Composting of swine slurry : firsts results.

Compostage du lisier de porc : résultats préliminaires.

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Abstract

Stricter legislation on disposal of pig slurry has stepped up the search for solutions that make it possible to produce compost instead of slurry and above all in structures outside the swine rooms, which do not involve far-reaching modifications to building design and swine management. In view of the unsatisfactory results obtained with biological oxidization of pig slurry on a bed of wood shavings, other methods must be identified. Liquid manure with a low TS content (≤ 6% in the case of pig slurry) must be mixed with straw for sorption of water and formation of a porous structure that can be used for composting. In the classical composting process, the material must be placed in windrows and a turning machine is required to add, mix and turn the substrate. To reduce composting costs, the process was divided into a sorption phase, in which the slurry was added to the substrate, and a maturing phase, in which the material was collected, forming a stack. An experiment based on this technique was carried out in 1997 at a piggery in the Western Po Valley using Winter wheat straw and corn stalk as substrate and forming a 25-kg/m^2 layer on a 50-m^2 covered concrete platform surrounded by a 20-cm high kerb. In the sorption phase, 240 l/m^2 of slurry were added to the substrate on three occasions (120 l/m^2 just after formation of the layer of substrate and 60 l/m^2 twice, at an interval of 15 days). After the 45-day sorption period, a 1.5-high stack was formed with the material. A period of 8 weeks was required for the maturing phase, after which 64 kg/m^2 of compost were obtained with a 26% TS content.

Résumé

Les réglementations contraignantes liées à l'utilisation du lisier de porc amènent à considérer des solutions alternatives telles que la production de compost à l'extérieur des bâtiments.

L'effluent d'élevage avec une teneur en matière sèche inférieure à 6% (notamment pour le lisier de porc) doit être mélangé à de la paille lors d'une étape d'absorption de l'eau et production d'une structure poreuse utilisable lors du compostage.

Dans notre étude, le procédé de compostage était ainsi divisé en une étape d'absorption au cours de laquelle le lisier est mélangé au substrat et une phase de maturation. Un premier essai basé sur cette approche a été effectué en 1997 dans une exploitation porcine de la vallée ouest du Pô en utilisant de la paille de blé et des résidus de maïs en tant que substrat et en formant ainsi une couche de 25 kg/m² sur une surface de 50 m² en plateforme béton.

Lors de la phase d'absorption 240 l/m² de lisier sont ajoutés au substrat en 3 fois (120 l/m² juste après formation couche de substrat et 2 fois 60 l/m² à intervalles de 15 jours).

Après 45 jours de période d'absorption, un tas de 1,5 m de hauteur a ainsi été constitué. Une période de 8 semaines était nécessaire pour la phase de maturation, à la suite de laquelle on obtient 64 kg/m² de compost présentant un taux de MS de 26%.

1 - Foreword

In the last few years, pig breeders have shown increasing interest in waste management methods that do not produce slurry, disposal of which is now regulated by ever tighter restrictions with therefore increasingly higher costs.

Different researches and experiments undertaken recently for stabling of pigs on litter have revealed that, although this solution is effective for service houses, pregnant sow houses and weaner houses *(Navarotto* & Al., 1991; *Simoni*, 1993), it cannot be used for rearing and fattening houses *(Bonazzi & Navarotto*, 1992; *Bonazzi & Navarotto*, 1993). Also, at existing piggeries, this solution involves expensive modifications to the swine rooms. Hence, the considerable interest shown at the moment in solutions that make it possible to transform pig slurry into manure or compost using structures outside the buildings in which the animals are housed (*Piccinini* et Al. 1995; *Balsari* et Al. 1996).

Composting could represent an effective solution to problems of pig slurry disposal in areas with a high animal population, making it possible to transfer the organic substances and excess nutritional elements towards areas where there is a shortage of these. The end product has a high content of total solids and good fertilizing characteristics such as to make transport of this, even over long distances, economically viable.

For example, it could be used in agriculture as fertilizer for herbaceous and tree crops - the most probable solution, characterized by the greatest opportunities for placement - or as a component for the production of composts for both vegetable and flower growers, as well as for recovery of downgraded areas and maintenance of public parks and gardens.

However, transformation of pig slurry into compost entails a number of difficulties to be ascribed mainly to its high moisture content which means that it must be mixed with byproducts of vegetable origin available directly at the farm such as wheat straw and corn stalks or outside this (pruning shoots and material resulting from maintenance of public parks and gardens and recovery of wood packing material), even if the quality and effective availability of these materials in the quantities required must however always be checked.

