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ESTIMATION TEST OF GASEOUS EMISSIONS FROM FISHPONDS WITH CONTRASTED INPUTS

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ABSTRACT: Daily operations in fishponds induce gas emissions, mainly of carbon dioxide (CO₂), oxygen (O₂), ammonia (NH₃), methane (CH₄), nitrous oxide (N₂O) and nitrogen (N₂). Estimating the effect of management practices on ammonia and greenhouse gas emissions is a new challenge for the sustainable development of fish farming and increased productivity of fishponds. Experiments were performed on eight fishponds at the aquaculture experimental platform of the University of Dschang, Cameroon. Gases were collected using a small static chamber floating on the pond surface for 24 hours. Results show that CO₂ gradients related to fish densities in the fishponds and to organic inputs. CH₄ emissions measured in the ponds related to higher oxygen levels in the water due to higher photosynthesis and a large deposit of dead plankton on the bottom. NH₃ and N₂O gradients were significantly correlated, while no correlation was detected between NH₃ and CO₂. It is assumed that higher N input (urea) or higher fish population (higher N excretion) induced higher NH₃ emissions and higher N turn-over, inducing limited N₂O emissions and nitrite accumulation below toxic levels. Further work in controlled conditions could provide more reliable emission measurements and confirm the observed trends.

Keywords: fishponds, Cameroon, nitrous oxide, methane, ammonia

INTRODUCTION: The phenomenon of global warming due to greenhouse gas emissions is not only related to the consumption of fossil fuels due to heavy industrialization, but also to human activities (Dobrescu, 2009). Animal farming, as a human activity, emits greenhouse gases that accumulate because of increasing food demand. Some methods for estimating them, especially on livestock farms, have been developed and implemented in a variety of contexts (Hobson et al., 2005; Loyon et al., 2007; Hassouna et al., 2010). Few of these studies have focused on fish farms, which can emit gases. In semi-intensive aquaculture in ponds, these gases come from fish metabolism, mineralization of fecal wastes, organic manures, and photosynthetic activity (because fish feeding is mainly based on natural productivity of the aquatic system). Most gases are carbon dioxide (CO₂) from respiration, oxygen (O₂) from photosynthetic activity, ammonia (NH₃) from fish excreta resulting from protein digestion, and methane (CH₄) and nitrous oxide (N₂O) from incomplete mineralization of organic matter. Their amounts are related to the biotransformation processes within the ponds (Efole Ewoukem et al., 2012). Development of a method to estimate gaseous emissions targets not only the assessment of fish farms' contribution to global warming or acidification, but also helps to implement sustainable models of fish farms.

1. MATERIAL AND METHODS: The study was conducted in 2010 at the aquaculture experimental platform of the Application and Research farm of the University of Dschang, Cameroon, with an average altitude of 1400 m. The climate is

tropical humid modified by altitude. Mean temperature ranges from 18-27°C and relative humidity ranges from 47-90%.

Eight 25-m² ponds with different species compositions and trophic levels were used for the experiment. The bottoms of ponds were covered with PVC liner. Trophic and species compositions are summarized in Table 1.

Air was collected continuously during 24 hours from random locations on pond surfaces and from the surrounding environment in 5- or 10-l Theldar bags (SKC sample bag 232) using a floating chamber. The chamber was made of 0.5 x 0.5 x 0.3 m PVC plates covered on one side to form a chamber. Floats were attached on the sides. A battery-powered aquarium pump (pump BK) was linked to the chamber to fill the bag via a flexible tube equipped with a microfilter.

Table 1: Trophic and species composition of fish ponds sampled. Tilapia = *Oreochromis niloticus*, catfish1 = *Clarias gariepinus*, catfish2 = *Clarias jaensis*, Carp = *Cyprinus carpio*, Chla = *Chlorophyll a*.

Ponds	Fish association	Fish density (Ind/m ²)	Mineral enrichment	Fertilizer and feed	Chla (mg/m ³)	Fish Biomass gain (g)
1	Tilapia + Catfish 1	1.2	none	chck. manure	2,7	1938
2	Tilapia + Catfish1+2	1.4	wood ash	chck. manure + urea+ bread	8,3	1955
3	Tilapia + Catfish 1	1.2	lime + wood ash	chck. manure + bread+ wheatbran	6	2046
4	Tilapia + Catfish1 + Carp	1.4	none	chck. manure + urea+ bread+ wheatbran	25,8	2771
5	Tilapia + Catfish1 + Carp	1.4	lime + wood ash	chck. manure + urea	2,1	2157
6	Tilapia + Catfish 1	2.2	Lime	chck. manure + urea+ bread	0,5	4332
7	Tilapia + Catfish1+2	1.4	lime	chck. manure + urea+ wheatbran	2,6	3890
8	Tilapia + Catfish1+2 + Carp	1.6	wood ash	chck. manure + wheatbran	4,3	2859

Gas analysis was performed using a photoacoustic gas analyzer (INNOVA 1412). Concentration gradients were calculated and interpreted on the basis of the mass balance of the system (Hassouna et al., 2010). Gas emissions were calculated as the difference between gas concentrations collected in the ponds and those of the ambient air in the surrounding environment. A gas gradient was retained when its absolute value was greater than the standard deviation of the mean concentrations.

2. RESULTS: The concentration gradients of gas samples and their ratios are summarized in Table 2. The net positive CO₂ gradient shown in the table indicates that the air collected from the chamber-concentrated pond emissions was not contaminated by outside air.

Table 2: Gas concentration gradients and their ratios.

