



HOME

WHAT'S NEW

CALENDAR

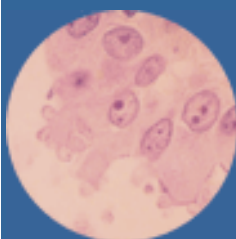
PRODUCTS

NEWS RELEASES

[Click here to
see past
issues!](#)



Spring 2001
Vol. 25 No. 1



[Cover & Credits](#) | [Forefront](#) | [Research for Clean Water](#) | [Les Recherches En Bref](#) |

COVER AND CREDITS

-  [Front Cover](#)
-  [Back Cover](#)
-  [Table of Contents and Credits](#)



Subscribe to the Agri-food Research in Ontario magazine [mailing list!](#)

| [Top of Page](#) |

FOREFRONT

-  [Research for Clean Water](#)

| [Top of Page](#) |

RESEARCH FOR CLEAN WATER

-  [The Lowdown on Manure Production in Ontario](#)
-  [Microbes and Manure](#)
-  [A Growing View of the Farm](#)
-  [Zeroing in on *Cryptosporidium parvum*](#)

-  [Formulating Phosphorus - Correct Pig Feed](#)
-  [Tracking *E.coli* Through the Soil](#)
-  [Highlights of More Research for Clean Water](#)
-  [In Search of the Perfect Spread](#)
-  [Constructed Wetlands Treat Rural Wastewaters](#)
-  [Plantfood or Toxin?](#)
-  [Composting Takes up the Challenge](#)

| [Top of Page](#) |



LES RECHERCHE EN BREF

-  [Les Recherches En Bref](#)

| [Top of Page](#) |

| [Research, Education, Laboratories & Risk Management Home Page](#) |

| [Central Site](#) | [Feedback](#) | [Search](#) | [Site Map](#) | [Français](#) |
| [Home](#) | [What's New](#) | [Calendar](#) | [Products](#) | [News Releases](#) |



This page maintained by the Government of Ontario

This information is provided as a public service, but we cannot guarantee that the information is current or accurate.
Readers should verify the information before acting on it.

Feedback and technical inquiries to: research@omafra.gov.on.ca

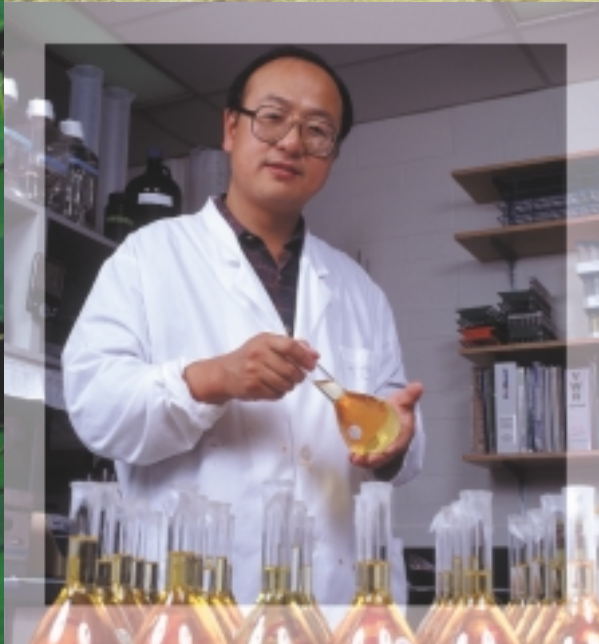
©Copyright 2000 [Queen's Printer for Ontario](#)

Last Updated: undefined NaN, NaN

Agri-food research La recherche agro-alimentaire

IN ONTARIO

EN ONTARIO



*Research
for
Clean
Water*

Ontario Ministry
of Agriculture, Food
and Rural Affairs
1 Stone Road West
Guelph, Ontario
Canada
N1G 4Y2

ISSN 1192-7704



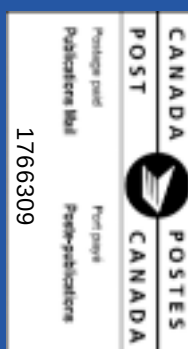
Ontario



This magazine is
printed on
recycled paper
using vegetable
based ink.



address correction requested



Agri-food research La recherche agro-alimentaire

SPRING 2001
VOL. 25 NO.1

IN ONTARIO EN ONTARIO

Formerly *Highlights of agricultural and food research in Ontario*



The Lowdown on Manure Production in Ontario 6

Microbes and Manure 7

A Growing View of the Farm 10

Zeroing in on *Cryptosporidium parvum* 12

Formulating Phosphorus - Correct Pig Feed 14

Tracking *E.coli* Through the Soil 16

Highlights of More Research for Clean Water 17

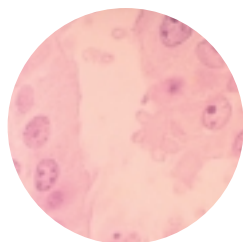
In Search of the Perfect Spread 20

Constructed Wetlands Treat Rural Wastewaters 21

Plantfood or Toxin? 24

Composting Takes up the Challenge 26

LES RECHERCHE EN BREF 28



Editor:
Robyn Meerveld

Creative Design:
Andrea Gomirato

Photos: David Barr

*Cover and inside
back photo of
Waterlily:* Masterfile

*Cover photo
researchers:* clock-
wise from top,
Adrian Unc, Beverly
Hale, and Hung Lee.

Back Cover Photo:
Ming Fan and his
research team.

About the authors

Articles pertaining to research at the University of Guelph were prepared by students in the SPARK - Students Promoting Awareness of Research Knowledge - program.

Information on research

For more information on research at the University of Guelph, or to contact one of the researchers, visit: www.uoguelph.ca or call (519) 824-4120

Agri-food research in Ontario (formerly *Highlights of agricultural and food research in Ontario*) is a publication of the Agricultural Research Institute of Ontario. ■ French translations provided by Communications Branch, Ontario Ministry of Agriculture, Food and Rural Affairs. ■ This publication is produced by the Ontario Ministry of Agriculture, Food and Rural Affairs. Copyrighted material may be reproduced as long as it remains in context, its source is recognized, and it is not used for monetary gain. Permission to reprint copyrighted material under any other circumstances may be given only to the Queen's Printer of Ontario. ■ Address corrections or requests to have your name added to the mailing list should be sent to: **The Editor, Agri-food research in Ontario Magazine, Ontario Ministry of Agriculture, Food and Rural Affairs, 1 Stone Road West, Guelph, Ontario, CANADA, N1G 4Y2** or e-mail: research@omafra.gov.on.ca. ■ © Queen's Printer for Ontario 2001 R03.01 8M

Check out recent issues at our website: www.gov.on.ca/OMAFRA/english/research/index.html

**Members of the
Agricultural
Research Institute
of Ontario**

Deborah Stark
Director of Research

Graeme Hedley
Chair

Bruce Christie
Peter Connell
Terry Cowan
Anita Gilmer
Ginty Jocius
Janet Parsons
Zaher Qaderi
Dona Stewardson
Tom Van Dusen
James Vidoczky
James Wadleigh
Jeff Wilson

Research for Clean Water

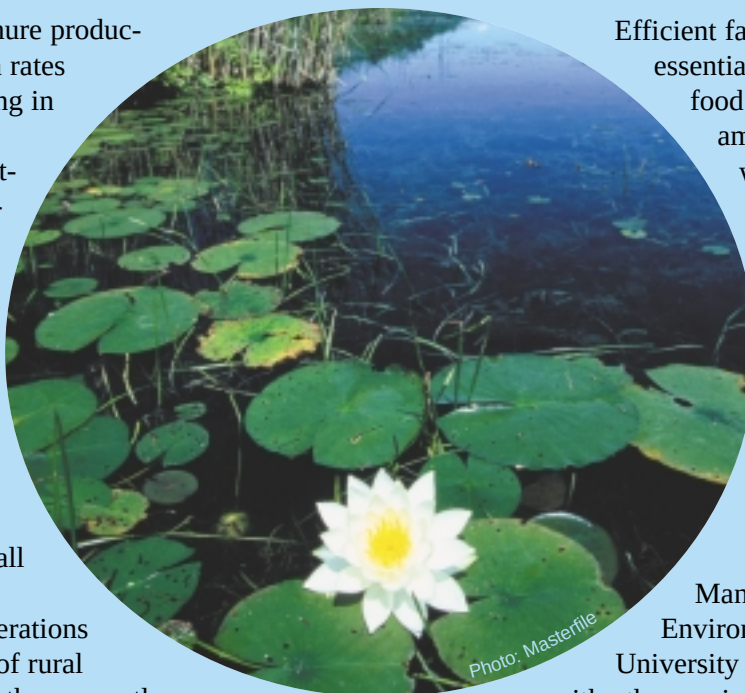
Safe, clean water in rural Ontario is a priority for everyone.

As world demand for animal protein increases, so too does the importance of good manure management for protection of water resources.

While actual manure production and application rates are low and declining in Ontario, livestock farms are consolidating into fewer, larger operations. Although the scale in this province doesn't approach the mega-farms of some U.S. states, about 20% of Ontario farms produce some 67% of all agricultural sales. Higher intensity operations are often the focus of rural water conflicts, whether correctly or not, because of the volume of manure they generate. But Ontario is also a leader in voluntary conservation practices through the Environmental Farm Plans.

Manure is a valuable natural resource. A source of essential nutrients like nitrogen, phosphorus, potassium, trace elements. It also contains carbon compounds which improve soil structure and stability.

The critical challenge is to balance society's need for safe, high quality potable water with the needs of agriculture, so farms can operate economically and sustainably.



Efficient farm production is essential. It means that the food prices we enjoy are among the lowest in the world - a key factor in our high standard of living. The farmers' challenge to be both cost competitive and environmentally sustainable therefore, becomes a challenge for all of us.

The Resources Management and Environment Program at the University of Guelph, together with other environmental research funded by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) contributes knowledge necessary to finding solutions to this challenge.

Highlights of research in manure management, waste treatment, water taking policies, and the Environmental Farm Plans and Best Management Practices they support are profiled in this issue.

For many years, research at the University of Guelph and OMAFRA has been aimed at developing efficient food production methods with minimal environmental impact. In addition to the studies presented in this magazine, many more are underway with the same goal: the protection of rural water supplies. Research to identify the source and movement of microbial pathogens in manure applied to agricultural land will continue to be a priority.