2 - The trial carried out

When organizing this experiment, reference was made to an experiment carried out in Northern France with satisfactory results (Callarec, 1996). The experimentation was carried out on a 50 m^2 (10 x 5 m) cement platform with a 1% slope with direction normal to the long side (to permit collection of waste liquid in two underground cylindrical tanks with a total volume of 0.2 m^3). The platform was equipped with protective kerbs to prevent any risk of percolation of the slurry in the water table.

The experiment was carried out using two different types of substrates: wheat straw and a mixture of wheat straw and corn stalks.

In both trials the substrate was distributed on the platform. and then pig slurry was applied on three occasions at an interval of about 15 days. Each distribution of slurry was followed by mixing of the mass using a straight blade hoe hooked to a tractor (sorption phase). Fifteen days after the last application, the material was placed on a maturation platform in stacks maturing period (fig.1).

During both the experimental periods they were recorded :
- distributed substrate main chemical characteristics (TS, total nitrogen);
- applied slurry main chemical characteristics (TS, VS, total nitrogen, ammonium nitrogen, pH);
- substrate temperature during the maturing phase (every week) by thermocouples LSI PT-100 finked to a digital thermometer;
- substrate main chemical characteristics (TS, VS, total nitrogen, ammonium nitrogen, pH, C/N ratio) at the end of sorption period and at the end of the maturing phase.

All input and output materials were weighted for mass balance determinations.

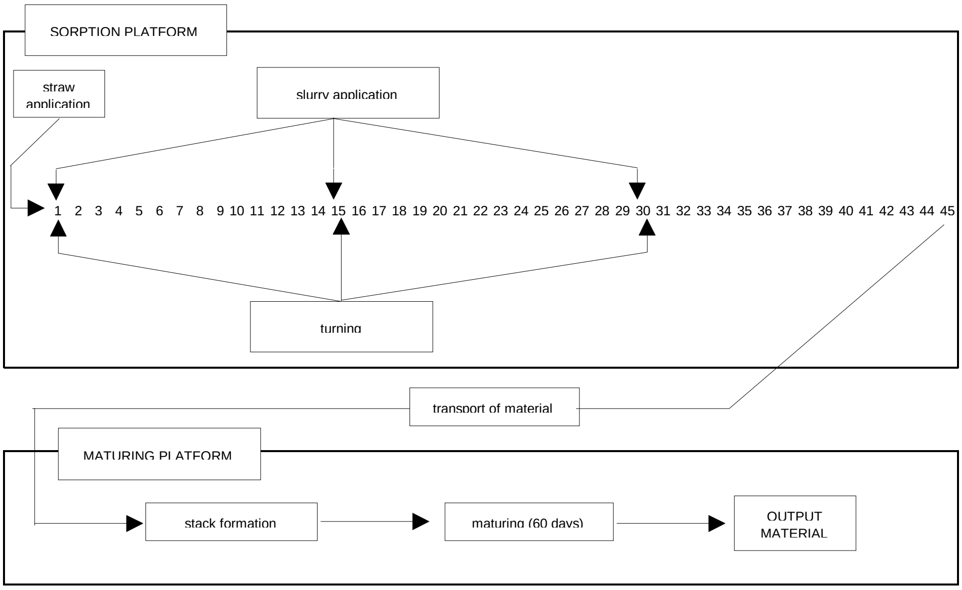

Figure 1
Diagram of the thin layer bed management.

2.1 - Test with wheat straw

At the start of the test on February 4 (day 0), 1.25 t of straw and 5.8 m^3 of slurry at 6% of TS were distributed on the platform. After fifteen days, 3.3 m^3 of pig slurry at 8.2% TS were added while 3.2 m^3 of slurry al 1.7% of TS were distributed 36 days later (tab. 1), with a delay of one week on the date planned because of slow absorption of the slurry by the straw substrate. On day 0+51, the material was stacked and a representative sample of the mass was taken.

	Slurry application		
	day 0	day 0 + 15	day 0 + 36
TS (%)	6.08	8.23	1.70
VS (%)	4.00	5.55	0.97
Total nitrogen (%)	0.55	2.68	0.29
Ammonium nitrogen (%)	0.32	1.71	0.17

Table 1
Test with wheat straw: chemical characteristics of slurry applied

Another sample was taken on day 0+169 when it was decided to end the test in that the temperature of the stack had reached a value slightly above ambient temperature. (fig. 2).

