Annual Report

NE 1001 Meeting June 2001

Administrative Advisor:	**Co-Chairs:**	**Secretary:**
Daniel Decker	Ellen Harrison	Michael Payne
Cornell University	Cornell University	Ontario Ministry
	Robert Tate	
	Rutgers University	

The Annual Meeting of NE 1001 was held at the University of New Hampshire in Durham, NH on June 11-12, 2001.

Attendees: Dan Decker, Cornell; Herschel Elliott, PSU; Bill Goldfarb, Rutgers; Beverley Hale, U of Guelph; Robert Hale, William & Mary; Ellen Harrison, Cornell; Anthony Hay, Cornell; Uta Krogmann, Rutgers, Mark LaGuardia, William & Mary; Aaron Margolin, UNH; Murray McBride, Cornell; Bill McDowell, UNH; Michael Payne, OMAFRA; Brian Richards, Cornell, Rose Mary Seymour, UM; Tammo Steenhuis, Cornell; Richard Stehouwer, PSU; Bradley Striebig, PSU; Robert Tate, Rutgers; Stefan Seiter, UNH; Christine Bean, UNH; Jacqueline Brabants, UNH; Peng Chen, UM; Jennifer Hargreaves, U of Guelph; Tony Ho, MOE; Maya Panangadan, UM; Bill Trumble, UNH

Meeting commenced at approximately 8:15 on June 11 with a welcome from the NE1001 chair, Ellen Harrison and introductions around the table. The meeting agenda was reviewed and approved.

Significant progress in meeting the project objectives was made over the year. Refer to the summaries of presentations in the Appendix to this report.

Objective 1. To evaluate the utilization of sewage biosolids in soil management in the Northeast by assessing the sustainability of soil quality, water quality and food safety (for people and other animals) where sewage biosolids are applied to agricultural land.

Project Progress: Research results for the following work were reported:

Phosphorus leaching from biosolids amended soils – Herschel Elliott, PSU

Long term leaching of trace elements – Brian Richards, Tammo Steenhuis, Cornell

Effects of long term biosolids applications on nitrogen & trace metal levels in ground water – Bill McDowell, UNH

Brominated diphenyl ether flame retardant levels in land-applied sewage sludges – Rob Hale, William & Mary

Nonyphenols in NYS sludges – Anthony Hay, Cornell

Alkylphenol ethoxylate degradation products in land applied sewage sludge – Mark LaGuardia,

Molybdenum in NYS soils and crops to which sludges have been applied – Murray McBride, Cornell

Alfalfa molybdenum uptake using an N-Viro alkaline sludge – Richard Stehouwer, PSU

Evaluation of enteric virus, protozoan and helminth persistence in class B limed sludge – Jacqueline Brabants, UNH

Survey of Wastewater Solids to Assess the Prevalence of Cryptosporidium and Giardia Species and Ascaris lumbricoides – C.L. Bean, J.J. Brabants, and A.B. Margolin, UNH

Objective 2. To evaluate the legal, social, and political aspects of long-term utilization of sewage sludge products in the Northeast and to identify modes of stakeholder participation in biosolids utilization decision-making.

Project Progress: Research results for the following work were reported:

Effects of process changes on odorant emissions from biosolids; a case study – Bradley Striebig, PSU

Land application of sewage sludge: Perceptions of New Jersey vegetable farmers – Uta Krogmann, Rutgers

***Recent developments in sludge management* law –** Bill Goldfarb, Rutgers

Local ordinances on land application – Ellen Harrison, Cornell

Ontario update – Michael Payne, OMAFRA

Transmission of microbial organisms, VOC's & odor from biosolids via soil & air – Tony Ho, MOE

Objective 3. To develop appropriate outreach materials and educational events for the Northeast that links the current research to actual field management of sewage biosolids products in the Northeast.

Project Progress:

Creation of a website for the project is underway.

An Extensionsubcommittee was formed to work on extension materials.

AGENDA NE 1001 Meeting June 11-12, UNH, Durham, NH

June 11

8-8:30 Introductions

Review meeting agenda

8:30 – 10:15 Water quality:

Elliott (PSU): Phosphorus leaching from biosolids-amended soils.

Richards (Cornell): Long term leaching of trace elements

Steenhuis (Cornell): Field and laboratory studies of leaching

McDowell (UNH): Effects of long-term biosolids applications on nitrogen and trace metal levels in groundwater.

10:15-10:30 BREAK

10:30-12 Organics:

Hale, R (Wm and Mary): Brominated diphenyl ether flame retardants background levels in land-applied sewage sludges

Hay (Cornell): Nonylphenols in NYS sludges

La Guardia (Wm and Mary): Alkylphenol ethoxylate degradation products in land-applied sewage sludges in land applied biosolids

12 -1 LUNCH

1-2:30

Update on current and new research and extension projects – open to all participants to share information

2:30-2:45 BREAK

2:45-3:45 Molybenum

McBride (Cornell): Molybdenum in NYS soils and crops to which sludges have been applied

Stehouwer (PSU): Alfalfa Molybdenum uptake using an N-Viro type alkaline sludge.

3:45-5:15 Perception, Legal and Regulatory Issues:

Krogmann (Rutgers): Land Application of Sewage Sludge: Perceptions of New Jersey Vegetable Farmers

Goldfarb (Rutgers): Recent Developments in Sludge Management Law

Harrison (Cornell): Local Ordinances on Land Application

Hale, B (Guelph): Ontario Update

7 PM DINNER

June 12

8 –9 Airborne Contaminants

Striebig (PSU) Effects of process changes on odorant emissions from biosolids; a case study

Payne and Ho (OMFRA) Discussion of tramsmission of mircobial organisms, VOCs and odor from biosolids via soil and air

9 –10 Pathogens:

Brabants (UNH Margolin student): Evaluation of Enteric Virus, Protozoan, and Helminth Persistence in Class B Limed Sludge".