Manure Management

- ✓ Further refinement of a single, integrated computer program for the management of manure, biosolids and mineral nutrients.
- ✓ Risk assessment and economic evaluation of environmental damage associated with live stock manure: dietary and handling strategies.
- ✓ Impact of manure and phosphorus applications on phosphorus availability.
- ✓ Quantifying water quality impacts of livestock farms and other rural uses.
- ✓ Optimizing methods of applying animal wastes and bio-solids on the land at desired rates.
- ✓ Evaluation of environmental impacts of manure treatment technologies.

Waste Application and Treatment

- ✓ Implication for current and future productivity of biosolid application to agricultural lands.
- ✓ Optimizing paper mill biosolids as a soil amendment on agricultural land in Eastern Ontario.
- ✓ Conditioning of degraded and marginal soils with paper mill biosolids prior to planting horticultural crops.
- ✓ Application of ground penetrating radar for design and testing of wastewater trenches and measuring spatial variability of soil moisture.
- ✓ Field and model studies of septic tank leaching bed performance.
- ✓ Treatment of farmstead runoff using chemical coagulation and flocculation.

Water Taking Priorities

- ✓ Enhancing capacity to address variability such as drought in rural water supplies.
- ✓ Field validation of the soil temperature and water regime components of the SHAW model under Ontario geoclimatic conditions.

Riparian and Wetland Management

- ✓ Design tools for riparian vegetative filter-strips incorporating watershed characteristics (including requirements for handling runoff from various cropping systems).
- ✓ Regional wastewater treatment technologies: design criteria for constructed wetlands associated with runoff from individual farm storages, or with municipal waste water treatment.

Evaluating Best Management Practices (BMPs)

- ✓ Assessing the incentive compatibility of BMPs from economic and social viewpoints.
- ✓ Evaluation of alternative policy approaches to support the adoption of BMPs.
- ✓ Quantifying the detrimental effects of improperly timed cultivation under no-till and conventional till practices.
- ✓ Evaluation of BMPs for increasing nitrogen use efficiency on farms (evaluation of test for nitrogen availability from soil and organic amendments, and localized wetland to reduce nitrate leaching and stream contamination).

Michael Goss Ph.D.

Research Director

Resources Management and Environment Program

University of Guelph

Email: mgoss@uoguelph.ca

The Lowdown on Manure Production in Ontario

by Ken McEwan,
Ridgetown College,
University of Guelph
Email:
kmcewan@ridgetownc.uoguelph.ca

Contrary to common belief, Ontario's manure production is actually decreasing. Between 1986 and 1996, the estimated volume dropped from 33.4 billion litres, to 30.9 billion, a decline of 7.5%. Cattle produced 63% of total manure volume, swine 31% and poultry 6%.

Table 1 highlights the fact that even in counties such as Perth, with high livestock numbers, only 30% of the total tillable area receives manure application - either solid or liquid. For Ontario as a whole, the amount

of tillable land receiving manure is 18.9%. On a per acre basis, 30.9 million litres applied to 9.6 million tillable acres represents a modest application rate of 3200 litres per acre.

When estimating future manure production, factors to be considered include: market trends in both the domestic and export markets; possible impact of new manure management technologies and international trade agreements. The World Trade Organization which has as its long term goals tariff reduction and ensuring fair trading practices; and the level of competition from other provinces and the American states.



On the assumption of projected beef cattle numbers falling, stable dairy numbers, modestly increasing swine numbers, and increasing poultry numbers, manure production is projected to drop to 27.1 billion litres in 2010. ■

Table 1. Tillable Acreage and Application of Liquid and Solid Manure in Six Counties or Regions of Ontario

Area Name	Total Tillable Area (Acres)	Area Under Liquid Manure (% of Tillable Land)	Area Under Solid Manure (% of Tillable Land)
Niagara	167,735	4.8	15.8
Oxford	376,111	11.6	12.3
Wellington	367,954	9	20.5
Perth	445,719	12.3	16.9
Huron	615,522	7	12.9
Bruce	449,159	3.5	21.3

MICROBES and Manure

by Michael Goss, Dept. of Land Resource Services, University of Guelph
Email: mgoss@lrs.uoguelph.ca

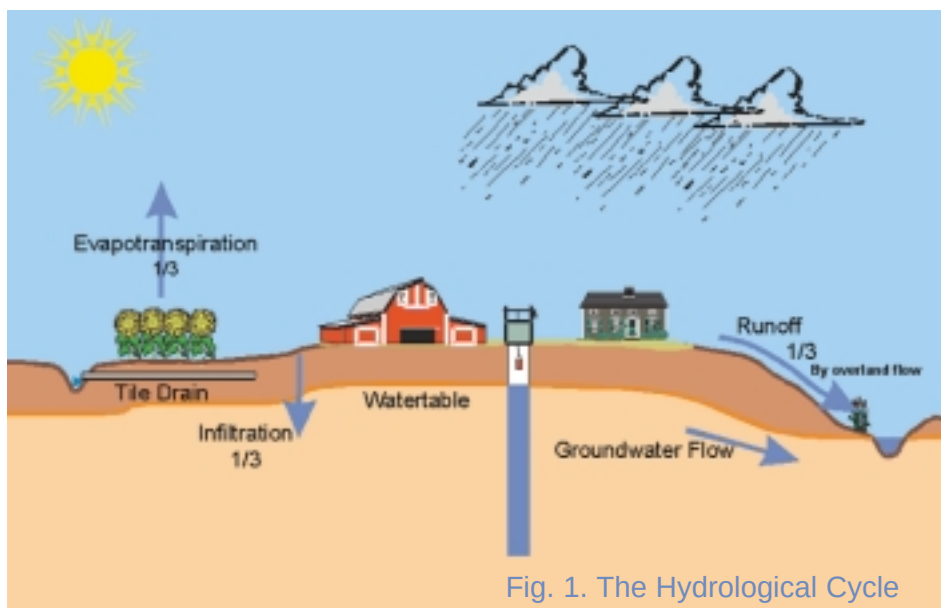


Fig. 1. The Hydrological Cycle

Manure's potential as an environmental contaminant is greatly influenced by the water cycle. It affects both the distribution of contaminants in the surface and ground water, as well as losses in gaseous form.

Contaminants from manure can enter surface water bodies through many routes. These include runoff

from fields and yards, direct deposition by grazing animals, via inter-flow water moving laterally in the near surface layer of soil, in discharge from tile drains, and in ground water which seeps directly into stream or lake beds, or is discharged from a spring.

Contaminants enter ground water by direct transport through rock and

overlying soil, or through man-made openings such as improperly sealed or poorly maintained wells.

The concentration and / or type of contaminants in manure may change at different stages of the management system. For example, contaminants may be made immobile, pathogens may die off, or the concentration of nutrients may change as water and organic content changes during storage.

Feed Manipulation is Key

Good manure management increasingly starts with a properly designed diet - to provide all the nutrients and roughage required for growth, maintenance, and reproduction, but without excess. Over the past decade major strides have been made in understanding of animal nutrition and the roles of nitrogen,

phosphorus, potassium and carbon. Variations in these nutrient levels in manure can be related to differences in type and quality of diet, as well as animal performance levels and environmental factors affecting water and food intake. The feed industry has been progressive in using research findings to fine-tune rations, with the following results shown in Table 1.

Nitrogen in manure is generally present in both organic and inorganic forms. The main inorganic form is the ammonium ion, which can be transformed into ammonia and released as a gas or converted to nitrate with nitrite as an intermediate. Nitrite and nitrate are of concern in potable water because of their role in cyanosis, affecting mainly newborns. Addition of ammonia to surface water can also negatively impact aquatic life.

Phosphorus in manure does not pose a direct threat to humans, but can cause eutrophication of freshwater bodies. One group of algae that respond to the phosphorus by growing rapidly is the blue green algae, some of which produce toxins that can cause illness in humans.

lates appear to mimic the action of natural estrogens, which function to stimulate the growth of female structures, and the development of secondary female characteristics.

Table 1. Feed related measures contributing to the reduction in pollution caused by animal production .

Changes in feeding regime	Possible reduction in manure content (%)	
Supplements	Nitrogen	Phosphorus
Increase use of supplementary amino acids and related compound combined with reduced levels of protein in foods.	20 – 25	-
Cellulase	5	-
Phytases	-	25-30
Modified grains: high available P corn		25
Growth promoting substances	5	5
Systems		
Precise feed formulation to animal needs	10 – 15	10 - 15
Phase feeding	15	15
Increased use of highly digestible raw materials	5	5

Table 2. Frequency of detection of selected pathogenic organisms in cattle.

Study description	Organism	Proportion of carriers
US 1997 Two national wide studies and two studies at state level (Wisconsin and Washington) of cow faeces	<i>E. coli</i> O157:H7	Faeces of mature cows: usually under 1% of the animals but as high as 5% Calves under 24 mths: 2.8%
Quebec, Canada, 1989 Faeces from slaughtered cows	<i>Salmonella</i> sp.	18% of animals
	<i>E. coli</i>	99% of animals
	<i>Yersinia</i> sp.	18% of animals
UK 1998 Three dairy cow herds	<i>Campylobacter</i> sp.	37% to 81% of animals
Switzerland 1999 67 larger cow herds	VTEC (verotoxin producing <i>E. coli</i>)	78% of the farms; 43% of the animals
	<i>Campylobacter jejuni</i>	32% of the farms
	<i>Campylobacter coli</i>	19% of the farms; 3% of the animals
	<i>Yersinia</i> sp.	22% of the farms; 1.7% of the animals (infection limited to animals younger than 8 months)

Relatively little work has been carried out to determine their environmental impact, but it is recognised that animal manure contains significant amounts of these substances, which are mainly produced during reproductive phases. The compounds do not appear to persist in soil.

Pathogen Populations

Animal manure can be a source of bacteria, viruses, protozoa and helminthic worms. The prevalence of bacterial pathogens, particularly salmonellas, is thought to be greater in swine and poultry manure than in cattle manure. However, cattle are important carriers of some pathogens, as shown in Table 2. Long-term colonizers live with more transitory strains in the alimentary tract of livestock, sometimes making identification of the source of a contamination event difficult. Liquid manure tends to be more uniformly contaminated than solid manure because of the ease of mixing and possibly because many bacteria are motile.

Pathogens can be found even if the animals present no symptoms, and a small number of infected animals can contaminate a whole source of manure. Consequently, the greater the number of animals on a farm, the greater the likelihood of pathogens being present in the manure. The bacterial group usually present in greatest numbers are faecal coliforms, and streptococci.