Pond	Gas gradients (mg/m ³)					Ratios of gas gradients		
	CO ₂	CH ₄	NH ₃	N ₂ O	NH ₃ /N ₂ O	NH ₃ /CH ₄	CO ₂ /CH ₄	CO ₂ /NH ₃
1	586.7	0.8	0.2	0.2	1.3	0.27	698	2541
2	789.4	-2.1	0.2	0.3	0.9	-0.11	-367	3338
3	920.9	0.9	0.3	0.4	0.9	0.37	1007	2742
4	870.9	-1.1	0.4	1.3	0.3	-0.41	-810	1991
5	482.3	nd	0.2	0.2	1.5	Nd	nd	2097
6	7104.9	-1.5	0.5	1.2	0.4	-0.31	-4805	15530
7	920.9	-0.7	0.4	0.7	0.6	Nd	0.0	nd
8	620.0	nd	0.2	0.3	0.9	Nd	0.0	nd

Generally, CO₂ emissions observed in 2010 were much higher than previous samples in 2009 (30-80 mg/m³). This high level is explained by a better rearing temperature for the fish associated with high microbial activity in the bottom in 2010. A positive gradient indicates higher CH₄ emissions in ponds 1 and 3, which had a low fish density (1.2 ind/m²), with a CO₂/CH₄ ratios of 700-1000, indicating low CH₄ emissions compared to those of CO₂. In contrast, negative gradients indicate lower CH₄ in ponds 2, 4, 6 and 7 having higher fish densities (1.4, 1.4, 2.2 and 1.4 ind/m², respectively) and using lime or ash for mineral enrichment. These CH₄ fluxes remain low compared to those of CO₂.

The observation of CH₄ consumption in these semi-intensive systems could be related to O₂ abundance in the middle and bottom of the ponds due to high algal development, responsible for activation of organic matter mineralization of bottom-soil micro-organisms (Loir and Mollo, 2008). CO₂ emissions seem independent from NH₃ and N₂O emissions, as no correlation was observed. Ponds had a stable gradient of NH₃, and some had an increase in the N₂O gradient. Higher emissions of gaseous N compounds were observed when urea and wheat bran were associated with pond supplementation or with high fish density.

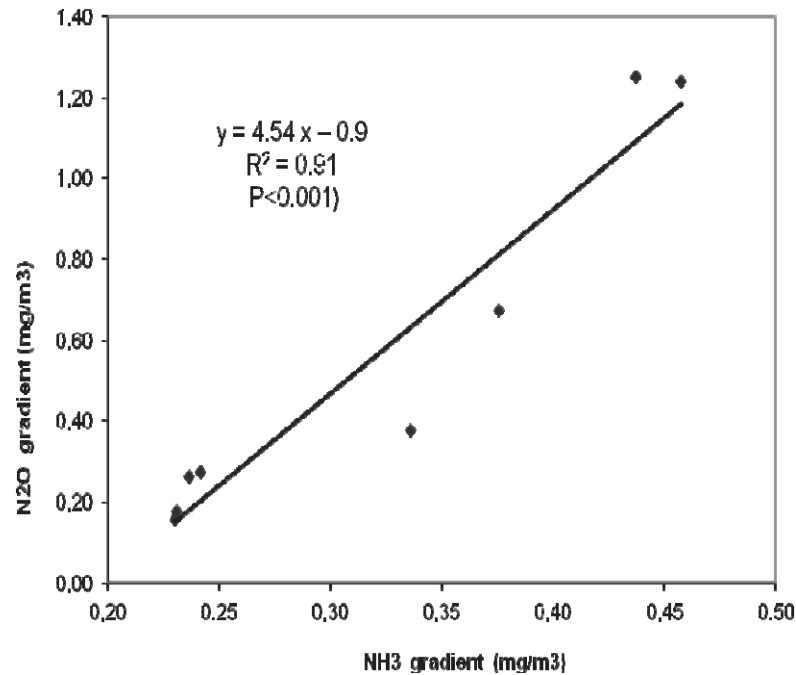


Figure 1: Correlation between NH₃ and N₂O emission gradients of tropical polyculture ponds with different levels of inputs, fertilizers and fish densities.

This result reveals that more nitrogen inputs per unit area leads to more recycling but relatively stable concentrations of NH₃ in water and gas emissions. This is confirmed by the strong positive correlation between NH₃ and N₂O gradients (Fig. 1).

Additionally, more nitrogen input into the system would lead to the production of more dissolved NH₃ (mineralization and excretion) and thus a higher NH₃ gradient. In this case, NH₃ does not accumulate because it is processed more intensively in the pond food chain, hence the increased N₂O gradient (due to nitrification and denitrification). This transformation could induce high concentrations of nitrites toxic to fish, but the high fish productivity indicates that nitrite quantities are below the toxic limit. The increase in nitrogen transformation is a consequence of its assimilation in the trophic chain, which supports the assembling of polycultures to optimize available resources (Verdegem, 2007; Rahman et al., 2008; Verdegem and Bosma, 2009; Efole Ewoukem, 2011) and build sustainable fish farming.

CONCLUSION: Pond management had a clear influence on daily emissions of CO₂, CH₄, NH₃, and N₂O. The CO₂ gradient increased with fish density. The NH₃ and N₂O gradients were correlated, and both increased with nitrogen inputs. A high CO₂/NH₃ ratio indicated a reduction in NH₃ emissions whenever nitrogen-based feeds are used. Lower nitrogen losses were assumed to result from higher nitrogen recycling. The CH₄ sink has been hypothesized to be linked to photosynthetic activity producing O₂ in the water. Pond management can both improve feed efficiency of fish production and reduce NH₃, N₂O and CH₄ emissions.

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