AMMONIA EMISSION FROM FYM HEAPS AND CATTLE AND SWINE SLURRY STORES

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ABSTRACT

Measurement of ammonia emission were performed from pig and cattle slurry storage and from manure heaps. Measurement from slurry stores were performed by means of a specific system consisting of a 0.138 m^2 captor, a trap containing 400 ml of a 1% boric acid solution, a vacuum pump, an interceptor trap, a volume meter and a flow-meter. The device is arranged to suck the air from the funnel with a flow rate of 9 l/min. The ammonia present in air is then fixed by the boric acid solution into ammonium borate and its concentration can be rapidly determined by titration with 0,1 N Sulfuric acid. The captors were mounted on a special polystyrene and wooden floating frame and placed on the slurry surface. The captors are let free to float on the slurry surface so that the area subjected to the measurement changes continuously. Measurements of ammonia emission from manure heaps were performed by means of Open Large Dynamic Chamber. Trials, carried out along the four seasons with cattle (8-10%TS) and pig (3-4% TS) slurry, pointed out ammonia losses up to 1.6 g NH_3.m^2 and 2.5 g NH_3.m^2 per day respectively. First results of ammonia emission measured from FYM heaps (autumn and winter) showed average emission close to 3.3 g NH_3 m^2 per day corresponding to losses ranging from approximately 5.4% to 9.4% of heaps TKN.

INTRODUCTION

Agriculture and especially livestock activity can contribute significantly to anthropogenic ammonia emission to air, these latter ranging in Western Europe from 2.8 to 5.2 Tg N-NH_3/year (ECETOC, 1994). Ammonia emission from animal waste storage are estimated to range from 2% to 23% of initial TKN amount (Svennson, 1991). In Italy, even tough during the last years the volume of stored slurry increased, measurement of ammonia emission from cattle and pig slurry stores - and from manure heaps as well - has not attracted the same interest of other sources such as soil after land spreading (Balsari et al., 1994). Most of available data on the topic come from northern Europe Countries trials, carried out in environmental conditions often very far from North Italian ones. Aim of the present study[1] was to collect data in Italian environmental conditions related to ammonia emission both from FYM heaps, swine and cattle slurry storage.

MATERIALS AND METHODS

Ammonia emission were measured in 2003-2004 from:
- pig slurry storage
- cattle slurry storage
- FYM heaps.

Ammonia emission from FYM heaps were measured by means of three Open Large Dynamic Chamber. Each device is made up of:
- a 24 m^2 <u>*chamber*</u> (length 6.0 m, width 4.0 m, height 2.4 m);
- a <u>*fan*</u> (max. flow rate 37650 m^3/h), connected to a galvanized sheet iron pipe (∅ 1 m,

length 10 m) equipped with an internal flow conditioner.

- An *air sampling system* made up of a pump, a flow meter, a volume meter and an acid trap.

Air flux generated by the fan passes over the soil surface covered by the chamber where manure heap is disposed and enters the pipe transporting ammonia - emitted by FYM -towards sampling system.

Ammonia emission from cattle and swine slurry stores were measured by means of a floating version of the funnel system (Balsari *et al.*, 1994). The device consists of a funnel of 0.138m^2, a trap containing 400 ml of a 1% boric acid solution, a vacuum pump, an interceptor trap, a volume meter and a flow meter. The device is arranged to suck the air from the captor with a flow rate of 9 l/min. The ammonia present in air is then fixed by the boric acid solution into ammonium borate and its concentration can be rapidly determined by titration with 0,1 N Sulfuric acid. The funnel is mounted on a special polystyrene and wooden floating frame and then placed on the slurry surface. The frame is let free to float on the slurry surface so that the area subjected to the measurement changes continuously.

Measurement from pig slurry storage were performed, with three replicates (3 funnels) along four seasons from an uncovered above ground concrete circular store. Emission were determined over time periods of six days, collecting acid traps four times during the first 24 hrs of trial and once a day for the following days. Slurry temperature of the first 10 cm layer was measured continuously.

(a) (b)

***Figure 1**. Devices used for ammonia emission measurement (a) Open Large Dynamic Chamber (b) the funnel system mounted on a floating device.*

***Table 1**. main chemical and physical characteristics of animal wastes used for the trials.*

Pig slurry	Spring	Summer	Autumn	Winter
TS (%)	4.1	3.8	3.7	3.9
pH	7.4	7.7	7.8	7.7
TKN (g/kg)	3.6	3.3	3.5	3.6
Cattle slurry				
TS (%)	9.2	9.0	10.3	9.6
pH	7.9	7.9	7.1	7.6
TKN (g/kg)	4.3	4.2	3.9	3.7
FYM				
TS (%)	-	-	22.3	30.6
pH	-	-	8.0	8.4
TKN (g/kg)	-	-	3.8	6.5

Measurement from cattle slurry storage were performed with the same experimental scheme described above, from an uncovered above ground concrete squared store.