As pathogenic species or strains are present in far fewer numbers than are benign or beneficial ones, the non-pathogenic ones are commonly

Endocrine Disrupting Substances

Synthetic estrogens such as alkylphenols and alkylphenolethoxy-

used as indicators of faecal contamination in water resources. Total coliform counts, numbers of faecal coliforms, and the presence of *Escherichia coli* (*E. coli*) are all used in this way. *E. coli* is a widely occurring micro-organism. Only some strains cause disease, and not all *E. coli* which have the O157:H7 serotype actually give rise to disease in humans. However, cattle and other ruminants appear to carry the ones that do cause illness.

Concentrations of *E. coli* O157:H7 in cattle faeces range from 102 to 105 cfu g⁻¹ fresh weight. The smaller numbers are common in younger animals. Infection in an individual animal is not continuous. Rather, animals undergo a series of re-infections, the number declining with age. The release of *E. coli* O157:H7 in the faeces seems to be greatest in July and August, and there may also be differences between years as well as between seasons.

Based on the limited studies that have been reported, there is no evidence of greater prevalence of *E. coli* O157:H7 in beef feedlots than in cow-calf operations. Current research is expected to result in effective vaccines to treat cattle, and thereby reduce the loading of the bacterium into manure. Farming

practices, such as those which use only organic manures rather than a mix of organic and inorganic fertilizers, would not be expected to increase the prevalence of *E. coli* O157:H7, provided that precautions are taken to avoid direct ingestion of contaminated fodder. Field application to fodder crops of manure that contained the microbe would represent a risk if insufficient time was allowed for bacterial die-off before the crop was harvested and prepared as feed.

Manure Treatment and Storage

Bacterial populations can change significantly during storage, and depend on whether manure conditions are anaerobic or aerobic. The type of manure application can influence the loss of potential contaminants to surface and ground water. Bacterial movement into tile lines can be greater after injection of manure, than after surface application.

Manure temperature and water content are also important. In composting, the most common manure treatment, it is difficult to ensure a uniform 55°C to ensure that all pathogens are killed. In solid manure stores, pathogens close to

the periphery of a pile may not be subject to the same temperature regime as those near the center. Treatments available to ensure sufficiently high temperatures throughout have been too expensive for most farms of the size typical in Ontario.

The pathogen *Giardia* appears to be sensitive to freezing, whereas survival of other organisms may be enhanced. For example, survival of *E. coli* O157:H7 is enhanced by cooler temperatures. Rotoviruses may be stable in faeces for as long as seven to nine months. The lifespan of other viruses can be adversely affected by certain bacteria if they are present in the manure.

Once in the soil, microbial survival depends on the availability of appropriate conditions of pH, temperature and moisture as well as suitable substrates. Indigenous soil fauna can also be highly competitive. Pathogenic bacteria associated with manure may not accumulate in soils containing earthworms. Free-living protozoa and nematodes are also predators of bacteria in the soil. But introduced bacteria may still be able to survive for an extended period after manure application. The survival of *E. coli* O157:H7 in the soil has received particular attention. In cold soils (<5°C) bacteria can survive for up to 100 days. Survival periods are shorter in coarse-textured soils than in finer-textured soils.

Antibiotic resistance of bacteria does not seem apparent in manure of animals routinely treated with antibiotics. This suggests that land application does not pose an additional threat to water resources from antibiotic resistant bacteria if manure is properly applied. ■

Table 3. Survival of potentially pathogenic organisms in manure

Organism	Survival under experimental conditions (days)					
	Frozen	5°C	30°C	Liquid manure	Compost	Dried
<i>E. coli</i>	>100	>100	10	100	7	1
<i>Salmonella</i>	>150	150	28	75	14	7
<i>Campylobacter</i>	50	21	7	100	7	1
<i>Giardia</i>	<1	7	7	300	14	1
<i>Cryptosporidium</i>	>300	50	28	>300	28	1
		5°C	22°C	37°C		
<i>E. coli</i> O157:H7		70	56	49		

Editor's Note:

Information cited in this article can be referenced at the following website:
www.walkertoninquiry.com

A GROWING View of the Farm



Computer software looks at the big picture of farming's effect on the environment and community.

The delicate balance of farm production, environmental protection and quality of life is getting new support, thanks to computer modelling.

Prof. John Ogilvie, a University of Guelph agricultural engineer, is leading the work on developing software from models that can give a more holistic view of the effects of farms on the surrounding community and environment. He says these models can suggest solutions that provide for maximum farm production, while maintaining the quality of life and the environment.

Ogilvie and Kevin Ma, a U of G engineering graduate, have collaborated with agricultural and environmental researchers on the University of Guelph Manure Systems Research Team to develop MCLONE4 (Manure - Cost, Labour, Odour, Nutrients, Environment). It's a piece of software that integrates a wide array of experimental research data on soil, water and farm animals to give a larger picture of what happens to nutrients and other organic material in a farm's physical environment, given a particular set of farm practices and conditions.

As part of the U of G Farming

By Corie Lok

Systems Research Team, which works with the manure systems team, Ogilvie and his colleagues are now integrating the environmental effects of farming with other social and economic factors that influence the quality of life and sustainability of farms. The team hopes to expand its understanding of farming's far-reaching effects on the community. The goal is to identify what links there may be between farms and farm practices and the surrounding community, in terms of both the environment and quality of life, says Ogilvie.

Here's how it works. Research data are fed into a computer model to simulate a real farm operation. The data establish the relationship between a particular farming practice and its effects on the environment and the community. The model can then predict these effects when data about a farm situation are entered into the software.

MCLONE4 can be used by farmers and farm advisers to determine how much manure should be applied to fields and how much it will cost them, taking into account the farm's



animals, fields, crops and manure management system. It recommends application rates that satisfy the crop's nutrient needs while minimizing the risks of environmental degradation, such as surface water contamination, and of odour spreading to neighbours and nearby communities.

MCLONE4 can be used as part of a farm's nutrient management program, which is now mandatory for farms in some Ontario townships. The software package has been on the market for about a year and sold across Canada and the United States.

Ogilvie, Ma, engineering graduate David Hough, Don Hilborn of the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and Ron Fleming of Ridgetown College are in the final stages of amalgamating MCLONE4 with NMAN 2000, a nutrient management software program developed by OMAFRA. Combining the two will eliminate duplication and provide more information than each of the packages did on its own. Ogilvie says the amalgamated software suite will recommend application rates not only for manure, but also for all biological material, including compost and sewage sludge, while minimizing environmental damage. ■

Towards a bigger picture

With models in place that predict the environmental effects of farming, the next step is to look beyond the environment. Other researchers on the Farming Systems Research Team are studying the social and economic aspects of farming, such as the factors influencing farmers' quality of life and the economics of certain farm practices like conservation tillage. The researchers are broadening their view of the effects of farming by looking for the links between farm practices and farm life and economics. These links will be formed into a computer model and software that predict the social and economic effects of farming practices.

More information on the manure systems work can be found at www.oac.uoguelph.ca/ManSys. Information on the farming systems work can be found at www.oac.uoguelph.ca/FSR.

Researcher Email: jogilvie@uoguelph.ca

This research is sponsored by OMAFRA, Ontario Pork, the Dairy Farmers of Ontario and the Canadian Farm Business Management Council.

ZEROING

IN ON

Cryptosporidium parvum

by Tara Trussell

New
recombinant
antibodies
improve ID

A more sensitive and effective method for identifying a dangerous waterborne pathogen may soon be available, as researchers at the University of Guelph develop new tests for detection.

Environmental biology Prof. Hung Lee is leading a project to develop recombinant antibodies (rAbs) -- proteins generated through molecular biology techniques that destroy foreign substances in the body, such as bacteria or viruses -- to detect *Cryptosporidium parvum*, an infectious parasite that can be found in contaminated water supplies.

Reliable detection is necessary for routine monitoring and prevention of illness, says Lee. He's collaborating with Profs. Chris Hall and Jack Trevors, research associate Dr. Susan Weir and graduate student Nicholas Pokorny, Department of Environmental Biology, as well as Dr. Magda Kostrzynska from Agriculture and Agri-Food Canada.

C. parvum is a protozoan parasite that lives in the intestines of animals and humans. There are more than 10 species of the *Cryptosporidium* parasite, with *C. parvum* being the one known to infect humans. It can cause cryptosporidiosis, a gastrointestinal illness with symptoms including nausea, diarrhea, abdomi-

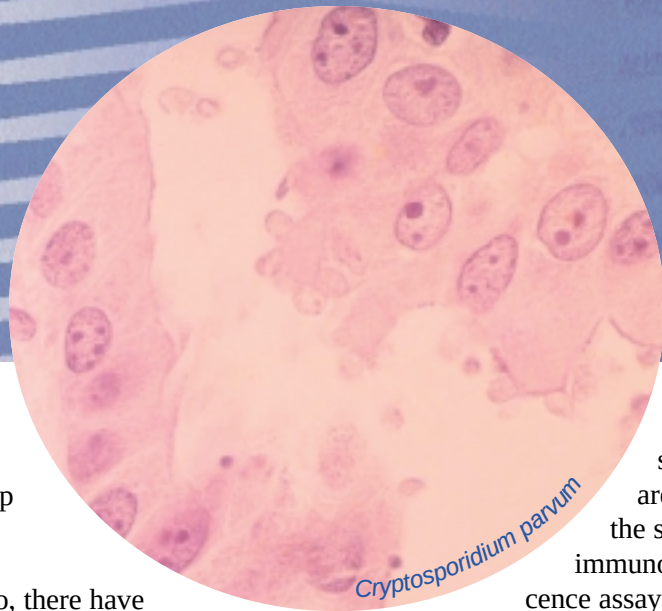
nal cramps and vomiting. It can be potentially life-threatening for people with compromised immune systems such as those with chronic illnesses, and young and elderly populations.

In Ontario, there has been an increased awareness of waterborne outbreaks of cryptosporidiosis, primarily caused when heavy rains increase the run-off of animal wastes from agricultural fields or



Professor Hung Lee and his team are developing recombinant antibodies to detect *Cryptosporidium parvum* in drinking water

human fecal contamination of the environment. Unwashed fruits and vegetables may also carry oocysts (a dormant form of the parasite) if manure containing the pathogen



was used or infected animals grazed where the crop was grown.