Bean (UNH): Survey of Wastewater Solids to Assess the Prevalence of Cryptosporidium and Giardia

10-10:15 BREAK

10:15-12

Updates on current and new projects (continued if needed from June 11)

Developing Collaborative Research

12-12:45 LUNCH

12:45-2 PM

Future meeting of NE 1001 - European connection?, discuss outside attendees

Report on other meetings/activities (eg. Emerging Pathogens Workshop; W-170, NRC panel)

Consideration of NE 1001 officers

Brief summaries of the presentations given throughout the 2 days are attached as appendices.

The June 11 afternoon session began with researchers and extension personnel giving brief updates on current and new projects. Dr. Bev Hale, U of Guelph, discussed a study looking at the fate of the Ontario regulated metals from land applied sewage biosolids. This is a work in progress that is also looking at mercury evasion. Rose Mary Seymour, U of Maine talked about a proposed study to look at the fate and movement of nutrients from biosolids (sewage biosolids + papermill biosolids) stockpiles. The study will work with field scale stockpiles and use lysimeters to collect leachate & infiltrate from the piles. Michael Payne, OMAFRA then discussed a current research study looking at runoff and leachate from smaller scale piles of dewatered sewage biosolids. In this study the DSB is stored on plastic sheets with a central leachate collection well. Runoff and leachate samples are being analyzed for nutrients, regulated metals and pathogens.

After the presentations there was a short discussion on the need for a “template” approach to describing sewage biosolids either used in reported research or transferred to a cooperating facility.

The template info need to include information on the type of waste stream(s), treatment process (aerobic, anaerobic, extended aeration, BNR, etc), treatment chemical additions (Al, Fe, polymers, etc), etc. Research papers often do not include this information which may be critical to understanding different results.

This followed with a discussion on sample preservation. Depending on the analysis to be performed, a different type of sample preservation may be required. One of the goals of the committee is to have different researchers work on common sludge and soil sources. There was general agreement that a protocol needs to be developed regarding the preservation of the various biosolids materials for the various testing that may be performed.

The day concluded with presentations on the issue of Molybdenum and a session on the perception, legal and regulatory issues around sewage biosolids land application (presentation abstracts attached in appendices).

Day 2, June 12 started with presentations on airborne contaminants and pathogens (attached as appendices). The remainder of the meeting was devoted to new issues, further steps and the future direction of NE1001.

NRC Panel report: Ellen Harrison gave a brief update on her involvement in the National Academy of Science committee that has been charged with the review, evaluation and recommendation regarding the risk assessment process used for chemical and pathogenic contaminants. The committee will review the risk assessment process with regards to human health to determine the appropriateness of the process. The final report is expected in March 2002.

Emerging Pathogens Workshop report – Aaron Margolin,UNH

- held in Cincinnati, 60 participants
- divided into 6 groups – bacteria, viruses, protozoa, biosolids, livestock manure
  - each group given a task list and requested to develop research/information needs
- final report
  - all groups very similar in recommendations
  - do not have knowledge to base rules on
    - many rules based on ability to regulate
    - lack of knowledge/data/research
  - currently tested organisms are not sufficient as indicators of current pathogen concentrations
  - need for more research
    - crossover contamination from livestock to humans
      - Hepatitis E in hogs —pregnant females
  - antibiotic resistance
    - concern but low priority because of lack of fundamental information

Other discussion topics included:

* how to alleviate public concerns over land application
  - use of adaptive regulations
  - move to Class A biosolids
    - cost issues
    - is Class A safe enough – pathogen regrowth questions
  - 503 allows state to be more restrictive
    - there are concerns with regional standard setting
      - inconsistency across jurisdictions

Future direction of NE1001

- how to join committee
  - request through State Research Director
- election of officers
  - the secretary requested to be replaced
  - Dan Decker will develop nominations for chair/co-chairs and secretary
  - nominations & elections to be done by email

Action: Decker to develop nominations and election process

- ➥ future meetings
  - research updates
    - need to establish standard forum for exchange of information
  - need to determine an appropriate method to develop extension recommendations
  - possibility of guest speakers
  - maintain 1 – 2 day format with _ day workshop
  - next meeting in Toronto in June 2002

    ➥ **Action: Payne and B. Hale to work on location**
  - need to get research information/results into extension format
  - establish NE1001 extension subcommittee
    - Uta Krogmann, Ellen Harrison, Michael Payne, Richard Stehouwer
    - consider regional workshops / symposiums with co-operative extension staff invited
  - committee members are to send Uta Krogmann extension materials
- ➥ need for development of information above & beyond Reg.503 as opposed to criticizing the reg
  - need to develop BMP's for the NE
  - BMP's need not be policy
- ➥ potential additions to the committee
  - natural resources economist – John Holstead UNH
  - pathogen risk assessment specialist - Chuck Haas
  - public health specialist – Bill Halperin, Rutgers

    ➥ **Action: Harrison to follow up**
- ➥ potential to work together to multiply both dollars and results
  - there is a need for co-operation to enhance projects
  - possible move towards IFIS grants
    - Bill Trumble to investigate eligibility of NE1001 projects
      - ♦ need multistate collaborative projects

♦ **Action Bill Trumble**

* there was a discussion on the use of byproducts and residuals in land application
- ➥ Richard Stehouwer is developing a chapter on other wastes for PSU Agronomy Guide
- ➥ byproducts & residuals are out of scope of this committee
- ➥ Uta Krogmann, Robert Tate, Ellen Harrison & Michael Payne agreed to assist Richard with information

♦ **Action: Richard Stehouwer**

* Consideration of a conference co-sponsored by NE1001. Bill Goldfarb & Uta Krogmann agreed to look into who is doing what with respect to biosolids conferences and inform committee members

♦ **Action: Uta Krogmann & Bill Goldfarb**

* The potential usefulness of a clearing house for information on use of off-farm residuals in agriculture (such as wall board, dredge materials) was discussed. Harrison, Krogmann, McBride, Payne, Elliott and Stehouwer expressed interest.

