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95-100. MANAGING AGRICULTURAL PRACTICES TO IMPROVE WATER QUALITY AT THE WATERSHED LEVEL
E. Aubin, Agricultural Engineering, Pavillon des Services, Université Laval, Ste-Foy, QC; J. Gallichand, Agricultural Engineering, Pavillon Comtois, Université Laval, Ste-Foy, QC; and P. Baril, Consultants BPR, Québec, QC.

This paper describes preliminary results obtained from a watershed management project in the Beauce region. The objectives of the project are to monitor the water quality of two similar watersheds and to implement corrective measures on one of them to improve water quality. The paper includes a description of the project, the results of the water quality monitoring of both watersheds and the approach taken to determine the interventions to be implemented. The methodology used permitted the discrimination of point and non-point pollution sources in the intervention watershed. The main sources of surface water pollution appear to be leaking pig slurry tanks, the accumulation of solid manure without containment in heaps behind barns, and the spreading in fall of this manure at excessive rates.

95-101. THE IMPACTS OF AGRICULTURAL PRODUCTION ON WATER QUALITY IN TWO SMALL WATERSHEDS
P. Enright, F. Papineau and C. Madramootoo, Agricultural and Biosystems Engineering Department, Macdonald Campus, McGill University, Ste. Anne de Bellevue, QC; and E. Leger, Saint-Jaques, QC.

A three year study of environmental pollution caused by agricultural production on two small watersheds has been initiated. The project is a multidisciplinary effort involving local farmers, an agronomist, and university researchers. The global objectives of the pilot project are to assist farmers in applying BMP’s for mitigating the effects of agricultural production on water quality, measure water quality parameters on a year round basis and document their temporal variability, determine the annual and temporal fluxes of agricultural pollutants, generate data sets for the validation of GIS based water quality models, and develop a methodology and associated screening tools which will be applicable for Quebec. This paper gives an overview of the structure of the project, describes the installations and instrumentations, the measurement strategies, and the preliminary results.

95-102. PRELIMINARY EVALUATION OF THE HYDROLOGY AND WATER QUALITY OF AN INTENSIVE AGRICULTURAL WATERSHED
P. Lapp, P. Enright, F. Papineau and C. Madramootoo, Agricultural and Biosystems Engineering Department, Macdonald Campus, McGill University, Ste. Anne de Bellevue, QC.

Water quality data from a flow weighted sampling program at the outlet of a small agricultural watershed were analyzed. Patterns of daily loads and concentrations were analyzed for suspended sediment, atrazine, and nitrate-nitrogen. Preliminary analysis indicate that surface runoff is the primary pathway for losses of sediment and atrazine. Losses of nitrate-nitrogen appear to be associated with flow through groundwater and tile drains. High concentrations of nitrate-nitrogen in late spring and early summer indicate improved fertilizer management and other nitrogen management practices are needed.

95-103. SIMULATION OF PESTICIDE TRANSPORT AT THE WATERSHED SCALE
A. M. Laroche, J. Gallichand and R. Lagacé, Agricultural Engineering, Université Laval, Québec, QC; and A. Pesant, Agriculture Canada, Lennoxville, QC.

Atrazine contributes to the contamination of surface water caused by pesticide applications. Water quality models can be very useful to investigate the impact of pesticide management strategies on surface water quality. The model HSPF (Hydrological Simulation Program - Fortran) has been developed by the USEPA and includes a module for simulating pesticide transport. This model was tested using data from a 78 ha watershed, located in Lennoxville, for which pesticide applications are known precisely. Pesticide concentrations were measured at the outlet of the watershed from February to November 1993. This short period of time precluded verification of the pesticide simulation. Variations of atrazine concentration were well simulated by HSPF, with simulated concentrations in the same range as observed values, and with peak concentration occurring approximately at the same time.

95-104. A NUMERICAL SOLUTION OF THE BOUSSINESQ EQUATION FOR SIMULTANEOUS EVAPOTRANSPERSION, RECHARGE, AND DRAINAGE
R. K. Singh, S. O. Prasher and R. B. Bonell, Agricultural and Biosystems Engineering, Macdonald Campus, McGill University, Ste. Anne de Bellevue, QC; H. S. Chauhan, Irrigation and Drainage Engineering, G. B. Pant University of Agriculture and Technology, Pantnagar, India; and S. K. Gupta, CSSRI, Karnal, India.