In Ontario, there have been periodic reports of outbreaks. One in the Collingwood, Ontario area in March of 1996 prompted the Ontario Ministry of Health to classify cryptosporidiosis as a reportable disease. Even so, it's not known how many cases actually occur every year; many people with an intestinal illness don't seek medical attention or are not tested for the parasite.

Here's a big part of the problem. Oocysts -- which are excreted in the feces of infected humans and animals -- contain a tough-walled shell that is difficult to kill or damage. This makes them able to survive under a variety of harsh environmental conditions. Oocysts are not killed by standard disinfectants, such as chlorine, used in municipal drinking water systems and swimming pools.

Professor Lee and his colleagues are developing a more sensitive method to detect *C. parvum* in environmental water samples from rural, agricultural regions. This method is based on the construction of recombinant antibodies against *C. parvum* oocysts, which are the forms normally found in the environment outside the host.

Currently, monoclonal antibodies (commercially manufactured antibodies

that are all of the same type) are used in the standard immunofluorescence assay-based detection of *C. parvum*.

However, monoclonal antibodies are very expensive, because they are produced in limited quantities from mammalian cells. As well, they are not necessarily species-specific. For example, a monoclonal antibody specified to detect *C. parvum* may also detect other non-parvum species or in some cases, an entirely different pathogen such as *Gardia*. The construction of a recombinant antibody allows for a potentially much higher specificity of selection for detecting the *C. parvum* species.

To construct these recombinant antibodies, the researchers first select antibodies naturally produced by animals infected with the *C. parvum* oocysts. Antibodies consist of constant and variable regions; the genes that code for the variable regions are isolated using molecular biology and recombinant DNA techniques. Random combinations of these variable region genes are catalogued and expressed on the surface of phage particles as the vehicle for screening and detection against *C. parvum*.

Once the antibody which binds to the *C. parvum* specifically is identified through screening, the genes

encoding that antibody can be transformed into a bacterium that rapidly reproduces, such as *Escherichia coli*. As the bacteria replicate, more antibodies are produced. *E. coli* bacteria can produce recombinant antibodies much faster due to a high metabolic rate being enhanced with rich nutritional conditions.

Lee says this bacterial system promises to be a much cheaper and productive way to produce recombinant antibodies than commercial sources of monoclonal antibodies. The easy availability of the variable region genes can also allow them to be readily modified by protein engineering methods to improve binding specificity and affinity to enhance *C. parvum* detection.

Future studies by Lee and his group will involve the construction of recombinant antibodies specific to *Cryptosporidium* sporozoites (active and potentially infectious state), which live within the intestines of susceptible mammalian hosts. ■

Researcher Email:
hlee@uoguelph.ca

This research is sponsored by OMAFRA and the Natural Sciences and Engineering Research Council. Scientists from GAP EnviroMicrobial Services and the Ontario Ministry of Health Laboratories, in London, Ontario are partners in the study.

Formulating Phosphorus



Professor Ming Fan and his research team are using dietary strategies to reduce phosphorus levels in swine manure by measuring endogenous P loss and the true efficiency of dietary P utilization.

Eating like a pig may soon take on a whole new meaning, as Prof. Ming Fan and his research group in the Department of Animal and Poultry Science at the University of Guelph, explore dietary strategies to minimize the detrimental effects of swine manure to the environment.

With growing environmental concerns over manure's impact on the environment, intensive hog farms are being targeted for the large volume of liquid manure waste they produce, high content of phosphorus and emissions of ammonia and various volatile sulfide compounds. Most crops use very little phosphorus, so high phosphorus content in manure can lead to runoff and eutrophication (depleted oxygen in the water) of surface waters.

excretion of phosphorus and the emission of ammonia and sulfides.

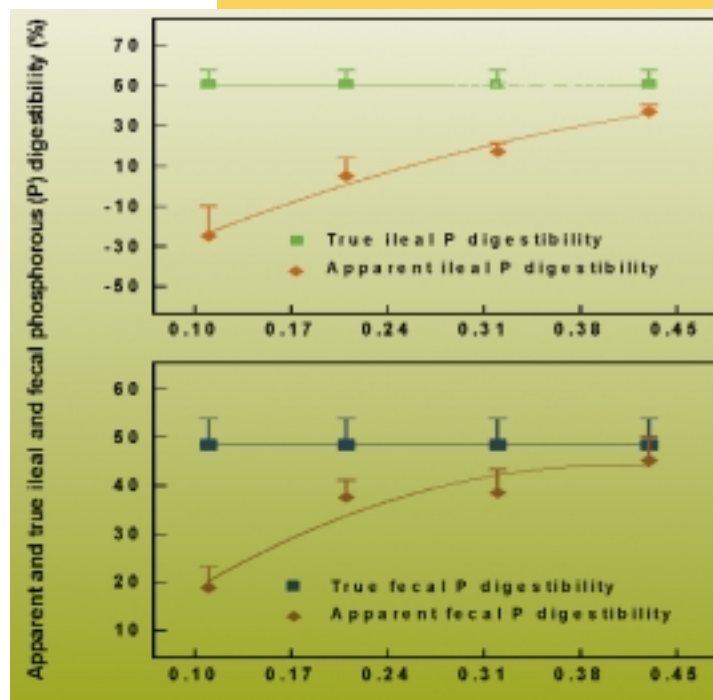
The key is to understand how nutrients are metabolized in the pig, says Fan. He and his team members, research technician Tania Archbold, Ph.D. student Sam Sheng and several undergraduate assistants, have developed a method for measuring endogenous phosphorus loss from the animal body and the true efficiency of phosphorus

utilization in feed by pigs. Ammonia and sulfide emissions cause offensive odors to the surrounding areas and may acidify surface soils and pollute drinking water resources. These factors led Fan and his team to investigate how practical feeding strategies can be developed, to reduce the

utilization in feed by pigs.

Phosphorus digestibility without correction for the endogenous loss is termed 'apparent' values; the values corrected for endogenous loss are called 'true' values. Fan found a particularly wide gap between the apparent and the true phosphorus digestibility values in feeds (see Fig. 1). The apparent values have been largely measured and reported from other researchers, and underestimate the true efficiency of digestive utilization of phosphorus in feeds for hogs by about 20 to 25 per cent. This results in extra dietary supplementation of inorganic phosphate salts,

Fig. 1. Determination of true vs. apparent phosphorus digestibility in feedstuffs of hogs.



- Correct Pig Feed

by Murray Tong

expensive ingredients and excessive manure excretion of phosphorus.

Fan and his team are continuing this area of research, to help the hog industry formulate swine diets on the basis of true digestible phosphorus supply. The newly developed method has also been used to measure improved digestive utilization of plant phosphorus in the transgenic phytase pig (also known as the Enviropig™) recently developed at the University of Guelph by a research team led by Profs. Cecil Forsberg, Department of Microbiology, and John Phillips, Department of Molecular Biology and Genetics.

In the area of controlling ammonia and sulfide emission, Fan and his students Yingxin Gao and Todd Rideout are exploring how dietary supplementation of various non-starch polysaccharides (water-soluble and insoluble fibre) can decrease the emission of these gases. Previously, the team had focussed on

improving feed conversion efficiency and refining dietary ingredients. Now, the corn-soybean meal-based diet, a typical diet used in Ontario and the Midwestern U.S. is likely deficient in the fibre content, says Fan.

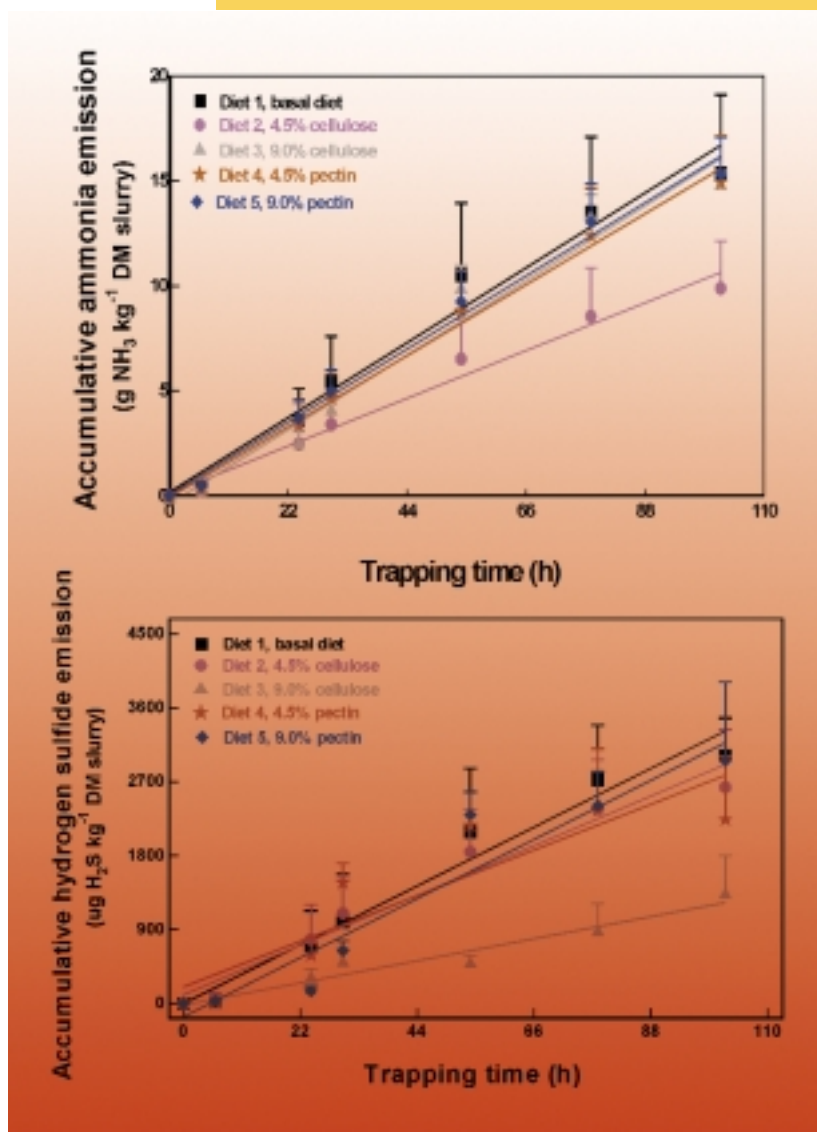
Microbes in the hindgut degrade fibre to obtain energy for their growth, and deficiency in dietary

fibre likely limits the multiplication of these micro-organisms. This causes reduced microbial protein and increased nitrogen excretion in the form of urea nitrogen, which is not stable, and easily turns into ammonia and is vaporized into the air. The challenge is that levels and sources of fibre likely affect ammonia and sulfide emission from

manure slurry (see Fig. 2). The team is now working on defining optimal sources and levels of fibre for the hog diets.