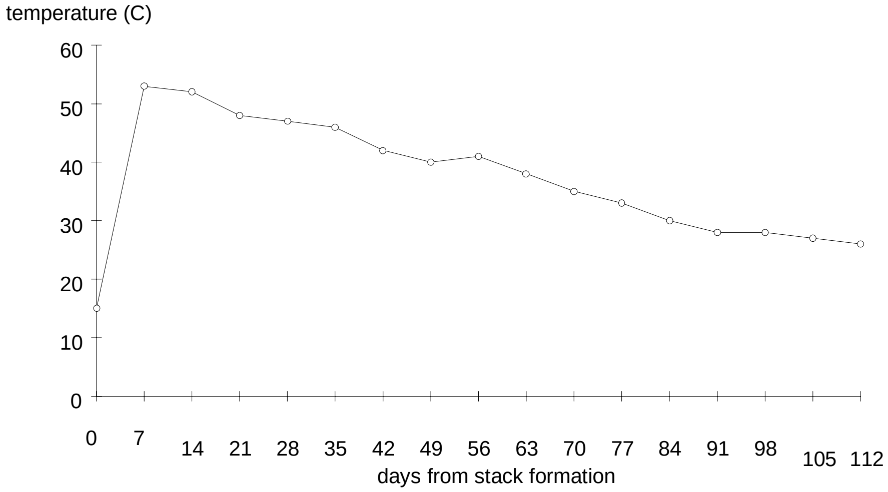

Figure 2
Test with wheat straw: temperature evolution during maturing period.

During the experiment, 12.3 m^3 of pig slurry were distributed on 1250 kg of wheat straw corresponding to a total mass of 13550 kg. At the end of the experiment, i.e. after 169 days, the total weight of the mass present inside the pilot system was 3840 kg. This value corresponded to a dry substance and nitrogen loss of 45% and 60% respectively (tab. 2)

materials	wet basis (kg)	dry matter (kg)	total nitrogen (kg)
substrate	1250	1087.5	6.5
slurry	12300	678.6	57.0
input material	13550	1766.1	63.5
output material	3840	976.9	25.3
output/input	28.3%	55.3%	39.9%

Table 2
Test with wheat straw: mass balance of the experiment.

The fraction of pig slurry distributed lost through draining off the platform of the pilot system was negligible. Briefly, during this first test, around 10 kg of pig slurry were disposed of by one kilogram of wheat straw. Assuming a slurry production per head of 0.54 kgTS and an effective duration of the process cycle equal to that of the test, this value corresponds to a requirement of 2 m^2 of covered surface per head and to use of 1 kg/head.day of wheat straw.

The analyses of the samples examined revealed that at the end of the sorption phase (on day 0+51), the substrate had not yet stabilized (C/N > 23; organic carbon = 45.6%). On the other hand, at the end of the maturing period (i.e. at the 169^{th} day), the organic carbon and C/N ratio values were within the limits regarding compost quality of Italian regulations (DLGS 22/97). Nevertheless, the TS content (25.44 against minimum of 60%) and the pH (9.50 against a permitted range of variation of 5.5-8) deviated considerably from the values indicated (tab 3).

	sampling time	
parameters	end of sorption period	end of maturing period
Total Solids (% WB)	23.52	25.44
Volatil Solids (% DM)	82.07	60.52
Aches (% DM)	17.93	39.48
Organic Carbon (% DM)	45.60	33.62
pH	9.50	9.50
Total Nitrogen (% ss)	1.91	2.37
C/N	23.88	14.17

Table 3
Test with wheat straw: analytical results of the experiment.

Briefly, the material obtained is odorless and can, to all effects and purposes, be considered manure, which, as such, can be used at the farm or in areas close to this, whereas possible sale as compost or transport over long distances requires further drying until an TS content of around 50% is reached.

2.2 - Test with wheat straw and corn stalks

At the start of the test on August 12 (day 0), 550 kg of straw, 880 kg of corn stalks and 7.7 m^3 of slurry al 3.5% of TS were distributed on the platform of the pilot system. On day 0+14, 3.5 m^3 of slurry at 2.8% of TS were distributed while on day 0+35, with a delay of one week on the planned date because of slow absorption of the slurry, 2.8 m^3 of slurry at 9.5% of TS were distributed (tab. 4).

	slurry application		
	day 0	day 0+15	day 0+36
TS (%)	3.54	2.80	9.55
VS (%)	2.01	1.54	5.85
Total nitrogen (%)	0.36	0.32	0.44
Ammonium nitrogen (%)	0.22	0.19	0.29

Table 4
Test with substrate of straw and stalks: chemical characteristics of slurry applied

On day 0+49, the material was stacked and a representative sample of the mass was taken. On day 0+106, as the temperature of the stack was close to 20°C, the test was considered as completed and a sample was taken to determine product physical-chemical characteristics (fig. 3).