Meeting adjourned at approximately 1 PM on June 12, 2001.

Presentation Abstracts / Handouts / Meeting Notes

Annual Meeting of NE 1001, June 11-12, 2001, University of New Hampshire
Research Pertaining to Objective 1: To evaluate the utilization of sewage biosolids in soil management in the Northeast by assessing the sustainability of soil quality, water quality and food safety (for people and other animals) where sewage biosolids are applied to agricultural land.

Phosphorus leaching from biosolids amended soils – Herschel Elliott, PSU

Laboratory and greenhouse column studies were conducted to characterize P forms and leachability of eight biosolids, a chicken manure (CM) and commercial fertilizer (triple superphosphate, TSP). Bahiagrass (*Paspalum notatum Flugge*) was grown for 4 mo on two acid, P-deficient Florida sands, representing both moderate (Candler series, hyperthemic, Typic Quartzipsamments) and very low (Immokalee series, hyperthermic, Arenic Aloquods) P-sorbing capacities. Amendments were applied at equivalent total P rates of 56 and 224 kg P ha^{-1}, simulating P-based and N-based nutrient loadings, respectively. Leachate P from all columns was dominantly inorganic and generally much lower for biosolids P-sources than for TSP. For the Candler soil, only TSP at the 224 kg P ha^{-1} rate exhibited P leaching statistically greater (α=0.05) than control (soil-only) columns. For the high P rate and low P-sorbing Immokalee soil, TSP and CM leached 21% and 3.0% of applied P, respectively. Leachate P for six biosolids was <1.0% of applied P and not statistically different from controls. The Largo biosolids, generated from a biological P removal process, exhibited significantly greater leachate-P in both cake and pelletized forms (11% and 2.5% of applied P, respectively) than the other biosolids. Biosolids-P leaching was correlated to the P saturation index (PSI = $[P_{ox}] / [Al_{ox} + Fe_{ox}]$) based on oxalate extraction of the pre-applied biosolids. For biosolids with PSI ≤ ~1.1, no appreciable leaching occurred. Only Largo cake (PSI = 1.4) and pellets (PSI = 1.3) exhibited P leaching losses statistically greater than controls. The biosolids PSI appears useful for identifying biosolids with potential to enrich drainage P when applied to low P-sorbing soils.

Long term leaching of trace elements – Brian Richards, Cornell

Effect of sludge processing mode, soil texture and soil pH on metal mobility in undisturbed soil columns under accelerated loading

Brian Richards, Tammo Steenhuis and Murray McBride

Cornell University - NEC meeting update June 2001

The effects of sludge processing (digested dewatered, pelletized, alkaline-stabilized, composted, and incinerated), soil type, and initial soil pH on trace metal mobility are being examined using undisturbed soil columns. Soils tested are Hudson silt loam (Glossaquic Hapludalf) and Arkport fine sandy loam (Lamellic Hapludalf), at initial pH levels of 5 and 7. Sludges were applied during four accelerated cropping cycles (215 t/ha cumulative application for dewatered sludge; equivalent rates for other sludges), followed by four post-application cycles. Also examined (with no sludge applications) are Hudson soil columns from a field site that received a heavy loading of sludge in 1978. Romaine *(Lactuca sativ*a) and oats *(Avena sativ*a) have been planted in alternate cycles, with oats replaced by red clover *(Trifolium pratens*e) for cycle 7 and later. Soil columns are watered with synthetic acid rainwater; percolates are analyzed for trace metals (by ICP spectroscopy), electrical conductivity and pH.

Twelve cropping cycles (Cycle 10a and 10b were two separate crops) have been completed, with metals data from the most recent cycle still being processed. Leachate and soil pH were substantially depressed in dewatered and pelletized sludge soil columns and increased for alkaline-stabilized and ash treatments. Acidification is proceeding in all columns due to accelerated leaching with synthetic acid rainfall. Columns with a target pH of 7 were thus limed after cycle 7 and again after cycle 11 to counter this; the pH 5 columns are being allowed to acidify, simulating unmanaged conditions soil pH levels in dewatered and pelletized sludge columns are dropping to or below 4.0 as a result.

Percolate metal concentrations continue to vary with sludge and soil treatments. Composted sludge and ash have the lowest overall metal mobilities. Dewatered and pelletized sludge had notable leaching of Ni,Cd and Zn in Arkport soils, especially at low pH. As of Cycle 10, percolate Zn concentrations are again increasing in the low pH columns as a result of the ongoing acidification. Alkaline-stabilized sludge had the widest range of percolate metals (relatively insensitive to soils) including Cu, Ni, B and Mo. Mo mobility from alkaline-stabilized sludge continues to increase as of Cycle 11. Old site column percolate concentrations showed good agreement with previous field data. Little leaching of P was observed in all cases.