All of these strategies are becoming increasingly important to the meat industry, where new regulations in Quebec, Alberta and Europe demand low phosphorus levels, levying hefty fines on polluters. Fan says Ontario may not be far behind in implementing similar standards for swine producers. ■

Fig. 2. Differential effects of sources and levels of fibre feeding on ammonia and sulfide emission from swine manure slurry.



Researcher Email:
mfan@aps.uoguelph.ca

This research is sponsored by OMAFRA, the Ontario Pork Producers Marketing Board, Agriculture and Agri-Food Canada, Canadian Pork Council, Multi-Partner Hog Environmental Management Strategy Program and the Natural Sciences and Engineering Research Council.

Tracking *E. coli* through the Soil

by Lucas Habib

One-third of all wells in Ontario are contaminated with *Escherichia coli* bacteria on a regular basis, although not necessarily the pathogenic strain, *E. coli* O157:H7. University of Guelph Land Resource Science Prof. Mike Goss and a team of researchers - Prof. Hung Lee, Environmental Biology, Prof. Gary Parkin, Land Resource Science, Prof. Hugh Whitely, Engineering, Prof. Jeff Wilson, Population Medicine, and graduate student Adrian Unc - are examining factors which cause *E. coli* bacteria to penetrate the soil and enter the drinking water supply after manure applications. They are in the first year of their three-year project.

Various strains of *E. coli* are found in all types of manure. Their presence in drinking water has been shown to be a good indicator that other microbes, which can cause sickness, may also be present. However, the lethal strain of *E. coli* O157:H7 is found only in cattle, sheep and goat feces, and in some wild species such as deer. Soil characteristics, such as texture and pH, can influence bacterial penetration in soils, while organic material in manure can block pores and halt the infiltration of rainwater.

Goss and his team are also comparing solid and liquid manure applications to determine which type has a greater impact in promoting soil penetration by bacteria. And they don't have to look

far to find problematic wells. Of the chronically contaminated wells in Ontario, 20 per cent are estimated to have been contaminated by farm or wild animal manure.

Soil layers may give natural protection to groundwater, or conversely, promote the movement of bacteria into the ground, where it can lead to water contamination. They're now employing water partition models to see how manure and soil characteristics interact to affect the dominant pathway of water flow over the land surface or through the layers of earth and rock.

Salt content of manure may also be a significant factor influencing bacterial movement. One unusual characteristic of bacterial cells is that they can change the electrical charge on their surface. The charge on *E. coli* is determined by the electrolytic properties (i.e., the electrical effects of the solution on objects surrounded by it) of the solution in which the bacteria is located. This is dependent on the salt concentration. Manure contains enough ions to

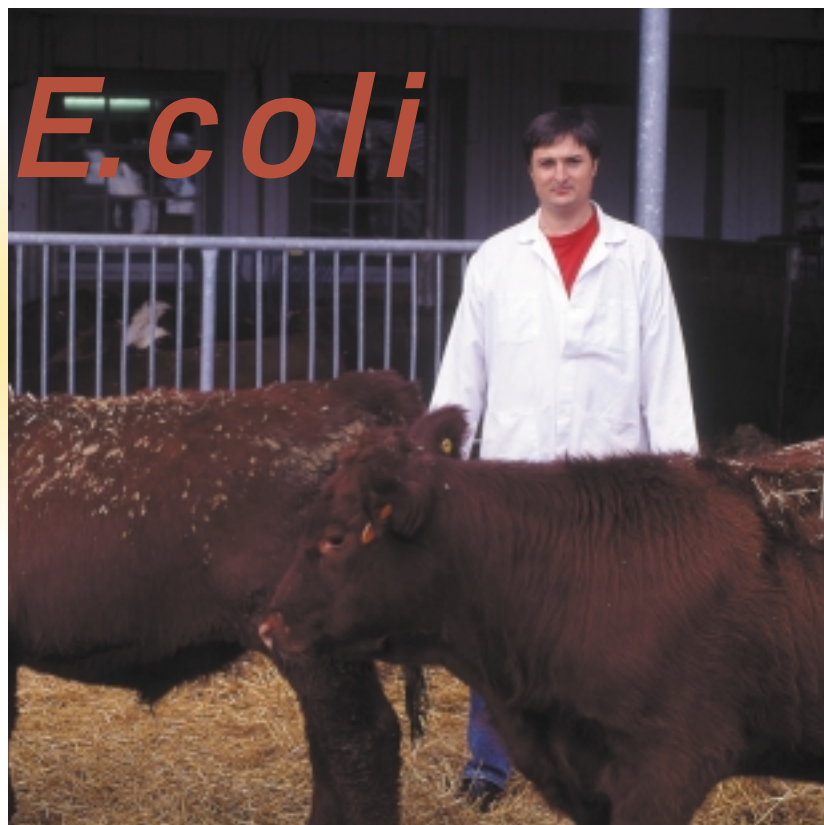
change the electrolytic properties of the soil, and therefore change the charge on the *E. coli* as well.

If the net charges on the bacterium and soil are similar, the bacterium is less likely to be retained on the soil, thereby moving rapidly with the water infiltrating into wells and groundwater. If the net charges on the bacterium and soil are sufficiently different, the bacteria will be held back on soil particles and are more likely to die before they can reach a well.

Goss hopes this research project will lead to better understanding and development of safer techniques for manure application in agriculture. ■

Researcher Email:
mgoss@lrs.uoguelph.ca

This research was sponsored by
OMAFRA.



Researcher Adrian Unc & colleagues are examining factors which may influence bacterial movement into drinking water sources - such as salt content of manure applied to soil.

Fine Tuning the Phosphorus in Nutrient Management Plans

The recently developed Ontario Phosphorus (P) Index will help address the risk of P runoff from agricultural land, and provide guidance for municipal decisions concerning the expansion of livestock operations.

Previously, manure applications to crop lands were based primarily on the nitrogen (N) requirements of the crop. Provincial monitoring shows that about half of Ontario's watersheds still exceed the provincial water quality objectives for P - coming from both urban and rural non-point sources.

The purpose of the P Index is to identify risks of P contamination based on site-specific characteristics of the soil, and management practices. This project will focus on P availability in manure, residual availability and contribution to soil test P levels, the potential downward movement of P and its fractionation into pools of differing bio-availability in soils with a long history of manure applications.

Ivan O'Halloran, Ridgetown College, University of Guelph
Email: iohallo@ridgetownc.uoguelph.ca

A Watershed View of Water Quality

Livestock are often assumed to be the largest contributor of contaminants in a rural watershed, but other impacts have not been well documented - for example: illegal connections of septic systems to drainage tiles, sewage treatment plant discharges of raw sewage, and wildlife impacts.

The Ridgetown College study will attempt to put into perspective the potential sources of contamination in a watershed - including, but not limited to - various agricultural practices.

A second part of the study deals with manure volumes on swine farms using wet/dry feeders to reduce water wasted in a pig barn. This can have a major impact on farmers using nutrient management planning to determine manure spreading rates, which in turn, affects the potential for contamination of ground and surface water.

Ron Fleming, Ridgetown College, University of Guelph
Email: rfleming@ridgetownc.uoguelph.ca





Concentrating the Value

Most farmers who handle solid manure do not collect manure pile runoff. Proper storage and land application may help to avoid water contamination, but are costly. If the liquid is not applied properly, the overall environmental impact might not be improved, and some farmers simply do not have the required land base. The technology proposed at Alfred College is designed to concentrate the fertilizing value of the manure in a small volume of sludge that can be used in the field much more efficiently. It could greatly reduce environmental impact, as well as labour and capital costs of proper manure pile and milkhouse wastewater runoff management.

Anna Crolla, Alfred College,
University of Guelph
Email: acrolla@alfredc.uoguelph.ca

Best Management Practices (BMPs) to Increase Nitrogen Use Efficiency on Farms

Nutrient management planning is a priority for Ontario farmers. Livestock producers who have manure with variable nutrient content, depending on the storage and mixing, face particular challenges in field application. Once applied to the field, the loss of nitrogen by volatilization is variable, depending on any delay before incorporation, and on climatic conditions at the time. A soil test around the time of planting would help farmers use a combination of manure and mineral fertilizer more effectively, while protecting water resources. Farmers are very aware of the large concentrations of nitrate, and even significant amounts of phosphorus, that can be removed in tile drain water. Allowing the water to pass through wetland areas before discharging into water courses may remove a significant fraction of the two elements that contribute most to eutrophication. Research will determine whether it can be recommended as a BMP within Ontario.

Mike Goss and Gary Parkin, Dept. of Land Resource Science, University of Guelph
Email: mgoss@lrs.uoguelph.ca

Assessing the Incentive 'Fit' of BMPs

A lot of research goes into developing and fine-tuning BMPs. But depending on local factors, there may be little financial incentive for adoption, although they may be of great environmental benefit, and vice versa. Adverse incentives can cause too much or too little environmental protection, or too great a cost to the agricultural firm and at too little a benefit to society. Some incentive mechanisms leave almost no discretion to the landowner or firm to innovate to find more effective solutions, while others may be better suited for individual circumstances and innovative solutions at lower cost. Evaluation of the most effective and readily adopted policy tools are necessary for successful reduction of the agriculture's impact on the environment.

Kim Rollins, Dept. of Agricultural Economics and Business, University of Guelph
Email: krollins@uoguelph.ca

The Impact of Environmental Farm Planning in the Grand River Catchment

In the short run it seems that there is generally a trade-off between production and environmental objectives, but this is not always the case. One rationale of environmental farm planning is that by achieving a sustainable resource base, production and profitability are enhanced in the long term. This research hopes to show what types of environmental actions will result in sustainable outcomes, and at what cost. The work will develop a series of land management scenarios, including quantifying the hydrological parameters which drive environmental degradation, the financial position of the farm business, and incentives to environmental farm planning. Both the private and social costs and benefits of environmental farm planning will be determined.

