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ATRAZINE ATTENUATION AND MICROBIAL RESILIENCE DURING INTENSIVE IN-VESSEL COMPOSTING OF BIODEGRADABLE WASTE

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Introduction

Pesticide residues may enter composting systems with treated plant material or food-related biowaste. Intensive in-vessel composting provides controlled temperature, moisture and mixing that can favor contaminant transformation, but xenobiotic stress may also disturb microbial functions governing nitrogen and phosphorus cycling. This study evaluated the attenuation of extractable atrazine together with the response of selected functional microbial markers during thermophilic in-vessel composting.

Materials and methods

Four closed reactors (about 10 L useful volume) were operated in parallel; atrazine treatment A1-A2 and biological controls B1-B2 were run in duplicate. The feed contained about 51.5% freshly cut grass, 45% food residues and 3.5% poultry manure, with approximately 10 kg biodegradable material processed per reactor. After a three-week conditioning stage, atrazine was nominally added at 0.1 mg kg^{-1} dry matter. Temperature was maintained at 45-55°C (target 50±5°C), moisture at about 50-60%, and the material was mechanically mixed. Because solid-phase recovery immediately after spiking was below the nominal dose, attenuation was calculated from measured extractable atrazine, using day 1 (81.35 µg kg^{-1}) as the analytical reference. DNA was extracted with DNeasy PowerSoil Pro and qPCR was performed on QuantStudio 7 using SYBR Green chemistry. Ct values were interpreted only within the same target assay; lower Ct indicates earlier amplification, not direct metabolic activity.

Results and conclusions

Measured extractable atrazine increased from 61.40 µg kg^{-1} DM at T0 to 81.35 µg kg^{-1} after 24 h, consistent with progressive homogenization/extraction, and then decreased rapidly to 25.75 µg kg^{-1} at day 11, 14.70 µg kg^{-1} at day 14 and 4.69 µg kg^{-1} at day 22. Relative to the day 1 analytical maximum, calculated apparent attenuation was 68.3%, 81.9% and 94.2%, respectively. The minimum measured concentration was 1.23 µg kg^{-1} at day 60 (98.5% attenuation), followed by 4.285 µg kg^{-1} at day 81 (94.7%). The late fluctuation indicates that redistribution, desorption, matrix heterogeneity or extraction variability may contribute to the measured profile; therefore, a simple mineralization model is not justified.

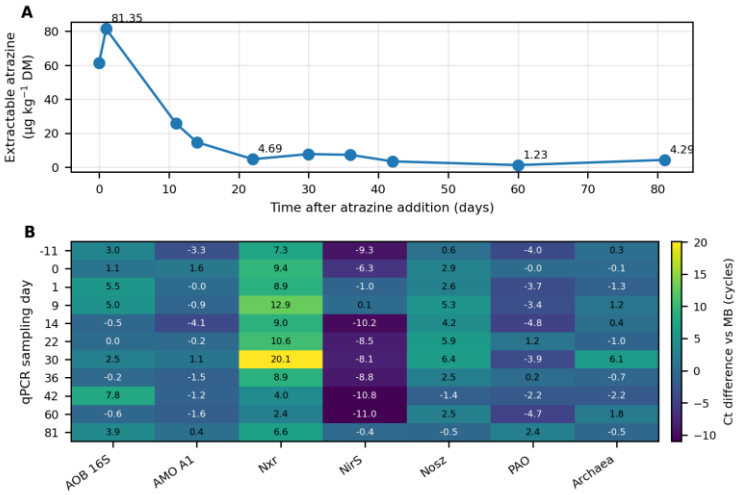


Figure 1 - Atrazine attenuation and microbial-marker response. (A) Measured extractable atrazine. (B) Ct difference versus biological reference MB for selected functional targets; negative values indicate earlier amplification than MB within the same assay.

The qPCR time series showed transient but non-persistent shifts in functional markers. *AMOA1* Ct changed from 20.83 at T0 to 15.19 at day 14, 17.72 at day 60 and 19.71 at day 81; *Nxr* changed from 22.12 at T0 to 15.15 at day 60 and 19.36 at day 81. The archaeal marker remained close to its initial range (23.34 at T0; 22.95 at day 81), while *Nosz* showed an oscillatory response and reached Ct 15.74 at day 81. These patterns are compatible with disturbance followed by recovery or reorganization of key nitrogen-cycle populations, rather than sustained inhibition.

Overall, thermophilic in-vessel composting strongly reduced the extractable atrazine fraction while maintaining a resilient functional microbial community. However, the experiment demonstrates attenuation, not complete mineralization: metabolites were not included in a mass balance, and residual concentrations fluctuated during maturation. Recovery-corrected atrazine/metabolite analysis and matrix-spike controls are therefore required for definitive treatment-performance assessment.

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