The Boussinesq equation was solved numerically to predict watertable fluctuations in subsurface-drained farmlands in the presence of evapotranspiration and recharge. The numerical solutions were verified with the existing analytical and numerical solutions. Some numerical examples are given to highlight the characteristics of the various parameters used in the numerical solution and to justify the inclusion of evapotranspiration into drainage design procedures for arid and semi-arid regions. The numerical solution was also tested under field conditions at two research sites in Sampal and Mundiana, India. The simulated results were in better agreement with the observed data sets after considering recharge and non-continuous functioning of the drainage pump.
95-105. PERFORMANCE OF A SIMULATION MODEL ON SHALLOW SOILS WITH SUBSURFACE DRAINAGE
P. L. Havard, A. Madani and K. Thompson, NSAC, Truro, NS; and S. O. Prasher, Agricultural and Biosystems Engineering, Macdonald College of McGill University, Montreal, QC.

The present study involves the validation of LINKFLOW, a computer simulation model, for the case of subsurface drainage on a sloping, shallow, slowly permeable soil. LINKFLOW, developed by Havard (1994), consists of finite difference solutions for the governing equations of 1-D unsaturated flow and 3-D saturated flow of water in the soil. Water table depths from the simulations are compared with observations made at subsurface drainage plots during the summer of 1991. Comparisons between simulated and measured values showed that the model can accurately simulate water table heights. Coefficients of variation for simulated and measured values were 0.25 and a relative error of 5.3% during the growing season. LINKFLOW can simulate the spatial influence of various water management systems over the entire field with regard to depth in the soil profile and with varying topography. However, further studies are to be done for longer time periods, increased number of observation wells per region, and at other locations to complete the validation and development of the model.

95-106. TRANSFER FUNCTION NOISE MODELS FOR IMPROVED SIMULATION OF DRAIN FLOW
J. W. Kaluli and C. A. Madramootoo, Department of Agricultural and Biosystems Engineering, and P. Duttileul, Department of Plant Science, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

Parameter uncertainty reduces the usefulness of deterministic models. The results of this study suggest that including a stochastic component to a deterministic model offers a solution to this problem. After the SOIL model was calibrated to minimize the mean square predictive error in the simulation of drain flow under Quebec conditions, it was found to overestimate drain flow in early spring. In the summer and fall seasons, drain flow was underestimated. The SOIL model performance was compared with that of two other models; a pure stochastic model and a combined model (deterministic SOIL model with a transfer function noise (TFN) model component). Based on the mean square predictive error, the combined model was the best.

95-107. EVALUATION OF THE SOIL AND SOILN MODELS IN QUEBEC CONDITIONS
J. W. Kaluli, C. A. Madramootoo and S. Babarutski, Department of Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

The SOIL and SOILN models were evaluated using Quebec field data. Calibrating the SOIL model to minimize the mean square predictive error, resulted in overestimation of early spring drain flow and underestimation of the same in summer and fall. These results suggest that the model parameters should be varied from one season to another. Inaccurate simulation of drain flow led to errors in the computation of nitrate N concentration [NO₃-N] in drainage water. To some extent such errors also affected the simulation of [NO₃-N] in the soil profile. However, for [NO₃-N] in the root zone, the major source of error might be faulty choice of the parameters controlling nitrification and mineralization. The SOILN model predictions of denitrification rate were within the 95% confidence limits of observed data. Although these models may be unsuitable for continuous simulation in Quebec, they could satisfactorily simulate drain flow and the dynamics of agricultural nitrogen if calibrated for each season.

95-108. PREDICTING NITRATE-NITROGEN MOVEMENT UNDER DIFFERENT TILLAGE AND RESIDUE PRACTICES USING LEACHM-N AND NTRM COMPUTER MODELS
V. K. Serem and C. A. Madramootoo, Agricultural and Biosystems Engineering Department, Macdonald Campus, McGill University, Ste. Anne de Bellevue, QC.