Field & laboratory studies in metal leaching - Tammo Steenhuis, Cornell

* laboratory study looking at the movement of metals
  - set up columns containing sludge mixed with glass beads
  - no absorption on glass beads
  - incubate for 7 days @ 4, 16, 28 or 37C
    - S, Zn & Ni leach most quickly
    - Percolate pH as low as 1.6
  - irrigate for 16 hrs @ .35 cm/hr
  - have completed 6 cycles (incubation : rain)
  - analysis of leachate showed that metals are leachable but what happens in soil
    - concern with microbes decreasing pH & enhancing metal loss
      - biocide added to reduce microbial activity
        - biocide used may not have killed all microbes but in fact caused a shift in population though respiration decreased
* Field study
  - site - a dairy farm that had land applied on different fields: low rate of sewage biosolids; manure mixed with cheese processing waste; commercial fertilizer
  - sampled soil, percolate and stream water from manured/food waste and from biosolids fields
    - lysimeter water analysis showed similar metal concentrations in biosolids & manured sites

Effects of long term biosolids applications on nitrogen & trace metal levels in ground water – Bill McDowell, UNH

Effects of biosolids application on groundwater quality

William H. McDowell & Tamara J. Chestnut

A gravel pit reclamation and top-soil manufacturing site in Hooksett, NH was studied to determine if current management practices pose a threat to groundwater quality. The site has had repeated applications of biosolids on an annual basis since 1989 with top-soil removal approximately every five years. Materials were stockpiled on-site up to 9 months prior to application. The site was instrumented with groundwater monitoring wells within the biosolids application area, in an adjacent control field, and both up- and down gradient from the biosolids treatment area. Hydrologic and chemical characteristics of the groundwater were monitored on a bi-weekly basis during the growing season (April – November) and monthly during winter.

Our results suggest that some combination of repeated applications of residuals, stockpiling of residuals on site, or application after the growing season has resulted in unacceptably high levels of nitrate in groundwater at the Hooksett study site. Additional research would be needed to determine an effective management strategy to minimize impacts on groundwater. At present, a history of extensive stockpiling seems to be the most likely cause of elevated N in groundwater at the Hooksett site. The presence of low-nitrate groundwater under some portions of the reclamation site suggests that under some circumstances, repeated application of residuals does not cause any increases in groundwater nitrate levels. No increases in trace metal concentrations were observed in any treatment wells, despite modest declines in pH associated with high nitrate levels.

Note: powerpoint presentation also attached to electronic version and to be available on the NE1001 WWW site.

Brominated diphenyl ether flame retardant levels in land-applied sewage sludges – Rob Hale, William & Mary

Persistent pollutants in land-applied sludges

(This appeared as Brief Communication in Nature, July 12, 2001)

Disposal of sewage sludge by application to agricultural and other land is widely practiced and is resumed to be environmentally beneficial, but we have found high concentrations of an environmentally persistent class of organic pollutants, brominated diphenyl ethers (BDEs), in 'biosolids' from four different regions of the United States. These compounds are widely used as flame retardant, and their presence suggests that the environmental consequences of land application of biosolids need further investigation. We also frequently detected BDEs in wild-caught fish, indicating another pathway for human exposure.

Over half of the sewage sludge produced annually in the United States is applied to land, amounting to roughly 4 million tons in 1998 (ref. 1). Sludges are treated before application to reduce odor and pathogen content and their metal burden is regulated. But attention has focused less on persistent organic pollutants since usage of the most notorious (for example, polychlorinated biphenyls) has decreased and pretreatment of industrial waste water has improved [1,2].

We analyzed 11 biosolid samples before land application from Virginia, Maryland, New York State and California, and found that they all contained high concentrations of BDEs. These flame-retardant polymers are structurally similar to polybrominated biphenyls, the use of which was curtailed after a significant contamination incident in 1973 involving livestock feed in Michigan [3].

However, global consumption of BDEs continues to increase, reaching 67,125 metric tonnes in 1999 (refs 4, 5). The most bio-accumulative and toxic BDEs (those containing 4–6 bromine atoms) are being increasingly detected in humans and wildlife from both developed and remote areas [5–7]. These were present in significant amounts in the biosolids we examined and their relative contributions matched those in 'Penta', the commercial formulation used as a flame retardant in polyurethane foam (Fig. 1). North America accounts for about 98% of global demand for Penta, estimated at 8,290 tonnes in 1999 (ref. 4).

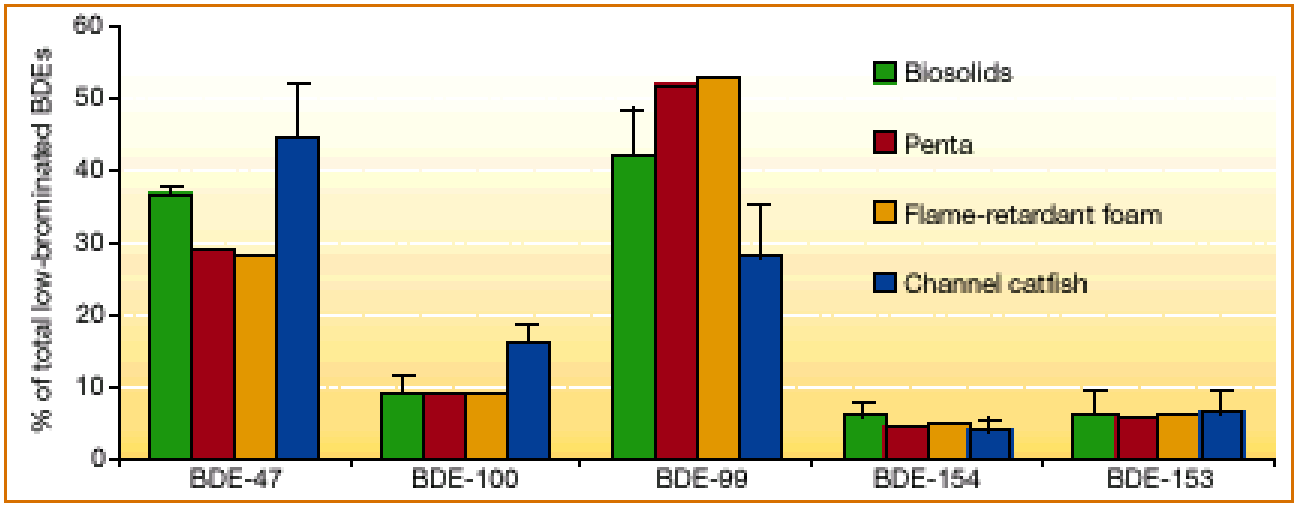

Figure 1 Brominated diphenyl ethers (BDEs) are produced commercially and occur in the environment as mixtures of compounds of varying bromination. Relative contributions of tetra- (BDE-47), penta- (BDE-100 and -99) and hexa- (BDE-154 and -53) brominated versions were similar in 11 biosolids obtained from four different regions of the United States, in the Penta commercial product (used as a flame retardant in polyurethane foam), in treated foam and in wild-caught fish (data shown are for 15 composite samples of channel catfish, *Ictalurus punctatus*, an omnivorous bottom-dwelling species) collected from Virginia lakes and rivers (error bars represent standard deviation). BDE-209 was not detected in fish but was present in biosolids.