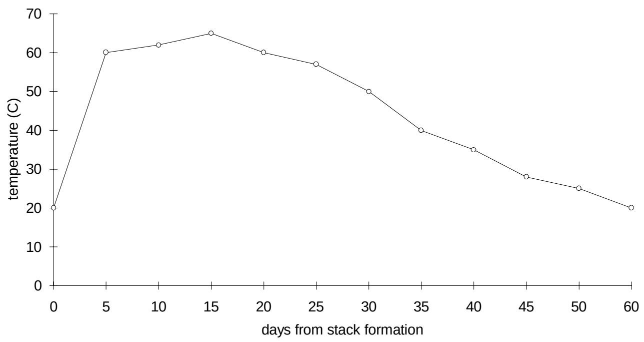

Figure 3
Test with substrate of straw and stalks: temperature trend during maturing period.

During the experiment, a total of 14 m^3 of slurry were distributed on 1430 kg of substrate, corresponding to a total mass inserted in the system of more than 15400 kg. At the end of the experiment (i.e. after 106 days), the material inside the pilot system weighed 4370 kg. Therefore, in the more than 3 months of the process, an approximate 72% weight reduction was obtained; also, the loss of dry substances was close to 48% with a 54% loss of nitrogen (tab. 5)

materials	wet basis (kg)	dry matter (kg)	total nitrogen (kg)
substrate	1430	1244.1	8.2
slurry	14040	642.2	51.6
input material	15470	1886.3	59.8
output material	4370	981.1	27.5
output/input	28.2%	52.0%	46.1%

Table 5
Test with substrate of straw and stalks: mass balance of the experiment.

The amount of pig slurry composted by one kilogram of substrate (straw + corn stalks) was close to 10 liters. Assuming a daily production per pig raised of 0.54 kgTS, this means that 2.1 m^2/head of bed surface per pig raised are required and that 1.2 kilograms of substrate per pig raised must be inserted in the system each day.

The analytical data of the samples examined revealed that at the end of the sorption phase (on day 0+49), the substrate was already sufficiently stabilized and characterized by organic carbon (35.73) and C/N ratio (17.02) values within the compost quality limits. In this test also, the related values of total solids and pH of the material (21.4 and 9.3 respectively) at the end of the maturing period (106^{th} day) were such that the product obtained cannot be classified as compost in our country.

Compared with the experiment carried out using only wheat straw as substrate, faster downgrading of the organic substance was observed with values of C/N and organic carbon on the dry substance very close to those of a compost already at the end of the composting period (49^{th} day) (tab. 6).

	sampling time	
parametrs	end of sorption period	end of maturing period
Total Solids (% WB)	20.87	21.45
Volatil Solids (% DM)	64.32	56.58
Aches (% DM)	35.68	43.42
Organic Carbon (% DM)	35.73	31.44
pH	9.50	9.70
Total Nitrogen (% ss)	2.10	1.58
C/N	17.02	16.87

Table 6
Test with substrate of straw and stalks: analytical results of the experiment

3 - Remarks on the results obtained

The results achieved during the preliminary tests revealed that composting of pig slurry on beds of limited thickness makes it possible to obtain, in short times and with limited use of substrate, a product similar to manure which can therefore be distributed on agricultural land without any legal constraints.

An initial outline economic assessment of this operating system, carried out assuming a 2000 m^2 system able to manage the slurry produced by a fattening piggery of 1200 heads, returned a management cost of the entire system of around 14 ECU/m^3 of slurry treated, whereas the production cost of the manure would be close on 45.2 ECU/t; a cost that has a 12.2% incidence on the Gross Income (calculated assuming a price of the pig of 1.3 ECU/kg).

These values could be considerably reduced assuming zero cost of the substrate (the farmer who picks up the manure at the end of the cycle provides the straw required to produce it). In this case, the cost for the breeder would drop to 6.4 ECU/m^3 of slurry treated with a 5.5% incidence on the Gross Income.

Lastly, assuming that at least half of the substrate used is produced at the farm and that the product obtained at the end of the process (manure) is sold on the market at 10.2 ECU/t from the farm, the cost of treating the slurry would be 7,6 ECU/m^3, with therefore a 6.6% incidence on the Gross Margin.

4. References

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