Two computer simulation models, Leaching Estimation and Chemistry Model (LEACHM-N), and Nitrogen, Tillage and Residue Management (NTRM) model, were used to estimate nitrate-nitrogen (NO₃-N) leaching in sandy loam soil under no-till (NT), reduced tillage (RT), and conventional tillage (CT) practices, with residue (R) and without residue (NR). Initial hydrologic and water retention data were obtained from soil column experiments. Model outputs were analysed by the paired comparisons t-test method and by the sum of the squared differences of the means. LEACHM-N estimated more NO₃-N leaching below 0.4 m in RT and CT treatments but underestimated NO₃-N concentration [NO₃-N] immediately after fertilizer application, showing up to 50% deviation. LEACHM-N overpredicted [NO₃-N] in the top 0.2 m soil layers in all treatments. Overall, model estimations were within one standard deviation of observed data. NTRM model performed well in depths below 0.4 m, but underpredicted tillage and residue simulations by NTRM. Based on the coefficient of performance and the t-test analysis, LEACHM-N performed better than NTRM.

95-109. WATER QUALITY MODELLING USING HYDROLOGICAL SIMULATION AND GIS
N. Al-Abed and H. R. Whiteley, School of Engineering, University of Guelph, Guelph, ON.

The objective of this study is to examine the capabilities of GIS and its usefulness in hydrological modelling and to create a user-interface between a hydrological model and a GIS package. We are using the Geographical Information System (GIS) ARC/INFO, ARCVIEW and the watershed model Hydrological Simulation Program Fortran (HSPF). The goal is to simulate the effects of changes in land use and in resource management strategies on water quality and quantity in the Grand River, Ontario. The HSPF model was chosen because it is a comprehensive model applicable for both urban and rural areas. The interface with GIS takes advantage of the layered spatial data files of GIS to organize input for hydrologic modelling. The information from each layer can be accessed individually or combined selectively with information from other layers to select the parameters of the hydrological model.

95-110. INVESTIGATING SOIL MACROPORES USING A VOLUME CT SCANNERS
N. Asare, R. P. Rudra, and W. T. Dickinson, School of Engineering, University of Guelph, Guelph, ON; and A. Fenster, Imaging Research Lab, Robarts Research Institute, London, ON.
Soil macropores have been identified through research as a major contributor to the rapid movement of water and solute in agricultural soils, especially fields with minimum or no-tillage practices. A laboratory volume CT scanner with a high resolution x-ray image intensifier (XR11) was used to investigate soil macroporosity (with macroporosity set at voids greater than 0.56 mm in diameter) at different depths for six undisturbed soil columns taken from both the A and B-horizons of a no-till plot. The A-horizon columns indicated relatively higher total macroporosity and more variation than the B-horizons. Results also indicated that the total porosity in the B-horizon was more influenced by voids less than 0.54 mm diameter (25.2%) than in the A-horizon (11.1%).

95-113. LAND MANAGEMENT EFFECT ON SPATIAL VARIABILITY OF HYDRAULIC PROPERTIES OF A FIELD SOIL
J. Y. Diwu, R. P. Rudra and W. T. Dickinson, School of Engineering, University of Guelph, Guelph, ON; and G. J. Wall, Agriculture Canada, Guelph, ON.

Spatial variability of physical and hydraulic properties of a field soil were investigated with the aim of determining the effect of tillage on such variability. Statistical parameters of mean, variance, coefficient of variation and skewness, as well as scaling factors were determined for each of the two sites. Correlation structure was also determined. In most cases the log-normal distribution was found to be the best fit distribution for the scaling factors. Spatial variability of soilwater properties in each horizon of both sites was found to be high. It was also found that tillage has a reducing effect on spatial variability of soilwater properties in the study field; moreover, the physical properties of the A horizon were found to dictate soilwater transport and retention characteristics in the field.

95-114. SUBSURFACE HYDROLOGIC REGIME BELOW A CULTIVATED PRAIRIE FIELD
B. Joshi and C. Maulé, Department of Agricultural & Bioresource Engineering, University of Saskatchewan, Saskatoon, SK.

Field data collected as part of a research program directed towards the determination of soil water fluxes in the vadose zone between the bottom of the root zone and the watertable are presented and discussed. The influence of the root zone and the existence of a possible zero flux plane is indicated by the data. Further analysis of this information together with data from a field tracer experiment will be used to estimate the soil water flux by alternative methods.