How BDEs are released from polymers has been uncertain, as these applications are considered to be non-dispersive [7]. However, breakdown of discarded polyurethane foam, which may contain up to 30% Penta by weight [5], may contribute to this. We found that the surface of foam became brittle and

sloughed off after 4 weeks of exposure to ambient summer conditions. The particles generated are easily transported and the polymer matrix preserves the formulation's original BDE composition. The total concentration of Penta-like BDEs in these biosolids was 1,100–2,290 μg per kg dry weight, suggesting that input was high and consistent, regardless of the region of origin and irrespective of pre-application treatment (see supplementary information). Concentrations exceed those in European sludges by 10- to 100-fold[8], which is commensurate with the greater demand for Penta in the United States. The European Commission recently proposed a ban on the use of Penta, on the basis of its reported exponential increase in human breast milk and perceived health risks [9].

The fully brominated Deca product constitutes 82% of the total global BDE market[4]. It is rarely reported in wildlife, perhaps because of its low bioavailability. Deca consists principally of a single BDE (BDE-209) and is used to curtail fires in textiles and in relatively stable, rigid polymers, such as those used in television and computer casings [5]. Unlike those of Penta constituents, BDE-209 concentrations varied widely among the biosolids we analyzed (84.8–4,890 μg kg^{-1}; see supplementary information). Although there is little evidence for the degradation of Deca to Penta-like compounds, some photolysis of Deca to less brominated diphenyl ethers is possible [5,7].

We also detected BDEs in 87% of fish sampled from Virginia waters (quantification limit in fillets, 5 μg per kg lipid; n=334). The principal Penta constituents (BDE-47, -100 and -99) predominated in these samples (Fig. 1). This finding indicates that significant environmental release of these pollutants is occurring in the United States and that humans may be exposed to them through their diet. Carp from one Virginia stream contained 47,900 μg kg^{-1} of total BDEs, rivaling the highest fillet burdens reported in the world so far[4].

These compounds are also detectable in urban and rural air [10], indicating the potential for long-distance atmospheric transport. It seems that BDEs are an important— but generally unrecognized — persistent organic pollutant in the United States. Extensive use of Penta and the high burden of BDEs in land-applied biosolids may facilitate environmental dissemination of less-brominated BDEs both locally and globally.

Robert C. Hale, Mark J. La Guardia, Ellen P. Harvey, Michael O. Gaylor, T. Matteson Mainor, William H. Duff

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US Environmental Protection Agency. *Biosolids Generation, Useand Disposal in the United States.* EPA530-R-99-09 (Washington DC, 1999).

2. National Academy of Sciences. *Use of Reclaimed Water and Sludge in Food Crop Production* (Washington DC, 1996).

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6. de Boer, J., Wester, P. G., Klamer, H. J. C., Lewis, W. E. & Boon, J. P. *Nature* **394,** 28–29 (1998).

7. Renner, R. *Environ. Sci. Technol.* **34,** 223A–226A (2000).

8. Sellstrom, U. *et al. Organohalogen Compounds* **40,** 383–386 (1999).

9. European Commission press release, 30 January 2001.

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Supplementary information is available at http://www.nature.com or as paper copy from the London editorial office of *Natur*e.

Questions and responses:

BDEs not included in 1988 National Sewage Sludge Survey

No field data in US. Europeans finding some in soils and some deca degradation products.

There are no standards for levels in fish. The Virginia Health Department has recently generated a threshold value for BDEs in fish....5 ppm <u>wet</u> weight basis.

TRI requires reporting of deca, not penta.

Europeans seeing exponential increase in levels. Potential developmental impacts cause concern. Penta effectively banned in Europe.

Nonyphenols in NYS sludges – Anthony Hay, Cornell

* Alkylphenol ethoxylates are surfactants in many everyday products. >500,00tons/yr in US. 80% are nonylphenol based
* In primary aerobic treatment degradation occurs in a few hours but 60-65% leave WWTP as stable metabolites
  - ethoxy groups removed down to 1-2 nonethoxy groups
* metabolic breakdown products are of greater concern than parents
  - weakly estrogenic
    - can cause drastic shifts in sex ratios at environmentally relevant concentrations
    - can bioaccumulate
    - tocicity level in fish as low as 50 ppb
    - low acute toxicity
* Denmark has set limit of 50 mg/kg
* Measured concentrations in sludges
  - Syracuse – 1840 mg/kg
  - Ithaca – 1790
  - Monroe Cty – 1129
  - Cayuga Hgts – 1241
  - Cortland - 1477
* Degradation – related strongly to aerobic vs anaerobic conditions (aerobic favors degradation)
  - in lab 30-90% degrade in 60 days
  - Swiss study- 10-20% remains after 1 yr
  - farm soil sampled in early December showed 3-4 ppm which represents about 50% of what would have been applied. This may indicate degradation or leaching.
* summary
  - NPE present in high conc in sludges
    - 2-3 times higher than in Canadian biosolids
  - levels in Europe have declined due to ban

Alkylphenol ethoxylate degradation products in land applied sewage sludge – Mark LaGuardia, William & Mary

