the exhaust air through acid traps (0.5 N sulphuric acid) at an airflow of 51 min$^{-1}$ (Portejoie et al., 2003) followed by alkaline distillation and a titration of the final acid ammonia solution. Measurements were carried out for over periods of 4–7 weeks during different seasons (Table 1).

2.2. Estimation of the annual emissions of NH$_3$, N$_2$O, CH$_4$ and CO$_2$

The estimation of the annual emissions of NH$_3$, N$_2$O, CH$_4$, and CO$_2$ was carried out by multiplying the farm measured gaseous emissions by the daily quantity of the different stored products (raw slurry and aerobic treatment by-products).

The characteristics of the daily volume of raw slurry were simulated for a farrowing-fattening farm (200 sows) using a mathematical model written in Visual C++ 6.0 developed by Boursier (2003). Slurry management was based on a distribution of the pigs into seven sow-groups in 11 housings according to age (one gestating, two nurseries, two weanings and six fattenings) and on the emptying of pits located under the housing at the end of each group.

Table 2 presents data for the volume and characteristics of slurry from the different types of pig housing to be treated or stored (Levasseur, 1998, 2002). The model for the calculation of the raw slurry volume gave sensible results comparable to those in the literature (Boursier, 2003). These figures were then used as input data for a second simulation model of the daily volume of biological treatment by-products using data (Tables 3a and b) based on farm measurements (Beline et al., 2004). The two models allowed the estimation of the daily quantities and characteristics of the different treatment by-products present at the treatment plant. From these results daily gaseous emissions were calculated applying
the farm emission factors measured from the different effluent stores.

3. Results and discussion

3.1. Farm measurements of gaseous emissions

Measured emission factors for CH4, CO2, NH3 and N2O from the different vessels and stores are given in Table 4.

Ammonia emissions

Ammonia emissions varied between 0.2 and 6.7 g[N] m⁻² d⁻¹ depending on the stored manure product. Raw slurry ammonia emissions were 4.1 g[N] m⁻² d⁻¹ for that stored before treatment and 6.7 g[N] m⁻² d⁻¹ for that held in the separate store before land spreading. These emission factors are similar to other published data (De Bode, 1990; Sommer et al., 1993; Guingand, 2002).

Emissions of ammonia from the stored solids produced by a decanter centrifuge and a compacting screw were similar. Peak emission factors were 38.4 g[N] t⁻¹ d⁻¹ for separated solids from a decanter centrifuge and 53.1 g[N] t⁻¹ d⁻¹ for solids from a compacting screw. For a storage period of 40 days, ammonia emissions averaged as 26.1 and 28.9 g[N] kg⁻¹ d⁻¹ respectively. This represents approximately 30% of the initial ammoniacal nitrogen in the solids.
Table 3a – Performance figures used in the simulation of farm models to compare traditional systems [storage/spreading] with biological treatment options (Beline et al., 2004)

<table>
<thead>
<tr>
<th>Characteristics of by-products</th>
<th>Solid fraction(a) from</th>
<th>Separated slurry(a) from</th>
<th>Aerated slurry(b)</th>
<th>Supernatant(c)</th>
<th>Sludge(c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Centrifuge decanter</td>
<td>Compacting screw</td>
<td>Centrifuge decanter</td>
<td>Compacting screw</td>
<td>Aerated slurry</td>
</tr>
<tr>
<td>Mass</td>
<td>13.0</td>
<td>4.75</td>
<td>87.0</td>
<td>95.25</td>
<td>99–101</td>
</tr>
<tr>
<td>DM</td>
<td>67.4</td>
<td>41.4</td>
<td>32.6</td>
<td>58.6</td>
<td>94–97</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>33.4</td>
<td>9.55</td>
<td>66.6</td>
<td>90.45</td>
<td>28–33</td>
</tr>
<tr>
<td>TAN</td>
<td>24.9</td>
<td>5.8</td>
<td>75.1</td>
<td>94.2</td>
<td>2–3</td>
</tr>
</tbody>
</table>

 DM, dry matter; TAN: total ammoniacal nitrogen.
\(a\) Expressed in % of raw slurry.
\(b\) In % of slurry entering the reactor.
\(c\) In % of aerated slurry.