Measurement from farmyard manure heaps were carried out on heaps assembled within the chambers (three replicates). Trials were repeated in two seasons (autumn and winter). Daily addition of fresh manure on the top of the heap (approximately 5% of initial amount of FYM) was performed. Emission were determined over time period of 24 hrs for a period of six days. Surface and centre heap temperatures were measured continuously. Air velocity within the chamber was set to 2 m/s, corresponding to a flow rate of approximately 19000 m^3/h.

Main chemical and physical characteristics of slurries and FYM are described in table 1.

RESULTS AND DISCUSSION

Emission rates from slurry storage are expressed as daily losses per m^2 of free surface area of the tanks. In both cases (pig and cattle slurry) ammonia emissions were related to season and, consequently, to slurry surface temperature (r^2 0.99 and 0.94 respectively). Winter ammonia emission showed to be 30% - 60% of summer ones.

Ammonia emission from pig slurry storage: daily emission rates ranged from 0.84 g NH_3/m^2 of the winter period up to approximately 2.5 g NH_3/m^2, this latter value referred to summer conditions. Slurry temperature ranged from approximately 6.0°C to 25.5°C.

Ammonia emission from cattle slurry storage showed the same trend observed from pig slurry, ranging from approximately 0.99 g/m^2 (winter) up to 1.66 g NH_3/m^2 (summer). Slurry surface temperatures were similar to pig slurry ones. Despite a higher TKN content, ammonia emission measured from cattle slurry in summer conditions were lower than those from pig slurry, due to the formation of a thick surface crust.

Table 2. *Main results of performed trials.*

	Pig slurry storage			Cattle slurry storage		
	Average daily emission	CV	Slurry temperature	Average daily emission	CV	Slurry Temperature
	g NH_3/m^2	%	°C	g NH_3/m^2	%	°C
Spring	1.51 (1.24-1.73)	16	15.6	1.33 (1.22-1.50)	11	16.2
Summer	2.48 (2.25-2.61)	8	25.5	1.66 (1.53-1.73)	7	24.3
Autumn	1.58 (1.39-1.89)	17	15.1	1.17 (1.06-1.33)	12	5.5
Winter	0.84 (0.74-0.96)	13	6.0	0.98 (0.83-1.06)	13	4.7

Table 3. *Main results of performed trials.*

	Average emission	% on heaps TKN content	Average daily emission	CV	Average heap centre temperature	Average heap surface temperature
	g NH_3/m^2	%	g NH_3/m^2	%	°C	°C
Autumn	19.7 (21.6-17.9)	9.4	3.3	13	11.4	6.12
Winter	20.3 (18.20-22.7)	5.4	3.4	11	5.1	5.0

Ammonia emission from FYM heaps are presented as cumulative NH_3 emission and as average daily NH_3 emission for each measuring season. Average daily emission rates as regards to exposed surface were higher in winter periods, up to 3.4 g NH_3/m^2, than in autumn season (3.3 g NH_3/m^2) due to the higher TKN content of winter heap. In fact, these latter values corresponding to 5.4% and 9.4% of heap TKN content. Emission trend was observed to follow the heap temperature one during the first five days as shown in fig. 2.

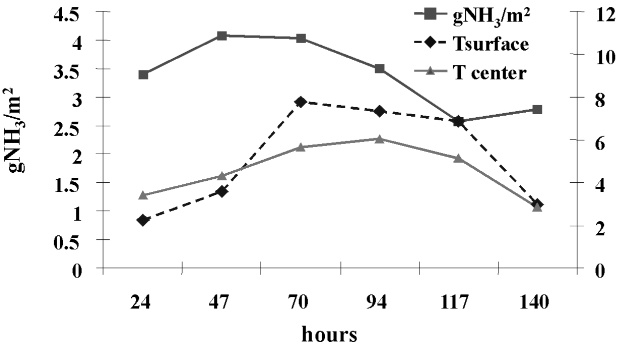

***Figure 2**. ammonia emission and heaps temperature trends*

CONCLUSIONS

Ammonia Emission Inventory (Pain *et al.*, 1998) uses emission factors for cattle and pigs, respectively, of 4.4 and 4.3g NH_3/m^2 per day for circular stores (Nicholson *et al.*, 2002). These values are higher than those measured from slurries in our experiences (1.6-2.5 gNH_3/m^2). This is probably due to: a) limited wind action on slurry surface determined by the presence of the funnel above the measurement area and b) the presence of a thick surface crust on the cattle slurry storage. Ammonia emission from FYM heaps have found to be high (from 5.4% to 9.4% of heap TKN content) if the short period of trial (six days) is considered. Values reported by other northern Authors (Svensson, 1991) are close to 20% of heap TKN for a whole year storage. Nevertheless, the facts that ammonia emission were measured from FYM heaps assembled at trials start and with a wind speed (2 m/s) probably much higher than in natural condition must be considered. FYM aeration, in fact, could have determined an unusual emission from the heap as reported elsewhere (Misselbrook et al., 2000). Furthermore it is known (Misselbrook et al., 2000, Amon et al., 1999) that in undisturbed heaps ammonia emission decrease with time. Further trials will be performed on FYM heaps for longer period with a lower wind speed and, in order to consider the effect of wind action on ammonia emission from slurry stores, trials will be carried out by means of a floating wind tunnel.

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