Kevin Parton, Dept. of
Agricultural Economics and
Business, University of
Guelph
Email:
kparton@agec.uoguelph.ca



Riparian Filterstrips 'Fit' for the Watershed

To maintain soil productivity and down stream water quality, the most effective vegetative filter-strips are based on the soil, land use, land management (including tile drainage) and topographic characteristics of the upland area. Research to evaluate these factors will help farmers and other land managers to evaluate and select BMPs, at the scale of a field or a vegetative strip, to meet environmental objectives for quality of soil and water resources set at a watershed scale.

Ramesh Rudra, School of
Engineering, University of Guelph
Email: rrudra@uoguelph.ca

Reducing the Impact of Drought

Agricultural producers use about one third of the fresh water consumed in the Ontario. Livestock requirements are the greatest farm demand, followed by specialty crops. Producers have experienced difficulties meeting their water requirements and increasingly find themselves competing with municipalities, industries and other users for variable water supplies.

The Canadian Climate Centre climate change model suggests that southern Ontario could experience a warmer and drier climate, which would reduce soil moisture and groundwater recharge, while increasing irrigation and livestock watering and cooling requirements.

Current water allocation arrangements may not assure agricultural producers access to needed supplies. By assessing the capacity of rural communities to meet these challenges, this project aims to suggest ways of reducing the impacts of drought on Ontario agriculture.

Reid Kruetzweiser, Dept. of Geography, University of Guelph
Email: reidk@uoguelph.ca

In Search of THE PERFECT SPREAD

by Julie Bhatia

Improvements in manure spreader technology may help maximize manure's benefits on crop growth, while minimizing its contribution to surface and groundwater contamination. Prof. Ben Hawkins of Kemptville College, University of Guelph, is redesigning the chopping and spreading action of solid manure spreaders to permit a lower and more even land application rate.

Problems related to ground and surface water are more likely to occur when high or uneven rates of manure are applied during periods when plant requirements for nutrients is low. Manure must be applied to the ground at a rate that supports uptake from plants, to prevent leeching and minimize surface and groundwater contamination

Commercial manure application is often lacking, as far as evenness and range of application rates, says Hawkins. He tested three or four conventional spreaders and found that they delivered the manure in a path equal to their width, limiting how fast manure can be unloaded. The spreaders were unable to break up larger clumps of manure, possibly leading to an uneven spread and the smothering of crops.

Hawkins is developing a spreader with more efficient chopping action and an increased range of spread, to ensure that animal wastes and biosolids are applied to the land at timely rates. Increasing the width of the spreader

would allow farmers to spread manure at a lower rate of application but still get manure onto the land at the same speed.

Knowing the rate at which manure is being applied to the land may become critical if regulations are passed requiring farmers to develop and comply with a nutrient management plan.. This means producers will need to balance the nutrient application with the crop uptake, and may force producers to address the inadequacies of current spreaders, says Hawkins.

Hawkins has examined other machinery available on the market in addition to conventional spreaders, such as chopping and feeding devices, to get ideas of how to redesign the manure spreader. The design of the chopping stage of the spreader has been completed and the prototype is being build for testing later this year. Hawkins is designing the spreader stage of the machine and plans to have its construction completed by the end of the year. More testing will then be carried out next spring.

Hawkins is also in the initial stages of determining the manure composition that best lends itself to spreading with conventional and modified spreaders. He's investigating treatment methods for manure that will produce a uniform product that can be spread more evenly on the land. ■

Researcher Email:
bhawkins@kemptvillec.uoguelph.ca

This research is sponsored by OMAFRA.

CONSTRUCTED WETLANDS:

a viable option to treat rural wastewaters

by **Chris Kinsley &
Anna Crolla**

Wastewater engineering often evokes images of large concrete basins accepting sewage collected across vast urban areas. These highly centralized systems work well in cities, where land is at a premium and population densities are high. In rural areas, with more space and often fewer tax dollars, different solutions are required. Over the past decade a concept of utilizing nature's inherent ability to assimilate contaminants in wetlands has attracted the attention of wastewater engineers. Using natural processes, constructed wetlands can provide a cost effective and environmentally sound means of treating a variety of rural wastewaters including: municipal sewage and stormwater runoff, manure pile runoff, milkhouse washwater, mine drainage and landfill leachates.

Researchers at the Ontario Rural Wastewater Centre at Collège

d'Alfred have been for several years applying wetland technologies to treat a variety of rural wastewaters. Constructed wetlands are becoming an accepted alternative to managing wastewaters emanating from farms, towns and rural industries.

Constructed wetlands, like natural wetlands, use a combination of biological, physical and chemical processes to remove contaminants from the water column. Solids settle out from suspension in the quiescent areas. A significant portion of the Biochemical Oxygen Demand (BOD), nutrients (mostly nitrogen and phosphorus) and pathogens are removed by sedimentation. The remaining suspended and soluble organic material is aerobically degraded by bacterial biofilm that attaches itself to the plant stems. Nitrogen is removed by ammonification and nitrification/denitrification. The bacteria convert ammonium to nitrate under

aerobic conditions. Under anaerobic conditions, nitrates are further converted to nitrogen gas and released to the atmosphere. Soluble phosphorus is removed by adsorption to iron and aluminum sites on the soils of the wetland floor. Pathogens are further removed through a combination of natural die-off, temperature, sunlight (ultraviolet light), water chemistry and predation.

Constructed wetlands can be divided into two major types: surface flow and subsurface flow wetlands.



Researchers Chris Kinsley & Anna Crolla of the Ontario Rural Wastewater Centre, Collège d'Alfred, University of Guelph

A surface flow wetland, like a marsh, has wastewater flowing on the surface to a depth of 0.1-0.3 m amid the stalks of the reeds and cattails. In a subsurface flow wetland, wastewater flows beneath the surface through a gravel matrix out of which wetland plants grow. The gravel in a subsurface flow wetland provides additional surface area for the growth of biofilm which increases the rate of contaminant degradation as well as allowing for increased depth in the wetland (0.5-1.0 m). The advantages of subsurface flow wetlands are less land area required for a system and viable operation in winter. Surface flow wetlands are typically limited to a seven month operating season in cool climates. On the other hand, surface flow wetlands tend to be less expensive to construct and are less likely to experience clogging problems.

Municipal Wastewater - Town of Alfred Pilot Study

The Village of Alfred is 70 km East of Ottawa and has a total population of approximately 1,200 people. Alfred's sanitary sewage is currently treated by a two-cell sewage lagoon which is discharged to a nearby brook twice a year. The lagoon cells were constructed in the early 1970s and are approaching their design capacity. The same problem is being faced by many towns and villages across rural Ontario and throughout North America. Utilizing a "march-pond-marsh" design, the Alfred pilot wetland was constructed to treat 20,000 - 60,000 m³ per year or 5-15% of the flow entering the Alfred municipal lagoon. Construction was completed in 1999 with full operation and moni-

toring commencing in June of 2000. In its first full season of monitoring, over 80 % BOD, 70% TN and over 92% TP was removed. Three years of monitoring is required before the Ministry of Environment will permit continuous discharge from the wetland to the brook. In the mean time, the treated effluent is being returned

Acknowledgments: Township of Alfred and Plantagenet, Ontario Ministry of Environment, Stantec Consulting Ltd., OMAFRA, Agricultural Adaptation Council, Ontario Clean Water Agency, South Nation Conservation, the City of Essex-Windsor and Jacques Whitford Environment Ltd..



to the lagoons.

The primary research objectives for the Alfred Pilot study are:

1. To demonstrate that a constructed wetland is consistently effective at treating the municipal lagoon effluent from the Municipality of Alfred-Plantagenet;
2. To evaluate phosphorus adsorption filters and vegetated filter strips as polishing steps;
3. To analyze the kinetic design rates and their variability for contaminant removal under Ontario climatic conditions.

Leachate - Essex Windsor Landfill Leachate Treatability Study

Landfill leachate is the contaminant laden wastewater which percolates through a landfill. Moisture within the landfill waste, surface and ground water infiltration and rainfall contribute to the formation of leachate. Landfill sites are most often located in rural areas, far from municipal sewer lines, and require on-site treatment of their landfill leachate.

The Essex-Windsor Solid Waste Authority's Maidstone Landfill, located in southern Ontario, is a closed landfill that produces a leachate with moderate but significant values of ammonia, chemical oxygen demand (COD) and BOD. The objectives of the study were to test the leachate from the Maidstone Landfill site for its treatability through a subsurface flow wetland and to identify the necessary design parameters needed to properly size and cost a wetland system. The Ontario Rural Wastewater Centre conducted the study under contract to Jacques Whitford Environment Ltd..

Two one m³ subsurface flow wetland cells were connected in series and filled with two inch gravel to a depth of 0.8 m and vegetated with reeds. Ammonia-nitrogen was considered to be the primary contaminant of concern in the Maidstone Leachate. To enhance ammonia removal, cell #2 was aerated. A third cell was connected in series with the first two cells, but filled with 1/4 inch slag from the steel manufacturing industry. The slag cell was added to assess its ability to precipitate certain metals. Leachate was fed through the system for 11 weeks with detention times for each cell varying between two to four days.

Ammonia concentrations were reduced by 98 % in the aerated second cell. The kinetic rate constant (rate of ammonia reduction) was found to be ten times that found in the literature for subsurface flow wetlands. This indicates that the addition of an aeration system can drastically reduce the size of a system designed for ammonia treatment. BOD removal was measured at 85%, while 20% of COD was treated. Analysis of the data showed no significant treatment resulting from the use of a steel slag adsorption filter. The data provided by this study are being used to design larger systems. ■

Researcher Email:
ckinsley@alfredc.uoguelph.ca

Ontario Rural Wastewater Centre

The need for better research and training in the areas of rural wastewater management has led to the creation in 1999 of the Ontario Rural Wastewater Centre (ORWC). The University of Guelph (Collège d'Alfred and the School of Engineering) with its partners in industry, Conservation Authorities and government have worked together to make the Centre a reality. ORWC's mandate is to provide training, demonstration and applied research in the areas of on-site disposal of household septage, nutrient and agricultural waste management, and rural municipal wastewater treatment. The Centre has three training and demonstration sites located in Southern and Eastern Ontario at Guelph, Alfred and the Baxter Conservation Area (south of Ottawa). The Centre offers courses utilizing demonstration technologies with the objective of providing hands-on learning opportunities to clients in the on-site wastewater treatment industry, agri-food industries and to the general public.

For more information on the ORWC and its training or research activities contact Chris Kinsley at (613) 679-2218 ext. 609 or Shelly Bonte-Gelok at (519) 824-4120 ext. 4167.