Emissions of methane and carbon dioxide

Emissions factors for CH\(_4\) and CO\(_2\) were measured as 0.60 and 0.35 g[C] m\(^{-2}\) d\(^{-1}\) for the supernatant store and 56.9 and 44.5 g[C] m\(^{-2}\) d\(^{-1}\) for raw slurry store. For both of the raw slurry stores, the CH\(_4\) emission factors were above the highest value of 36 g[C] m\(^{-2}\) d\(^{-1}\) cited in previous studies (Martinez et al., 1995, 2003; Husted, 1993, 1994). This could be the consequence of frequent additions to the stores and the frequent stirring of the slurry before withdrawing quantities for treatment. This may also explain the surges of the emissions of CH\(_4\) (Fig. 1a,b). Similar results were also observed by Sneath et al. (2006). The same emission behaviour is observed for CO\(_2\), indicating that CH\(_4\) and CO\(_2\) are produced concurrently. High production of CH\(_4\) and CO\(_2\), around 50 g[C] t\(^{-1}\) d\(^{-1}\) and more than 700 g[C] t\(^{-1}\) d\(^{-1}\) respectively, for the solid separated fractions is due to high concentration of biodegradable organic matter (about 270 g kg\(^{-1}\) of total volatile solid) and the relatively high temperature (65 °C) of the heaps.

For each of the three aeration vessels, CH\(_4\) emissions were very low; less than 1 g[C] m\(^{-2}\) d\(^{-1}\) compared to raw slurry store at around 50 g[C] m\(^{-2}\) d\(^{-1}\). This is possibly because methane production is inhibited by intermittent aeration when compared to anaerobic degradation (Martinez et al., 2003). Also, aerobic treatment leads to the degradation of volatile fatty acids (VFA) which are necessary precursors to methane production. As expected, for the store of other treatment by-products (aerated slurry, biological sludge and supernatant

Table 3b – Assumptions used in the simulation of the annual gas emission from farms using traditional spreading and those with biological treatment units

<table>
<thead>
<tr>
<th>Raw slurry storage</th>
<th>V(<em>{\text{pit}}) (m(^3)) (=) equal to 180 d of storage raw slurry; H(</em>{\text{pit}}): 3 m; Emptying every six months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before spreading</td>
<td>H(_{\text{pit}}): 3 m; Emptying every six months</td>
</tr>
<tr>
<td>Before treatment</td>
<td>V(<em>{\text{pit}}): 300 m(^3); H(</em>{\text{pit}}): 3.5 m; Equal to 7 weeks of daily production</td>
</tr>
<tr>
<td>Solid separated fraction storage</td>
<td>V(_{\text{pit}}): hydraulic retention time equal to six times the daily volume of produced slurry</td>
</tr>
<tr>
<td>Biological aerobic treatment by intermittent aeration</td>
<td>V(<em>{\text{pit}}): (m(^3)) of hydraulic retention time equal to 6 d production; H(</em>{\text{pit}}): 4 m</td>
</tr>
<tr>
<td>Decantation and storage of aerated slurry</td>
<td>V(<em>{\text{pit}}): hydraulic retention time equal to 6 d production; H(</em>{\text{pit}}): 4 m</td>
</tr>
<tr>
<td>Biological sludge storage</td>
<td>V(_{\text{pit}}): 180 d of storage</td>
</tr>
<tr>
<td>Supernatant storage</td>
<td>V(<em>{\text{pit}}): 180 d of storage; H(</em>{\text{pit}}): 4 m; Emptying every 6 months</td>
</tr>
</tbody>
</table>

V\(_{\text{pit}}\): volume of pit; H\(_{\text{pit}}\): height of pit.

Due to the high hydraulic retention time (over 30 d), the three types of aeration did not produce any ammonia. This has also been described in other published works (Evans et al., 1986; Burton, 1992; Beline, 1998).

During the decanting of aerated slurry, ammonia emission varied between 0.60 and 0.82 g[N] m\(^{-2}\) d\(^{-1}\) with a mean value of 0.16 g[N] m\(^{-2}\) d\(^{-1}\). For the store of decanting separated sludge, ammonia emissions were of similar order with a mean value of 0.26 g[N] m\(^{-2}\) d\(^{-1}\). The average emission from the supernatant was 0.25 g[N] m\(^{-2}\) d\(^{-1}\).

Nitrous oxide emissions

Nitrous oxide was detected only during biological aerobic treatment because manure store under anaerobic conditions rarely results in nitrous oxide production (Osada et al., 1998; Phillips et al., 1997). Nitrous oxide is mainly the by-product of the nitrification/de-nitrification processes under both aerobic and anaerobic conditions (Beline, 1998). Such conditions were generally not present during the storage of raw slurry.

Whatever the type of aerator, observed nitrous oxide emissions were still low, equal to 0.03% of total ammoniacal nitrogen (TAN) with the surface aerator, 1.4% with the fine-bubble diffuser and 0.8% with the submerged ejector aerator; this represents less than 1% of the total nitrogen entering the treatment plants. These results are in accordance with the literature (Osada et al., 1995; Beline and Martinez, 2002).
fractions), CH$_4$ and CO$_2$ emissions were lower than those of raw slurry store due to their reduced biodegradable organic matter levels (Safley and Westerman, 1988; Husted, 1993, 1994).