95-115. A SIMULATION STUDY OF SOIL EROSION AFFECTED BY THE PRESENCE OF A FROZEN SUBLAYER

Soil erosion affected by the presence of a frozen sublayer was studied through simulation in the laboratory under varied land slope (2 and 9%), rainfall intensity (5, 10, and 30 mm/h). Tarpaper was used as a frozen sublayer of the partly-frozen soil to prevent water from percolating. The depth of thawed top soil above the impermeable frozen sublayer was set with three levels: 10, 30, and 300 mm, in which 300 mm treatment (full depth) was used as no-frozen sublayer treatment as a comparative study with summer conditions. Both the 10- and 30-mm thaw depth treatments had significantly higher sediment concentration, soil loss rate and total soil loss than no-frozen sublayer treatment (300 mm). Runoff and soil loss did not happen in no-frozen sublayer treatment until rainfall intensity increased to 30 mm/h. The presence of a frozen sublayer greatly increased runoff and soil loss not only by its own effect, i.e. mainly limiting the water percolation into subsoil, but also by its strong and complex interactions with the other factors.
95-116. ROLE OF WATERTABLE MANAGEMENT IN POLLUTION CONTROL
S.J. Jebellie and S. O. Prasher, Department of Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste-Anne de Bellevue, QC.

The role of watertable management systems in reducing pollution from agricultural lands was investigated by measuring the fate and transport of metribuzin herbicide in a three year field lysimeter study. Nine large pvc lysimeters, 1 m long x 450 mm diameter, were packed with a sandy soil. Three watertable management treatments, consisting of two subirrigation treatments with constant watertable depths of 400 and 800 mm and a free drainage treatment, were used. Metribuzin was applied in the summer months of 1993 and 1994 and water samples were collected at different time intervals after each natural or simulated rainfall event, from the 450 and/or 850 mm depth below the soil surface. The results from the two sampling seasons showed that the metribuzin concentration reduced with soil depth and time. Comparison of metribuzin levels in the three treatments showed a considerable reduction in the 400 mm subirrigation treatment at 850 mm depth. It seemed that the shallower watertable in the 400 mm subirrigation treatment provided more favourable moisture conditions in the crop root zone for the soil biomass to degrade metribuzin faster.

95-117. WATERTABLE MANAGEMENT AND CROPPING SYSTEMS FOR IMPROVED WATER QUALITY
J. W. Kaluli and C. A. Madramootoo, Department of Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

The effects of watertable control (WTC) and cropping systems on subsurface drainage discharge and nitrogen (NO3-N) leaching to tile drains were investigated. Experimental plots were 75 m long and 15 m wide. Watertable treatments included watertable control at 0.5 m or 0.75 m below the soil surface, and free drainage (FD). Cropping systems investigated included corn monoculture and corn-ryegrass (Zea mays L. and Lolium multiflorum Lam.) intercropping systems. Plots were fertilized with 270 kg N/ha. Highest annual average leaching (16.3 kg N/ha) as in 0.5 m WTC plots with intercropping. In monocropped plots, the 0.5 m WTC reduced annual drain flow and leaching by 51% and 58% respectively, compared to freely draining plots. Freely draining, intercropped plots lost on average 8.3 kg N/ha, which was 49% less than in monocropped plots. Intercropping combined with WTC resulted in the least loss of nitrates to drainage water.

95-118. EFFECT OF SUBIRRIGATION AND INTERCROPPING OF RYEGRASS IN MAIZE ON SOIL MOISTURE AND WATERTABLE LEVELS IN A SANDY LOAM SOIL IN QUEBEC
S. A. Qureshi, G. T. Dodds and C. A. Madramootoo, Department of Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

A watertable management study was conducted in Soulanges county, Quebec during summer of 1994. Three watertable levels (freely drained (1.0 mm), subirrigated to 0.5 m or 0.75 m from surface), and two cropping systems (monocropped maize, maize with ryegrass), were factorially combined. Soil moisture content (SMC) at three depths (0-0.15, 0.15-0.30, and 0.3-0.5 m), and watertable depths (WTD) were monitored biweekly, and some meteorological data collected. The 0.5 m, 0.75 m controlled watertables provided the same SMC trends in both cropping systems, but SMC in freely drained plots was always lower than in subirrigated plots. For each water management system, cropping system did not affect SMC. WTDs were lower in the freely drained plots than in the subirrigated plots. Positive correlations occurred between SMC at 0-0.15 m and WTD (strong) or rainfall (weak). These results will be discussed in the context of best management practices for corn production in Quebec.