Plantfood... or TOXIN?



Processed sewage, commonly known as biosolids, contain nitrogen, phosphorus and other micronutrients essential for plant growth, and organic materials which enhances soil quality. But biosolids also carry heavy metals such as chromium, in concentrations ranging from 15 parts per million to more than 1,000 parts per million. These metals can potentially enter the food and water supply, if applied to crop land.

By Corie Lok

To address this risk, land resource science professor Beverley Hale, along with Murray McBride of Cornell University, are studying how metals such as cadmium, lead, copper, nickel and zinc are absorbed by plants and soil, to see if the levels are higher than normal after sewage biosolids have been spread on the land surface. Metals in foods can pose a risk to human health, says Hale. This work will contribute to managing that risk by identifying whether biosolids application is a significant source of metals in foods.

Hale is testing two variables that may affect metal absorption: soil type, and the time between biosolids application and plant harvest.

Metals can originate from industry but are also a natural part of soil, plants, food and human waste. Many metals are essential as trace elements for plant growth and other biological functions, but are toxic at higher levels. Concentrations in biosolids, measured in

parts per million, vary depending on the number and types of metal sources in the area where the biosolids were produced.

Everything from industry to natural phenomena, such as the types of rock in the area where water is draining through, will affect the metal concentration.

Land application is one of only a few disposal methods for the estimated 300,000 dry tonnes of treated sewage produced in Ontario yearly, and has been in practice for more than 20 years. Provincial regulations stipulate that only treated sewage biosolids and septage can be applied to agricultural fields, and only after the biosolids, the receiving field, application method and timing meet strict provincial criteria.

Quality and application rate of biosolids are determined by their nitrogen and metal content. Hale says in most cases, either the allowable applied nitrogen level or the allowable applied solids from biosolids is reached before the maximum allowable addition of metals.

About half of Ontario's treated sewage is spread on land and an estimated 40 per cent is incinerated. The remainder is sent to landfills.



Researcher Beverley Hale is studying the fate of metals in biosolids, following applications to silty loam and sandy soil. Soil type and time between biosolid application and harvest may affect metal absorption.

Incineration has been falling out of favour over the last decade because of its high costs and the polluted air it produces. Landfill space is scarce and costly. With more advanced treatment technologies and stricter by-laws, sewage going into treatment plants -- and biosolids coming out -- are a lot cleaner than in years past, and land application is becoming a more viable option.

But in the wake of public concern and the "not-in-my-backyard" syndrome, it's become controversial. However, there will be risks no matter what method is used to dispose of treated sewage, says Hale. She believes the key is to compare the risks and stack them up against the benefits.

In her research, Hale is examining the metal uptake by beet root and chard in test fields at Elora and Cambridge Research Stations, after sewage biosolids have been applied. Beet root is a test subject because the edible portion is in direct contact with soil and it's the part most likely to absorb metals first. Chard was chosen because green leafy vegetables have been known to bioaccumulate heavy

metals. Hale's experiments are looking at an extreme case. Sewage biosolids are being applied at twice the allowable levels set by the



Beet root and chard are the test crops being used to examine the absorption and bioaccumulation of heavy metals, and changes in bioavailability over time.

Ontario Ministry of Environment (OME).

The two experimental sites were chosen for their different soil types -- the Elora site is composed of silt loam soil, while the soil at the Cambridge site is sandy. Hale believes metals might leach more quickly from sandy soil, which has less organic material, than from

soils with higher organic content.

Most previous studies looking at metal uptake by plants measured the metal content in plants immediately after application of sewage biosolids. Hale thinks metal bioavailability changes with time after biosolids application because soil pH changes and organic material decomposes. Because of these changes over time, she is looking for any differences in plant metal uptake on soils where biosolids were applied every spring and on land where biosolids were spread more than 20 years ago.

She is also studying how much of the metals are bound to the organic portion of soil and how much dissolves in the soluble portion. The chemical form and location of metals in soil play a role in determining if and how much metals leach from soil as well as the metals' bioavailability to plants. ■

Researcher Email:
bhale@lrs.uoguelph.ca

This research is sponsored by
OMAFRA.

COMPOSTING takes up the Challenge

by Amanda Elias

A team led by Prof. Ron Fleming, Ridgetown College, University of Guelph has designed a unique in-vessel (meaning "in a contained channel") composter that will help prevent pathogenic contamination of water and reduce odour. Fleming is collaborating with research technician Malcolm MacAlpine and Prof. Jim Morris from Ridgetown College and Tom Smith from Global Earth Products.

The system uses forced aeration and mechanical turning of the compost material. This ensures the microorganisms that break down the organic compounds in the compost can do their job under optimal conditions. The researchers tested many composting substrates, such as straw and wood fibre, to identify the most cost-effective, manageable materials.

Here's where the system could fit in. Most swine farm operations in Ontario utilize liquid manure systems. Urine and fecal waste -- composed of 90 to 99 per cent liquid with the balance being solid waste -- is collected in holding tanks or gutters below the slatted barn floor.

But odours are a problem, both when the manure is stored and when it is spread. And volumes are growing. As well, untreated manure can

pose very real threats to the health and safety of surface and ground waters, says Fleming. Close to 75 per cent of the nitrogen contained in the raw manure is in the form of highly volatile ammonia, which is readily released into the atmosphere if not covered with soil soon after spreading. It's also highly soluble in water. But with composting, nitrogen becomes fixed in the cell walls of the bacteria; it's no longer a problem.

Fleming's composting system has been designed, refined and tested to address both odour and contamination issues. The result is compost material that eliminates the impact on water quality inherent with raw manure and creates a marketable product in the process, he feels.

The system at Ridgetown is comprised of three concrete composting channels, each 2.2 m wide, 1.8 m deep and 15.2 m long. Though this is an experimental setup, it's big enough to handle the manure from a small to medium swine farm. Ideally, the channel is housed indoors to keep out precipitation, eliminate environmental waters and keep tighter controls on the crucial composting temperatures.

The prototype used for turning the compost is called MARVEL



designed by Lagace Systech Corporation, specifically for this application. It's powered by an electric motor driving a hydraulic pump. The turner travels down the channel on steel tracks, mixing and turning the manure and substrate as it moves along.

In this system, the liquid manure is stored in a covered underground storage tank, typical of many farms. Then it's transferred into the channel

by a pipe attached to a flow meter, to monitor manure flow into the channel. Excess manure is drained out of the channel, collected and sent back to the manure storage tank. The channel is aerated by an electric fan that forces outside air to the aeration floor. Temperatures are measured at the top and bottom of the compost mass. Optimum levels of aeration are determined by temperature readings taken at various locations in the channel.

Fleming and his team have experimented with various composting substrates, including wood fibre, corn

stover, corn cobs and straw. They compared different volume, mass and nutrient compositions of the resulting products and found that all materials provided suitable conditions for accelerated composting in the desired temperature range, about 55 to 70°C maintained by the biological activity of the composting microbes. The design target ratio for liquid manure to straw substrate (by weight) was about six to one, which provided ideal composting conditions.

Fleming says the critical elements of successful composting in any system are temperature and the presence of oxygen. Under aerobic conditions, the by-products of composting are carbon dioxide, heat and water. Favorable conditions are maintained by the addition of organic matter that feeds the bacteria with the proper ratio of carbon to nitrogen, and keeps heat production within the desired range. If oxygen is unavailable, the organic matter produces methane, hydrogen sulphide, and other gases, accounting for the strong odours characteristic of liquid swine manure.

Ideal temperature ranges in the channel encourage the growth of thermophilic (heat-loving) bacteria. Composting ideally continues under aerobic conditions for two to three weeks, at which point the partially

composted material is removed to an external storage facility for an additional nine to ten weeks of curing to break down the remaining organic material and remove additional moisture. Bacteria such as *E. coli*, *Salmonella*, and protozoa such as *Cryptosporidium* are eliminated by high temperatures in the compost. The high temperatures also destroy the seeds for various weeds.

The system developed at Ridgetown has achieved a throughput of liquid manure equivalent to that produced by about six feeder pigs per square metre of channel. A farm-scale system for composting liquid manure has recently been installed on an Ontario swine farm. The Ridgetown team will monitor it over the coming months, to determine if the system is economical as a manure management option.

Fleming says the marketable compost product which results from this system provides hog farmers with additional opportunities to sell to nurseries and garden centres, golf courses and landscaping companies for rehabilitation of depleted soils. ■

Researcher Email:
rfleming@ridgetownc.uoguelph.ca

Funded by OMAFRA



The compost turner is shown moving through the aerated, mechanically turned channel containing straw, applying liquid manure as it moves along. The ratio of liquid manure to straw substrate (by weight) was about six to one, which provided ideal composting conditions.

Table 1. Average losses of compost constituents in an experimental, aerated, mechanically turned composting channel (1999).

Constituent	Straw	Corn Cobs	Corn Stover	Wood Fibre	Leaves
Total mass	55.8%	69.6%	42.5%	38.4%	45.2%
Dry matter	49.6	58.2	17.6	22.2	41.8
Carbon	54.6	69.3	31.4	32.6	54.3
Organic matter	56.8	66.2	29.4	25.2	53.5
Total N	17.9	14.4	13.2	-9.1	9.1
Average # days	31.8	52	31	38.7	51

Les recherche en bref

Fertilisant... ou toxine?

Des chercheurs analysent les effets sur l'environnement des biosolides issus des matières d'épuration épandus dans le sol

Les matières d'épuration traitées-connues sous le nom de biosolides-sont de bons fertilisants pour les cultures. Mais les inquiétudes au sujet de la migration éventuelle de composants des matières d'épuration comme les métaux lourds dans le sol, l'eau et les plantes ont incité un chercheur de l'Université de Guelph à examiner ce qui arrive à certains métaux une fois que les biosolides issus des matières d'épuration ont été appliqués dans le sol. Ces travaux contribueront à gérer les risques à la santé humaine en déterminant si l'application des biosolides représente une source importante de métaux dans les aliments.

À partir d'essais reposant sur deux variables, le type de sol et le temps écoulé entre l'application des biosolides et la récolte, le professeur Beverley Hale pense que les sols légers peuvent lixivier plus rapidement et que la biodisponibilité change avec le temps. Elle étudie également la quantité de métaux solidaire de la partie organique du sol et la quantité qui se dissout dans la partie soluble.

Cette recherche est subventionnée par le ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario.

