Anthropogenic Organic Compounds in Biosolids

Kang Xia*, and Greg Pillar
[1]Department of Crop and Soil Science, The University of Georgia
*** corresponding author:** email: kxia@uga.edu; phone: (706) 542-0899

INTRODUCTION

The continued exponential growth in human population has created a corresponding increase in generation of biosolids, end product of wastewater treatment plants (WWTPs). Currently there are more than 16,000 public owned domestic wastewater treatment plants, serving 72% of the population in the United States. These WWTPs generate more than 40 million tons of biosolids annually (EPA, 1999).

Due to their close association with human activities, biosolids often serve as a sink for anthropogenic organic chemicals and their partial metabolites that cannot be completely degraded during the wastewater treatment processes (La Guardia, 2001; Bhandari and Xia, 2003; Keller et al., 2003). Land application and landfilling are commonly used for biosolids disposal (EPA, 1999). However, these biosolids disposal practices could pose a high potential of continuously introducing anthropogenic organic chemicals into the water resource due to surface runoff and leaching.

A variety of anthropogenic organic chemicals were identified in the biosolids collected from 12 WWTPs, serving rural, industrial, and urban communities, in Georgia and South Carolina.
4-nonylphenol (4-NP), a non-naturally occurring endocrine disruptor, is one of the most detected organic chemicals. Its level was detected at as high as 1400 mg kg^{-1} in biosolids from a WWTP serving an industrial community. Approximately 2.2% of 4-NP in this biosolids was easily leachable.

To protect the environment especially our water resources, there is an urgent need for better understanding of the behavior, fate, and transport of anthropogenic organic chemicals in biosolids.

OBJECTIVES

- **To investigate the occurrence of anthropogenic organic chemicals in biosolids**
- **To test the leachability of target organic chemicals in biosolids.**

MATERIALS & METHODS

- **Biosolids and compost samples were collected from 12 WWTPs in Georgia and South Carolina (Table 1).**
- **5 grams of freeze-dried sample was extracted using 20 mL hexane/acetone (1:1 V:V) on an accelerated extraction system (ASE 100, Dionex).**
- **1 mL extract was analyzed on a GC/MS/ using electron impact at 70 eV at a MS range of 40 – 500 u. Chromatogram peaks were qualified using NIST database.**
- **To mimic the biosolids/water mixture that would occur during surface runoff or subsequent leaching from soils, biosolids were mixed with synthetic rain water, comparable to that found within most areas of Georgia, at 1:4 ratio (W:V ratio), stirred for 1 h, and filtered (120 μm mesh) to collect elutriate.**
- **Target compounds in the elutriate were extracted using C18 solid phase extraction, concentrated and analyzed using the same GC/MS analytical method for biosolids samples.**

RESULTS

Table 1. Characteristics of the WWTPs investigated

WWTP Code	Location	Population served	Community served	Wastewater treatment
1	GA	33,000	Mostly residential	Aerobic
2	SC	125,000	Textiles and refractory industry	Anaerobic
3	SC	30,000	Mostly residential	Aerobic
4	GA	60,000	Mostly residential	Aerobic
5	SC	50,000	Mostly residential	Aerobic
6	GA	25,000	Mostly residential	Aerobic
7	GA	40,000	Mostly industry	Anaerobic
8	GA	70,000	Urban residential area	Aerobic
9	GA	30,000	Mostly residential	Anaerobic
10	GA	29,000	Residential and industry	Aerobic
11	GA	600,000	Urban area and industry	Anaerobic
12	GA	175,000	Residential and industry	Anaerobic

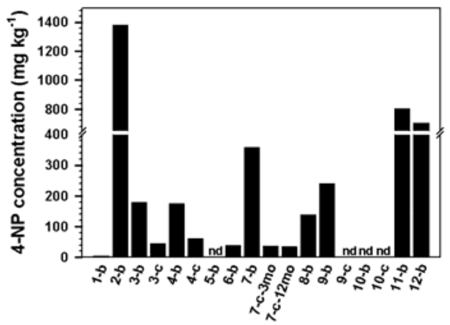

Figure 1. Concentrations of 4-NP in biosolids and composts from selected WWTPs in Georgia and South Carolina. The numbers indicate the WWTP code. b, biosolids; c, compost; c-3mo, biosolids composted for 3 months; c-12mo, biosolids composted for 12 months; nd, not-detectable.