Mark J. La Guardia, Robert C. Hale, Ellen Harvey and T. Matteson Mainor
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Abstract:

Alkylphenol polyethoxylates, widely used in commercial and household detergents in the U.S., can degrade during the wastewater treatment process to more toxic, estrogenic and lipophilic compounds. These include octylphenol (OP), nonylphenol (NP), nonylphenol monoethoxylate (NP1EO) and nonylphenol diethoxylate (NP2EO). In Europe, unlike the U.S., these compounds have been receiving considerable attention; in some cases regulations have been established to control their usage. Here we examined eleven U.S. sewage sludges (biosolids) for OP, NP, NP1EO and NP2EO. Nine exceeded the proposed European Union land application limit (50 mg/kg, sum of NP, NP1EO and NP2EO), by 3 to 20 times. NP concentrations ranged from 5.4 to 887 mg/kg, (dry weight). OP, reportedly 10 to 20 times more estrogenic than NP, was detected in these same nine biosolids at levels up to 12.6 mg/kg. Three biosolids were also subjected to the United States Environmental Protection Agency, Toxicity Characteristic Leaching Procedure Method 1311, to determine if NP, NP1EO and NP2EO can be leached from the biosolids. NP and NP1EO were both detected in the leachate, the former at concentrations from 9.4 to 309 Φg/L.

Molybdenum in NYS soils and crops to which sludges have been applied – Murray McBride, Cornell

* cattle are sensitive to Cu/Mo ratio

- should be greater than 2:1 in feed (esp. forages which are a major component of the diet)
- Mo is antagonistic to Cu absorption

* some sludges contain high Mo concentrations & when applied to forage crops used for cattle feed the ratio can be less than 2:1
* increasing S can cause depression in Cu availability
  - 0.3 % in forages can depress Cu availability
* the bioavailability of Mo, Cu & S varies with crop species but the ratio in the plant does not vary significantly
* Also working with Bev Hale, U of Guelph looking at uptake & bioavailability of Mo & other metals from old application sites
  - Tom Bates sites at Elora & Cambridge

Alfalfa molybdenum uptake using an N-Viro alkaline sludge – Richard Stehouwer, PSU

Alfalfa production with lime-stabilized biosolids: Effect on yield, Cu, and Mo.

Application of lime-stabilized biosolids increases soil pH, and may suppress Cu uptake and increase Mo uptake by forage crops, resulting in decreased Cu/Mo ratio in the forage. This 3-year field research project was started in the spring of 1999 to compare lime-stabilized (N-Viro process) biosolids with conventional ground ag-limestone. Materials were applied at 0, 0.5, 1.0, and 2.0 times the soil lime requirement and chemical fertilizer N and P were added to the ag-lime treatments to match the N and P supplied by the biosolids. Materials were incorporated to 15 cm and alfalfa was planted. All treatments were applied again in the second year of the study by surface broadcasting without incorporation. Alfalfa was harvested 2 times in year 1, 3 times in year 2, and 1 time (to date) in year 3 (2001).

Lime stabilized biosolids increased alfalfa Mo in both the first and second years. The highest observed Mo uptake coefficient was 9.67 for the first cut of 2000. At this cutting alfalfa grown with the highest amount of biosolids had a Cu/Mo ratio of 2.5, the lowest observed during the experiment. However, application of additional biosolids following the first cutting, decreased Mo uptake coefficients (6.27 for the second cut, 2.06 for the third cut of 2000), and increased Cu/Mo ratio of alfalfa grown with the highest amount of biosolids (3.3 second cut, 8.1 third cut). These data would lead to very different cumulative Mo loading limits: 0.3 kg/ha for first cutting of 2000, 16.2 kg/ha for third cutting of 2000, and 4.2 kg/ha using all data.

Neither ag-lime nor biosolids affected alfalfa yield in 1999, the establishment year. In 2000 both materials increased yield, with biosolids giving a larger increase. In the first cutting of 2001, ag-lime did not increase yield, while biosolids did. Alfalfa without biosolids appeared to have boron deficiency symptoms.

Evaluation of enteric virus, protozoan and helminth persistence in class B limed sludge – Jacqueline Brabants, UNH

* Survey of wastewater solids to evaluate pathogen indicators
* Class A designation is based on current inadequate detection methods.
* Fecal coliform not a sufficient indicator. Crypto remained infective after lime treatment and inactivation of fecal coli.
* Current recovery protocols are not adequate.
* what is safe
  - why no outbreaks
    - need to look at what was checked
    - officials usually check serum antibodies
    - fecal sampling may give better indications of effects
  - need to stop looking at 503 as universal
    - need to look at modeling
      - does it hold for immuno-compromised individuals – children, elderly
      - may be long term effects from virus which occur after 55yrs of age
  - need to understand biological impacts before choosing human indicators
    - but better indicators may be a moving target (CE)
      - may never be a “silver bullet” indicator
      - may be more value in looking at where material is spread
        - change standards with climate & site characteristics

Survey of Wastewater Solids to Assess the Prevalence of *Cryptosporidium* and *Giardia* Species and *Ascaris lumbricoides*