Sur la piste du E. coli

À la poursuite des mouvements de la bactérie dans le sol

Une équipe de chercheurs de l'Université de Guelph, dirigée par le professeur Mike Goss et en collaboration avec le Scottish Agricultural College (SAC) de Aberdeen étudient les facteurs qui influencent la pénétration de la bactérie *Escherichia coli* (E. coli) dans le sol et l'exposition éventuelle des réserves d'eau potable. Le professeur Goss espère que ce projet de recherche permettra de mieux comprendre la situation et d'élaborer des techniques plus sûres d'épandage du fumier dans les exploitations agricoles.

Les facteurs que le professeur Goss et son équipe étudient sont notamment si la bactérie E. coli a plus de chances de se retrouver dans le ruissellement direct superficiel par suite de la contamination des eaux de surface, ou dans le ruissellement souterrain par suite de la contamination du réseau de drainage souterrain. On compare les applications de fumier solide et liquide afin de déterminer quel type influe le plus sur la pénétration de la bactérie dans le sol. Les chercheurs essaient également de déterminer si la teneur en sels du fumier et la charge superficielle de bactéries ont une incidence quelconque sur la capacité de E. Coli de pénétrer le sol.

Cette recherche est subventionnée par le ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario.

Le *Cryptosporidium* *parvum* dans le collimateur

De nouveaux anticorps recombinants améliorent la détection par immunofluorescence

Des chercheurs de l'Université de Guelph travaillent à l'élaboration de nouveaux tests pour la détection du *Cryptosporidium parvum*, un parasite protozoaire qui vit dans les intestins des animaux et des humains et est la cause de la cryptosporidiose, une maladie gastro-intestinale parfois mortelle.

Actuellement, des anticorps monoclonaux fabriqués commercialement sont utilisés dans la détection par immunofluorescence standard fondée sur les bioanalyses de *C. parvum*. Malheureusement, les anticorps monoclonaux sont très coûteux, produits en quantité limitée, et ne sont pas nécessairement spécifiques d'espèce. La nouvelle méthode de détection plus sensible est fondée sur la fabrication d'anticorps recombinants contre les oocystes de *C. parvum*, lesquels sont les formes que l'on retrouve normalement dans l'environnement à l'extérieur de l'hôte. Selon le Dr Hung Lee, chef de projet, ce système bactérien promet d'être beaucoup moins coûteux et plus productif.

Cette recherche est subventionnée par le ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario et le Conseil de recherches en sciences naturelles et en génie. Des scientifiques des GAP EnviroMicrobial Services et des laboratoires du ministère de la Santé, localisés à London, en Ontario, participent à cette étude.

À la recherche de l'épandage parfait

Un épandeur de fumier solide entièrement repensé promet des récoltes plus vigoureuses et des réserves d'eau plus propres

Des améliorations apportées à la technologie des épandeurs de fumier pourraient contribuer à maximiser les effets positifs du fumier sur la croissance des récoltes, tout en réduisant sa contribution à la contamination superficielle et souterraine. Le professeur Ben Hawkins du Kemptville College, de l'Université de Guelph, repense la conception du mécanisme de hachage et d'épandage du fumier solide afin de permettre une application plus uniforme du fumier sur le sol, avec un taux d'application plus faible.

L'épandage commercial de fumier manque souvent d'uniformité et les taux d'application varient. Le professeur Hawkins travaille à l'élaboration d'un épandeur dont le mécanisme de hachage sera plus efficace et dont la portée d'épandage sera plus grande afin que les déchets d'origine animale et les biosolides soient appliqués sur le sol au taux souhaité. Connaître le taux d'épandage du fumier peut devenir d'une importance essentielle pour les agriculteurs si les règlements exigeant qu'ils élaborent des régimes de gestion des éléments nutritifs sont adoptés et s'ils sont tenus de s'y conformer. Le professeur Hawkins essaie également de déterminer la composition du fumier la mieux adaptée à l'épandage avec des épandeurs traditionnels et modifiés.

Cette recherche est subventionnée par le ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario.

Marais artificiels

Une solution viable pour traiter les eaux usées rurales

La capacité intrinsèque de la nature d'assimiler des contaminants dans les marais a suscité énormément d'attention au cours de la dernière décennie. À partir de processus naturels, les marais artificiels peuvent offrir un moyen rentable et respectueux de l'environnement de traiter un éventail d'eaux usées rurales y compris les eaux d'égouts urbains et les écoulements d'eaux pluviales, les ruissellements de tas de fumier, les eaux de lavage de laiterie, les eaux d'exhaure et les lixiviats de décharge. Les chercheurs de l'Ontario Rural Wastewater Centre du Collège d'Alfred ont appliqué les technologies des marais au traitement d'un éventail d'eaux usées rurales.

Cet article examine les deux principaux types de marais artificiels et leur capacité d'éliminer les contaminants d'une colonne d'eau. Il décrit également plusieurs projets, notamment : le Marais artificiel de la ferme laitière Dignard et ses taux d'élimination des déchets, ainsi que l'étude pilote de la Ville d'Alfred d'un modèle « marais-étang-marais » conçu pour traiter les eaux d'égouts urbains.

Sont également inclus un rapport sur la Essex Windsor Landfill Leachate Treatability Study dans lequel on examine la traitabilité du lixiviat d'un site d'enfouissement à l'aide d'un marais à écoulement souterrain. Les paramètres d'exploitation d'un système de marais de bonne dimension et à coût raisonnable sont identifiés, et on

inclut également une description de l'Ontario Rural Wastewater Centre.

Ces travaux bénéficient de l'appui du ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario ainsi que de nombreux autres organismes locaux.

Le compostage relève le défi

À la recherche d'une solution pour le fumier de porcs

Une équipe de chercheurs sous la direction du professeur Ron Fleming, de Ridgetown College, à l'Université de Guelph, a mis au point une nouvelle méthode de compostage économique et respectueuse de l'environnement. MARVEL est un composteur « en compartiments » (ce qui signifie qu'il opère dans un « circuit fermé ») qui fait appel à une injection d'air forcé et à l'agitation mécanique des matières compostées afin de prévenir la contamination de l'eau par des pathogènes et de réduire les odeurs.

Le système comporte trois compartiments de compostage en béton, suffisamment grands pour contenir le fumier d'une ferme d'élevage de porcs de petite à moyenne dimension. Idéalement, ce système devrait être utilisé à l'intérieur afin de le protéger des précipitations, d'éliminer les eaux environnementales et de maintenir un contrôle sévère sur les températures idéales de compostage. L'agitateur de compost se déplace le long du canal sur des rails d'acier, mélangeant et retournant le fumier et le substrat sur son passage. Le ratio visé entre le fumier liquide et le substrat de paille en poids était d'environ six pour un,

ce qui offrait des conditions de compostage idéales.

Le système a obtenu un débit de fumier liquide équivalent à celui produit par environ six porcs d'engraissement par mètre carré de compartiment. Le compost commercialisable qui est produit à l'aide de ce système donne aux producteurs de porcs la possibilité de le vendre également à des centres jardin, à des terrains de golf et à des paysagistes.

Une vue agrandie de la ferme

Un logiciel informatique donne une vue d'ensemble

L'équilibre délicat entre la production agricole, la protection de l'environnement et la qualité de vie peut compter sur un nouvel appui, grâce à la modélisation informatique. Des chercheurs de l'Université de Guelph ont mis au point MCLONE4 (Manure-Cost, Labour, Odour, Nutrients, Environment), un logiciel qui intègre des données sur le sol, l'eau et le bétail afin de donner une vue d'ensemble de ce qui arrive aux éléments nutritifs et autres matières organiques dans l'environnement de l'exploitation agricole en fonction des pratiques et des conditions de l'exploitation. L'équipe espère améliorer sa compréhension des effets à long terme de l'exploitation agricole sur la collectivité.

La fusion de MCLONE4 et de NMAN 2000, un logiciel de gestion des éléments nutritifs élaboré

par le ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario est presque achevée. La combinaison des deux programmes éliminera le chevauchement et permettra d'obtenir plus d'information que si l'on utilisait un seul programme à la fois. Le logiciel fusionné recommandera des taux d'application non seulement pour le fumier, mais aussi pour toutes les matières biologiques, y compris le compost et les boues d'épuration, afin de réduire les répercussions sur l'environnement.

Cette recherche est subventionnée par le ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario, Ontario Pork, les Dairy Farms of Ontario et le Conseil canadien de la gestion d'entreprise agricole.

La fibre trouve un allié

Une nouvelle ration pour les porcs aurait des effets bénéfiques sur le fumier

Des chercheurs de l'Université de Guelph examinent comment des stratégies alimentaires pourraient diminuer les effets nocifs du fumier de porc sur l'environnement. L'équipe du professeur Ming Fan a élaboré une méthodologie visant à évaluer la perte en phosphore endogène par l'organisme de l'animal et l'efficacité réelle de l'utilisation du phosphore dans les rations par les porcs. Ils sont arrivés à la conclusion qu'en sous-estimant l'utilisation digestive réelle du phosphore dans la ration des porcs on a créé des sup-

pléments alimentaires coûteux avec des sels phosphoriques inorganiques et d'autres ingrédients onéreux ainsi qu'une excrétion excessive de phosphore dans le fumier.

Le professeur Fan et son équipe poursuivent leurs recherches afin d'aider l'industrie du porc à formuler des rations pour les porcs établies en fonction de l'apport en phosphore digestible réel. Les nouvelles méthodes mises au point par les chercheurs ont servi à évaluer l'utilisation digestive améliorée du phosphore d'origine végétale par le porc transgénique qui digère la phytase (connu également sous le nom de « Enviropig ») et à examiner comment divers polysaccharides non amylacés d'origine alimentaire peuvent diminuer les émissions d'ammoniac et de gaz sulfurés. Ces stratégies prennent de plus en plus d'importance pour l'industrie des viandes alors que le Québec, l'Alberta et l'Europe mettent en place une nouvelle réglementation qui exige de plus faibles teneurs en phosphore. Le professeur Fan avance que l'Ontario pourrait bien se préparer à adopter des normes similaires pour les producteurs de porcs.

Cette recherche a été subventionnée par la Commission ontarienne de commercialisation du porc, Agriculture et Agroalimentaire Canada, le Conseil canadien du porc, le Programme de gestion de l'environnement pour l'industrie porcine, le Conseil de recherches en sciences naturelles et en génie et le ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario.