Greenhouse off-gas emissions under temporary nitrogen overloading in a full scale WWTP adopting intermitted aeration

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Abstract
Greenhouse Gas (GHGs) emissions are emitted during the biological wastewater treatment and the emissivity may vary because of different designs and operational conditions of the WWTPs. In this study, N_2O and CH_4 off-gas emissions were measured in a full scale WWTPs (40.000 PE) under the typical diurnal flowrate fluctuations and when the anaerobic supernatant from the dewatering operations were released. The result showed that the shock of nutrient loadings in the mainstream generates increase the N_2O emissivity up to 330 mgN/m^2 h, while the aeration stripped CH_4 from the wastewater up to 5000 mgCOD/m^2 h. Separate biological nitrogen removal in the downstream of the anaerobic digestion could decrease and reduce the fluctuation of the nitrogen loadings in the mainline.
Keywords
Greenhouse gas emissions, N_2O emissions, nitrification, denitrification

INTRODUCTION. Wastewater treatment processes produce the three major greenhouse gases (CO_2, CH_4 and N_2O) that cause global warming. However, N_2O and CH_4 contribute for the global warming potential approximately 300 and 25 times respectively greater than that of CO_2 (Houghton et al., 2001). Global emission rates from sewage treatment were estimated at 0.22 TgN_2O-N/year for 1990, accounting for about 3.2% of the anthropogenic N_2O emissions. The main causes of N_2O emission were attributed by the AOB activity (nitritation) with low DO levels, high NO_2^- concentrations and variation of the ammonia loading rate. The wastewater flowrate influent in the WWTP, tends to follow a diurnal pattern that results in a variation of the nutrients loading rate, especially when the anaerobic supernatants from the dewatering operations are also released in a short time in the mainstream. In this work, the off-gas emissions were measured in a full scale WWTP with the aims to evaluate the impact of the daily nutrients variations on N_2O and CH_4 emission.

MATERIAL AND METHODS. The off-gas measurement were carried out in Carbonera WWTP (Veneto Region, North of Italy), which treats around 15.000 m^3/d of municipal wastewater. The nitrification and denitrification is accomplished by time based-intermitted aeration in a Schreiber bioreactor (volume 6000 m^3), with the following working sequence: 1 h anoxic, 6 h aerobic, 1 h anoxic. The sewage sludge (primary and secondary) were anaerobically treated resulting in 75 m^3/d of nitrogenous reject water, which were discharged in the mainstream for 5 days per week with a flowrate between 60-80 m^3/d. The characterization of the influent and the anaerobic supernatant during the sampling days (period June-July 2015) were reported in table 1.

Table 1. Characteristics of the sewage influent and the recycled anaerobic reject water of the WWTP with relatives loads.

Parameters	Influent WWTP		Anaerobic Supernatant		%Incidence
	Av.±SD (mg/L)	Load (kg/d)	Av.±SD (mg/L)	Load (kg/d)	%
Flowrate		15400 m^3/d		75 m^3/d	
Total COD	183±15	2818	255±23	17±	5
Total N	21.8±0.8	336	645±14	49±	16
Total P	2.0±0.1	31	50±4	4±	13

As far as off-gas emissions are concerned, the N_2O and CH_4 from the surface of the SBR tank were captured from a static chamber and then measured and on-line determined using the Bruel and Kjaer photo-acoustic analyzer (Type 1302, Copenhagen, Denmark). The emission rates for each compounds were calculated according with (Chiumenti et al., 2007)

RESULT AND DISCUSSION. N_2O emissivity increased during the aerobic phase due to the low DO concentration (DO range mg/L) and the extensive aeration phase length. Moreover, CH_4 is accumulated during the anoxic phase and when aeration start a peak of emission was observed. (Figure 1b). The cumulative emissions reported in Figure 2 (a and b) aim to quantify the total specific emissions at the end of the treatment cycle: the observed emissions were 1.7 gN/m^2 and 9.1 gCH_4/m^2 for N_2O and CH_4 respectively. At this conditions, the annual global emissions were estimated at 54 gN/AE y and 71 gCH_4/AE y.

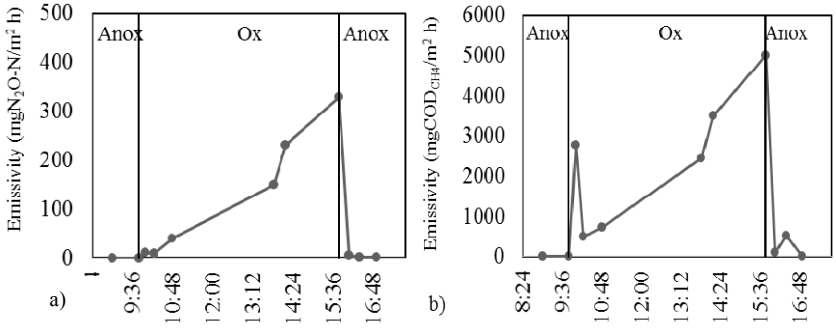

Figure 1. Profile of instantaneous emissivity of N_2O and CH4 during a treatment cycle of intermittent aeration.

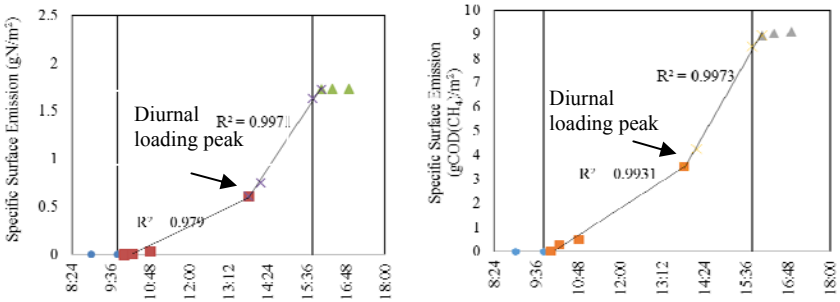

Figure 2. Cumulative Specific Surface Emissions of N_2O and CH_4 during a treatment cycle of intermittent aeration.

CONCLUSIONS

Extensive aeration length and shock of the nutrients loading due to the release of the anaerobic supernatant may cause increasing of N_2O and CH_4 emissions in the mainstream during the wastewater treatment. The separate treatment of the anaerobic supernatant could reduce the nutrients overloadings and mitigate the GHG emissions in the mainline.

REFERENCES.

J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, C. Johnson, Climate change 2001: the scientific basis, 2001.

Mosier A, Kroeze C, Nevison C, Oenema O, Seitzinger S, van Cleemput O: An overview of the revised 1996 IPCC guidelines for national greenhouse gas inventory methodology for nitrous oxide from agriculture. Environ Sci Policy 1999, 2:325-333.

Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990–2020, Office of Atmospheric Programs Climate Change Division, US-EPA, Washington, June 2006.

Joachim Desloover, Siegfried E Vlaeminck, Peter Clauwaert, Willy Verstraete and Nico Boon. Strategies to mitigate N2O emissions from biological nitrogen removal systems. Current Opinion in Biotechnology 2012, (23) 474–482.