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Thirty-eight samples representing various regions, seasons, treatments and percent total solids were analyzed for the presence of *Ascaris lumbricoides, Cryptosporidium* oocysts and *Giardia* cysts. In addition to assessing the prevalence of these organisms, two concentration methods were evaluated for recovery of *Ascaris lumbricoides, Cryptosporidium* oocysts and *Giardia* cysts. Samples were processed using ethyl acetate sedimentation and zinc sulfate flotation and subsequently examined for the presence of *Ascaris lumbricoides* ova and larva. The resultant product was subjected to immunomagnetic separation and direct immunofluorescence to recover and visualize *Cryptosporidium* oocysts and *Giardia* cysts. Of the samples tested, 7.9% and 10.5% were positive for *Ascaris* ova using ethyl acetate sedimentation and zinc sulfate flotation respectively. Twenty-one percent of the samples were positive for *Cryptosporidium* oocysts and 15.8% were positive for *Giardia* cysts using ethyl acetate sedimentation. Of the samples processed using zinc sulfate flotation, 5.26% contained *Cryptosporidium* oocysts and 2.6% contained *Giardia* cysts. Of the thirty-eight samples tested 15.8% were positive for *Ascaris* ova, 23.7% were positive for *Cryptosporidium* oocysts and 15.8% were positive for *Giardia* cysts. The preliminary data does not demonstrate that zinc sulfate flotation is more effective than ethyl acetate sedimentation at recovering *Ascaris* ova. The data generated indicates that there is no correlation between the presence of *Ascaris lumbricoides* and the presence of *Cryptosporidium* oocysts and *Giardia* cysts. Further investigation is required to determine if a better indicator organism exists as an index of other eukaryotic pathogens such as *Cryptosporidium* and *Giardia*, and to develop more efficient recovery methods.

Research Pertaining to Objective 2: To evaluate the legal, social, and political aspects of long-term utilization of sewage sludge products in the Northeast and to identify modes of stakeholder participation in biosolids utilization decision-making.

Effects of process changes on odorant emissions from biosolids; a case study – Bradley Striebig, PSU

- odors are not considered by EPA to be a health threat
- measured using odor index approximations
  - odor detection vs threshold limits
  - there is very little data on impacts
- Step 1 - Sample collection
  - air samples – bag, canister & solid sorption
  - water & soil
    - need to be cooled to 4C to slow microbial activity
    - storage depends on treatment process
      - aerobic – need to maintain air in canister
      - anaerobic – need to exclude air
- Step 2 - Sample analysis
  - use mass spec
  - need to concentrate “odors”
    - cryogenic concentration
    - solid phase sorption (to carbon)
  - olfactory testing
    - panel analysis of odor type
    - need to be consistent to establish what it is & how offensive it is
    -
- Step 3 – Data analysis
  - need to identify odorants
    - by split chromatography or olfactory

- data interpretation using odor index
* most odors are produced in digestion & treatment process after digestion can reduce odors
* summary
  - odor index is a way to compare analytical data to physiological response
    - can assist to manage odors
    - assists to id chemical constituents
    - gives dependable results that can be useful as a predictive tool

Land application of sewage sludge: Perceptions of New Jersey Vegetable Farmers – Uta Krogmann and Virginia Gibson, Rutgers

Understanding farmers' perceptions and choices regarding land application of sewage sludge is key to developing locally accepted strategies for managing sewage sludge. Semi-structured interviews with mostly open ended questions were conducted with 50 fruit and vegetable farmers at the New Jersey Annual Vegetable Meeting in 1999. The in-depth interviews indicated that the application of sewage sludge to land is currently not a common agricultural practice for these growers. Thirty-eight of the 50 never considered using sludge products. Of the remaining 12, 7 did not use them, 4 had stopped using them and one was using them but was unaware that it contained sewage biosolids. Twenty-three did not find sludge use acceptable, 8 were ambivalent, 9 thought it acceptable and 10 were undecided.

Perceived risks, including heavy metals in sewage sludge (soil build up, crop uptake), negative public perception, odor complaints, and increase of contaminants in water supply, outweigh economic incentives and soil improvement benefits. When naming benefits and drawbacks, farmers tend to think first of their crop and their land, and do not mention the environment. It is only when they are questioned directly about environmental benefits and risks that they discuss these aspects. Communication efforts should focus on practical information farmers can relate to.

***Recent developments in sludge management* law –** Bill Goldfarb, Rutgers

* difficult to get information because many suits are settled out of court or are lower court decisions which are not reported. Bill requested that people send him lower court cases and settlement information.
* Rutgers is recommending an "indemnity clause" for farmers

Sludge Legal Issues

1. Siting:

Is a municipal ordinance prohibiting or limiting land application of sludge legal under state land use laws? Has it been legally enacted?

Is the ordinance preempted by federal or state solid waste law? State law re the existence and scope of preemption varies based on extent of home rule in a particular state.

Does a local ban violate the Interstate Commerce Clause?

There are three patterns depending on state laws: 1) complete state preemption where state law fully occupies the field (VA, MD, NJ fall into this category); 2)partial preemption where ordinances can not be inconsistent with state law (PA is an example); and 3) states which give local authority to municipalities (NY, OH for example).

2. Liability

Against whom? Farmers? POTWs? Sludge Contractors? Indirect Dischargers? Lessors/Owners of farmland? Insurance companies? Joint and Several liability would apply.

To whom? Neighbors? Trespassers? Farm Workers? Sludge contractor employees? Sludge landfill workers? Federal and State governments or neighbors for cleanup? Lessors of farmland? State re preserved farmland?

For what? Personal injuries and decreased property values (stigma damages up to 5 miles), cleanup expenses. Loss of crop and livestock. Punitive damages.

Likely defenses? Sovereign immunity (POTWs) Right-to-Farm laws (Will they protect farmers? Maybe!). Causation not proven. Contractual defenses – exculpatory clauses in contracts, leases, indirect discharge agreements and insurance policies. Indemnification Agreements.

Who may be liable for violation of a 503 permit besides POTWs? Sludger can. What about a farmer or lessor with knowledge of the permit's terms and conditions?

Citizens Suits under CWA and comparable laws may be possible..

Proving cause is very difficult. "Reasonable probability" under civil law is more current test.