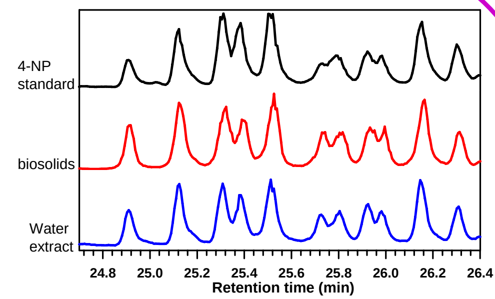

Figure 2. GC chromatogram for 4-NP isomers in 4-NP industrial standard (black line), biosolids from WWTP #11 (red line), and simulated rain water extract of biosolids #11 (blue line). The identical distribution pattern of 4-NP isomers among the 3 samples indicates waste water treatment processes did not alter the chemical nature of 4-NP.

Table 2. Selected identified organic chemicals in biosolids

Compound name	CAS #	Use	Toxicity
3,5-Dimethylaniline	108-69-0	Intermediate used in manufacture of azo dyes	LC_{50} (48h)=17 mg L^{-1} for medaka fish (Tonogai et al., 1982)
2-Isopropyltoluene	527-84-4	Solvents, synthetic-resin manufacture, metal polishes, organic synthesis	Possibly cause Chromosome damage (NIH)
4-methyl-phenol (p-Cresol)	106-44-5	solvent, disinfectant and chemical intermediate in the production of synthetic resins	possible human carcinogen (EPA, 1990), LC_{50} (24h)=21 mg L^{-1} for Crucian Carp (Verschueren, 1983)
3-Methylindole	83-34-1	Perfume and Food flavoring additive	Toxic to lung tissues (Regal et al., 2001), Ecotoxicity is unknown
2,3-dichloroaniline	608-27-5	Dye and pharmaceutical ingredient, pesticides	LC_{50} (96h)=2.3 mg L^{-1} for amphipod (EPA, 1988)
1-(1-chloroethenyl)-2-methyl- benzimidazole	78708-24-4	fungicides	Ecotoxicity is unknown
4-nonylphenol isomers	104-40-5	Metabolite of surfactant, plastic and rubber stabilizer, demulsifier	Endocrine disruptor
Benz[a]anthracene	56-55-3	products of incomplete combustion of wood	probable human carcinogen; LC_{50} (96h)=5 μg L^{-1} for Daphnia pulex (Trucco et al., 1983)
1,1,4,4-Tetramethyl-6-ethyl-7-acetyltetralin	88-29-9	Synthetic musk found in fabric softner	Not available
Anthraquinone	84-65-1	Geese repellent	Not available

CONCLUSIONS

- **The wastewater treatment processes in WWTP are not effective in degrading certain anthropogenic organic chemicals.**
- **Various anthropogenic organic chemicals were identified in biosolids and composts from the selected WWTPs (Table 2).**
- **4-NP was detected in biosolids from most of the WWTPs (Figure 1), up to 1400 mg kg^{-1} 4-NP in biosolids from WWTP #2. This level is more than 100 times higher than the current European Union limit for 4-NP in biosolids.**
- **WWTP #2 receives influent mainly from local textile and refractory industry. The biosolids generated from this WWTP are disposed of through landfilling.**
- **Lower levels of 4-NP were detected in biosolids from WWTPs that treat mostly residential wastewater than those that receive mainly industrial wastewater. This suggests that industry is likely the major source of 4-NP in biosolids.**
- **The composting process decreases the 4-NP content significantly, from 65% to 100% (Figure 1). Composting of biosolids is most likely a cost effective means for reducing organic chemicals in biosolids.**
- **Approximately 2.2% of 4-NP in biosolids was extracted using synthetic rainwater (Figure 2), indicating the leachability potential of 4-NP.**