Overall, the farm measurements described here show the impact of the biological treatment on gaseous emissions. The higher the ammonium and organic matter level of the stored product, the higher the emissions of NH$_3$, CH$_4$ and CO$_2$. Gaseous emissions were greater from the non-aerated effluent stores (raw slurry and separated solid fraction) than from the stores holding the various biological treated by-products (aerated slurry, sludge, supernatant) which contain notably less nitrogen and organic matter (Table 1). Indeed, biological treatment by intermittent aeration led to a decrease by 70% of the total nitrogen content and by 90% of the TAN content. In addition, it enables the biodegradation of the organic matter (Beline et al., 2004). Thus, the reduction of gaseous emissions from the stores can be attributed to the modification of raw slurry characteristics by the biological treatment.

### 3.2. Prediction of annual gaseous emissions

The simulation (Table 5) of a model farm including the raw slurry characteristics, volumes produced, and the related gas emissions from the stores used, enabled the environmental assessment of four slurry management systems: (i) traditional management based on storage and spreading, (ii) treatment option 1 (storage+biological treatment+decanting), (iii) treatment option 2 (storage+compacting screw+biological treatment+decanting), and (iv) treatment option 3 (storage+decanter centrifuge +biological treatment+decanting). Around 3950 tons of slurry would be produced per year, which is equivalent to around 83 tons of carbon and 17 tons of nitrogen. Using the assumptions of Table 3b (storage parameters and management of by-products), the model was used to simulate the quantities and characteristics of the different by-products of the three treatment schemes (Table 5) as well as the corresponding gaseous emissions (Table 6).

For the traditional farm system of manure management and disposal, annual gaseous emissions of CH$_4$ and CO$_2$ are 14.7 and 11.5 t[C], respectively, which represents 30% of the raw slurry carbon (CH$_4$:17.7% and CO$_2$:13.9%). Ammonia emissions are 824 kg/year, equivalent to less than 5% of raw slurry nitrogen. In terms of greenhouse gases (GHG), the traditional system emits 413 t[CO$_2$-eq.] of N$_2$O and CH$_4$ according to the global warming potential (GWP) defined by IPCC (1995) which established the GWP of CH$_4$ at 21 t[CO$_2$-eq.] and of N$_2$O at 31 t[CO$_2$-eq.].

Treatment option 1 (storage+biological treatment+decanting) is predicted to emit less ammonia than the traditional system: 265 kg[N] per year of nitrous oxide would be produced, respectively, produced mostly from the raw slurry pit in the case of CH$_4$ (76%). For CO$_2$, there are quantities from raw slurry storage (35%) and from the

### Table 4 – Farm measurements of gaseous emissions (Mean values given. ND: no detection)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>NH$_3$, g[N] m$^{-3}$ d$^{-1}$</th>
<th>N$_2$O, g[N] m$^{-3}$ d$^{-1}$</th>
<th>CH$_4$, g[C] m$^{-3}$ d$^{-1}$</th>
<th>CO$_2$, g[C] m$^{-3}$ d$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw slurry store</td>
<td>4.1</td>
<td>ND</td>
<td>56.9</td>
<td>44.5</td>
</tr>
<tr>
<td>Store used to supply treatment (with stirring)</td>
<td>6.7</td>
<td>ND</td>
<td>49.8</td>
<td>41.9</td>
</tr>
<tr>
<td>Storage of solid separated fraction$^a$</td>
<td>26.1</td>
<td>ND</td>
<td>53.4</td>
<td>762.7</td>
</tr>
<tr>
<td>From centrifuge</td>
<td>28.9</td>
<td>ND</td>
<td>50.4</td>
<td>1170</td>
</tr>
<tr>
<td>Biological aerobic treatments by intermittent aeration</td>
<td>ND</td>
<td>0.015</td>
<td>0.87</td>
<td>12.1</td>
</tr>
<tr>
<td>Subsurface aeration 1-2 h of aeration+4 h anoxic period</td>
<td>ND</td>
<td>0.58</td>
<td>0.13</td>
<td>16.9</td>
</tr>
<tr>
<td>Fine-bubble diffuser 20 h aeration+4 h anoxic period</td>
<td>ND</td>
<td>0.27</td>
<td>0.09</td>
<td>4.1</td>
</tr>
<tr>
<td>Submerged ejector 20-30 min of aeration+15-20 min anoxic period</td>
<td>ND</td>
<td>0.16</td>
<td>7.6</td>
<td>4.8</td>
</tr>
<tr>
<td>Aerated slurry decantation</td>
<td>0.26</td>
<td>ND</td>
<td>5.6</td>
<td>6.7</td>
</tr>
<tr>
<td>Biological sludge storage</td>
<td>0.25</td>
<td>ND</td>
<td>0.62</td>
<td>0.35</td>
</tr>
<tr>
<td>Supernatant storage</td>
<td>0.25</td>
<td>ND</td>
<td>0.62</td>
<td>0.35</td>
</tr>
</tbody>
</table>

$^a$ Emission values from solids given as g d$^{-1}$ per tonne rather than per m$^3$ or m$^2$.
biological treatment vessel (52%). Overall, the GHG emissions
for treatment option 1 are 185 t [CO2-eq] Around 15% of the
raw slurry carbon is transformed into gas (CH4:5% and
CO2:10%). Raw slurry nitrogen is lost as N2O (0.8%) and NH3
(1.5%). The largest part of the loss is thus attributed to
emission of di-nitrogen gas (N2), albeit unquantified by
measurement.

