Elimination of Trace organic contaminants (TrOCs) from biosolids: Influence of different pretreatment methodologies prior to *Bacillus subtilis* digestion

Vasanth Kumar Vaidyanathan[a], Hubert Cabana[a]*,

[a]*Faculté de Genié, Université de Sherbrooke. Sherbrooke, Quebec. Canada.*

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Email address: vasv2201@usherbrooke.ca

Abstract:

The humongous volumes of biosolids (BS) from Wastewater Treatment Plant (WWTP), generated at an annual rate of 660000 metric tons in Canada, has to be either disposed or land-applied (Environment Canada 2012). However, owing to the strict laws levied by the Canadian Council of Ministers towards environment protection, this contaminant-laden BS can neither be land-filled nor put into land application without stabilization (Environment Canada 2009). Moreover, BS serves as a crucial channel in the transfer of trace organic contaminants (TrOCs) from the wastewaters to the soil, which has considerably catechized the quality of the BS (Xia *et al*., 2010). This BS evidently has the incidence of multiple TrOCs, like pharmaceuticals, pesticides and personal care products (Xia *et al*., 2005). This stumbling blocks accentuate the inefficiency of WWTPs in removing these contaminants and the exigency to implement new ameliorated processes to address the challenge posed by the presence of TrOCs in BS. In this context, BS valorization strategies along with bioaugmentation have leapt out, which are crucial in BS management, but exhibiting several limitations. Several pre-treatment (PT) processes were developed to address these limitations.

In this present study, effect of different PT technologies over TrOCs concentration and their subsequent removal during bioaugmentation by *Bacillus subtilis* was evaluated (Table 1). The removal of TrOCs in BS was evaluated based on the removal of phenols, pharmaceuticals and pesticides. It was observed that, out of 76 TrOCs analyzed, 10 pharmaceuticals (176 µg/kg), 3 phenolic compounds (0.6 mg/kg) and 1 herbicide (6 µg/kg) were detected in the BS. From the study on the *Bacillus subtilis* treatment for 28 days, 64% removal of TrOCs with 12% solid reduction was pronounced. With an attempt to escalate this aerobic digestion, various PT, including alkali, ultrasonication, freeze-drying, enzymatic were employed for the treatment of BS. Alkali PT of the BS allowed a satisfactory removal of 78% TrOCs, but the high alkalinity of the BS had an adverse effect on its microbial community. The freeze-drying PT methodology of BS, followed by aerobic digestion, abetted the improvement of lignocellulolytic enzyme cocktail production leading to an increase in TrOCs removal of 69% and 46% solids reduction. On the contrary, the enzymatic PT methodology enhanced the digestion of BS, which further aided in improving the lignocellulolytic enzyme cocktail production (laccase- 237 U/L, lipase-285 U/L, protease- 782 U/L, phosphatase- 505 U/L) that led to 17.21% solid reduction and 86% overall TrOCs removal; which evinces the significance of the PT processes. Among the tested PTs, the enzymatic PT methodology stands out as an unparalleled approach to improve the TrOCs removal through their solubilization and increased bioavailability, providing a feasible management strategy for the valorization of BS in WWTP.

Reference:

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Table 1. Bioaugmentation effect of *Bacillus subtilis* on various pre-treatment strategies on solid reduction and TrOCs removal

Pre-treatment	Total Solids	Phenols [c]	Pharmaceuticals[a]	Pesticides[b]
Control	12.2±1.6	60.8±2.1	53.4±0.9	78.6±1.2
Sonication	18.6±1.7	51.4±3.6	63.1±1.7	82.0±2.8
Freeze-drying	46.0±2.2	42.2±1.2	84.3±1.4	81.9±3.8
Enzymatic	17.2±0.7	70.9±1.9	90.5±3.8	96.8±1.9
Alkali	33.6±1.9	66.3±2.1	84.4±0.9	83.1±1.5

[a] Removal of ten pharmaceutically active compounds (Acetaminophen, Carbamazepine, Trimethoprim, Naproxen, Ifofsamide, Caffeine, Ibuprofen, Atenolol, Ketoprofen, Cyclophosphamide) from an initial concentration of 176 μg/kg of BS

[b] Removal of pesticide (Diuron) from an initial concentration of 6 μg/kg BS

[c] Removal of three phenolic compounds (phenol, 2-nitrophenol, 4-nitrophenol), from an initial concentration of 0.6 mg/kg BS