Local ordinances on land application – Ellen Harrison, Cornell

The Role of Municipalities in Regulating Land Application of Sewage Sludges and Septage

About half of the more than seven million tons of sewage sludges produced annually in the US are applied to agricultural lands and this percentage is increasing. This use of sewage sludge, the semi-solid residue of waste water treatment, represents an economical disposal option and provides the benefit of recycling the nutrients and organic matter sludges contain. However, sewage sludges also contain contaminants and pathogens from the homes, industries and businesses that use the sewer system. They can also emit strong odors. Land application thus raises a number of environmental, health and nuisance concerns. Application to agricultural lands, turf or in mine reclamation can generate very strong citizen concern.

Although the combination of federal and state regulatory requirements is significant in forming the initial base for sewage sludge management decisions, local regulations also play an increasing part in seeking to protect the health, safety, and welfare of citizens. The authority of a municipality varies from state to state. New York State has granted strong home rule to its municipalities. The New York State Constitution grants broad authority to local governments to devise regulations so long as they do not conflict with state laws. Inconsistency between state and local laws in New York is allowed so long as it is not expressly prohibited and if it addresses local needs. In contrast to New York, Virginia has granted few powers to its municipality, thus setting the stage for a recent court decision which overturned a local ordinance banning sludge application.

Beyond the question of the extent of the municipality authority delegated by the state, the remaining primary legal constraints that localities face are the U.S. Constitution Commerce Clause challenges and conflicts with right-to-farm statutes. The Commerce Clause is broadly interpreted by the courts to mean that states may not pass laws that "discriminate against or unduly burden interstate commerce." A 1995 court decision that addressed a commerce clause challenge allowed the Rappahannock County, VA sludge ordinance to stand, demonstrating that a well crafted law can stand given a legitimate local interest. Right-to-farm laws vary from state to state. In NYS, farms engaged in "sound agricultural practices" in agricultural districts are protected from nuisance suits. Additionally, municipalities may not enact laws that "unreasonably restrict or regulate farm operations" within an agricultural district except where public health and safety are threatened. Local ordinances must be carefully formulated to address these potential constraints.

Local ordinances vary widely in the issues and the level of detail they address. Some are short laws which may simply ban certain practices. Others are lengthy, detailed laws. Issues addressed may include human health risks, risks to animal health (both livestock and wild animals), water and soil quality, nuisance issues such as odor, liability and uncertainty, monitoring, and enforcement. The local law may impose restrictions on the type, amount, quality, or source of sludge. Some specify management practices, notification requirements, and additional monitoring beyond that required by federal or state rules. As a result of concern over the inability of state and federal agencies to provide consistent enforcement of rules due to staffing shortages, local ordinances frequently supply enforcement provisions which at a minimum would allow local enforcement of state requirements. Local ordinances may also include fees to cover municipal costs.

More detailed discussion of the legal issues including a review of pertinent case law is available in a recent publication. The publication also provides examples, drawn from existing local ordinances, that show how municipalities have addressed specific local concerns such as odors or ground water protection. This information is available in an article by Ellen Z. Harrison and Malaika M. Eaton published in the Natural Resources Journal (V.41, no. 1, p 79-123). By permission, the article is also

posted on the Cornell Waste Management Institute web site where there is also a wealth of other information about sewage sludges (see www.cfe.cornell.edu/wmi and go to the sludge section).

Work towards Objective 3: To develop appropriate outreach materials and educational events for the Northeast that links the current research to actual field management of sewage biosolids products in the Northeast.

Ontario update – Michael Payne, OMAFRA

- 2000 in Review
  - Walkerton
    - impacts on public perceptions
    - Sewage Biosolids land Application in 2000
      - very wet year and land application was difficult
      - lack of storage forced land application when conditions were not the best
      - year ended with significant quantities still in storages in some areas

- Sewage Biosolids Land Application in 2001
  - Pelletization
    - significant increase with TO plant coming on line
    - need for field trials to determine nutrient availability
  - Regulatory Changes & Revisions
    - introduction of Nutrient Management Act which will deal with all land applied nutrients including sewage biosolids
    - need to revise current guidelines for clarity consistency and to address areas of concern

Transmission of microbial organisms, VOC's & odor from biosolids via soil & air – Tony Ho, MOE

Transmission of Microbial Organisms Via Soil & Air

- Significant Public Concerns
- Don't have much "Quantitative" Information, esp. Health Significance

Biosolids Application in Ontario

- Background
- Concerns/ Current Research Interests

Biosolids Generation/ Uses In Ontario

- 400,000 tones annually (dry wt.)
- 54% (216,000) land applied of which 90% are Class B
- 32% land filled / disposal in lagoons
- 14% incinerated

Ontario Guidelines for Land Application of Biosolids

- First Published in 1978
- Last Revised in 1996
- Major criteria e.g. loading rates, metals limits, waiting periods and separation distances were established in 1978
- Do not have numeric limits for pathogens
- Stabilization Requirement
- Waiting periods
- Separation Distances

Concerns

- Since
  - Walkerton
  - Movement of Agriculture / Domestic Wastewater Bacteria Through Soil (Doug Joy, U of G, 1994)
  - Modeling of Risks by Bioaerosols in Biosolids Land Application Sites (Dowd et. al., Texas A.M./ Arizona U)

- How safe are the separation distances?

  Ontario Studies
  - Agri-Food Canada (1st of 2 Year Study)
    - Factors Affecting Survival of E. Coli in Swine Manure in Soil (strain variability, temperature, manure in soil, injection Vs broadcast)
  - MOE / Durham Region Public Health Dept (Preparing Terms of Reference)
    - Health Impacts Due to Bioaerosols from a Gun Club which stockpiles paper fiber biosolids (PFB)/ uses PFB compost for barriers

MOE / OMAFRA Interests

- Studies to determine adequacy (risks) of current separation distances for protection of ground/ surface water quality and public health due to bioaerosols
- Best Management Practices e.g. breaking of macropores, injection/ incorporation to minimize pathogen mobility

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