For the treatment option 2, nitrogen emissions are 133 and
392 kg[N] of N2O and NH3, respectively. Nitrous oxide is
produced only from the biological treatment reactor while
NH3 is emitted from the raw slurry pit (54%) and from the
solid fraction storage (33%). Carbon emissions are 4.3 and
12.6 t[C] in the form of CH4 and CO2, respectively. The main
source of CH4 is from the raw slurry storage (73%), while CO2
is produced from each stage: raw slurry storage (21%), solid
fraction storage (41%) and biological treatment (30%). Total
GHG emissions are 186 t [CO2-eq]. Around 20% of the raw
slurry carbon is lost as gas (CH4:5.2% and CO2:15%). By
contrast, only 0.8% and 2.3% of the raw slurry nitrogen would
be lost as N2O and NH3 emissions.

Fig. 1 – Evolution of emission rates of CH4 (–) and CO2 (—) during storage of raw slurry with stirring (a) and without stirring (b). Periods of pulse stirring over a day are marked on the upper graph.
For the treatment option 3, nitrogen emissions are predicted as 121 and 577 kg[N] for N₂O and NH₃, respectively. As observed for the two other treatment units, N₂O emissions arose mostly from the biological reactor. Ammonia emissions derive principally from raw slurry storage (36%) and solid fraction storage (55%). Carbon emissions are predicted as 4.7...
and 16.3 t[C] as CH₄ and CO₂, respectively. Methane emissions again come mostly from raw slurry storage (68%) while CO₂ emissions are produced from raw slurry storage (16%), the solid fraction storage (57%) and from the biological reactor (21%). GHG emissions are 190 tCO₂-eq. For this option, around 25% of the raw slurry carbon and 53% of the raw slurry nitrogen are transformed in gas. Carbon emissions are principally as CO₂ (representing 20% of the raw slurry carbon) while N emissions are principally as N₂ (assumed to be 50% of the raw slurry nitrogen). By contrast, CH₄ emissions represent only 6% of the raw slurry carbon and N₂O and NH₃ are equivalent to 0.7% and 3.3% of the raw slurry nitrogen.

Extending these calculations, total nitrogen emitted as NH₃ and N₂O for a year is 824, 404, 525 and 698 kg for the traditional system, treatment option 1, treatment option 2 and treatment option 3, respectively. Ammonia emissions accounted for 100% of nitrogen emissions for the traditional system and between 65% and 83% for the biological treatment systems. The biological reactors are predicted to emit the remaining nitrogen as the products of de-nitrification including small amounts of N₂O.

Whatever the biological treatment unit, the majority of the emissions of polluting gases for the systems occurred during the storage of the separated solid fraction (up to 55% of NH₃ and 57% of CO₂) and the raw slurry (up to 79% of NH₃ and 74% of CH₄). This implication is that the gaseous emissions would be reduced more if these two products were managed differently, such as by the use of covers (De Bode, 1990; Chadwick, 2005).

In all cases, the environmental assessment shows a decrease in greenhouse gases and NH₃ by using biological treatment compared to traditional manure management practice based on 6 months storage before spreading (summarised in Fig. 2). The reduction for NH₃ is 30-50% when the biological treatment included mechanical separation and 68% when it does not include separation.

4. Conclusions

Farm measurements confirmed the production of minimal amounts of ammonia and methane during and after biological treatment when compared to a traditional anaerobic storage of raw slurry. However, biological treatment did result in the production of N₂O and, in place of methane, quantities of CO₂. The net effect of these opposing effects were reconciled in a modelling exercise. The results of this study showed that aerobic biological treatment of pig slurry can greatly reduce overall emissions of the polluting gases NH₃, N₂O, CH₄ and CO₂ when compared to traditional manure management based on 6 months storage before land spreading. The reduction was 30-50% for NH₃ when the biological treatment included mechanical separation and was 68% when there was no separation. The impact of total greenhouse gases (CH₄+N₂O) was reduced by about 55% (calculated as CO₂ equivalent), whatever the biological treatment process.

This study also underlined the influence of effluent composition and management method on the resulting gaseous emissions. The higher the ammonium and organic matter content, the higher the emissions of NH₃, CH₄ and CO₂. The different emission rates obtained in this study reflect the difference in the waste materials and their treatment.

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