95-201. ICE EFFECT ON DESIGN OF LIQUID MANURE TANK WALLS
J. Jofriet, School of Engineering, University of Guelph, Guelph, ON; and J. W. Johnson, Ontario Ministry of Agriculture, Food and Rural Affairs, Toronto, ON.

Cylindrical reinforced concrete tanks are the most common structure used for storing liquid manure over the period when land application is not feasible. In most parts of Canada ice forms in a liquid manure tank and the wall has to be designed for the radial pressure exerted by the ice when it expands. The magnitude of the ice load is mainly a function of the ice thickness. Godbout and Marquis (1990) have recommended a design thickness of 0.5 m for the Quebec City region and an average design pressure of 50 kPa over the thickness of the ice layer. This means a design ice load of 25 kN/m of circumference. A subsequent study by Carrier et al. (1995) indicates that an ice thickness of 0.16 m would be appropriate for design in southern Ontario. Twenty linear elastic finite element stress analyses of cylindrical tanks were performed to determine hoop stresses in the wall from a radial ice load applied near the top, and at midheight. Design curves are provided for eight tank geometries to allow structural designers of liquid manure tanks to quickly calculate these hoop stresses. After combining these hoop stresses with those from the manure and other loads, they can be used to design the wall thickness and the hoop reinforcing steel. A sample calculation of ice load hoop tension is provided in the Appendix.

95-202. STRUCTURAL DESIGN OF LIQUID MANURE TANK WALLS
J. Jofriet, School of Engineering, University of Guelph, Guelph, ON; and J. W. Johnson, Ontario Ministry of Agriculture, Food and Rural Affairs, Toronto, ON.

Liquid manure is commonly stored in reinforced concrete cylindrical tanks when land application is not possible. The structural design of liquid manure tanks requires a consideration of all loads and of appropriate support conditions. The most important loads that a cylindrical liquid manure tank must be designed for were reviewed. The selection of an appropriate support condition at the bottom of the tank wall is discussed. The assumption of a radial spring is recommended for tanks in which floor and wall are not monolithic. The determination of the internal hoop forces in the wall of a cylindrical liquid manure tank is difficult if the boundary support at the bottom of the wall is other than sliding or hinged. Design curves are provided to aid designers determine the hoop tension in the wall and in the footing. As well, the radial displacements can be determined using the same design curves. Friction and passive earth pressure can be considered to provide the horizontal support at the wall footing. The frictional resistance is easy to calculate; the passive earth
pressure can only be estimated. An example analysis of the hoop tension in a liquid manure tank is provided in the Appendix.

95-204. LOADS IN A MODEL GRAIN BIN DURING IN-BIN DRYING
Y. Shan, Q. Zhang and M. G. Britton, Department of Biosystems Engineering, University of Manitoba, Winnipeg, MB.

An experiment was conducted to study loads in a model grain bin during in-bin drying with near-ambient air. Vertical forces on the floor and wall were measured separately with force transducers. Lateral and vertical pressures at three depths were recorded using diaphragm pressure sensors. Freshly harvested wheat was first dried by blowing near-ambient air through the grain bed and then three wetting-drying cycles were performed. During the first drying cycle when the grain was dried from initial moisture content of 14.1% (db) to an average of 10.3% (db), changes in vertical forces on the bin floor and wall were negligible. Grain wetting caused significant increases in structural loads. The greatest increase in vertical force on the floor was 153%. The vertical force on the bin wall changed from +2.47 kN (downward) to -5.90 kN (upward). A ten (10) fold increase in lateral pressure was observed in the lower section of the bin. Lateral pressure became much higher than vertical pressure during wetting. The highest lateral to vertical pressure ratio (K) was 1.95.

95-205. CONCRETE TOWER SILO COATINGS: RESULTS OF EVALUATION TESTS
H. E. Bellman, Walkerton, ON; and S. P. Clarke, OMAFRA, Kemptville, ON.

Over time, conventional, top-unloading, concrete tower silos deteriorate due to the corrosive action of silage acids. One way to prevent this deterioration is through the use of barrier coatings on the inside wall surface. This paper outlines briefly some silo coating evaluations that have been conducted at the University of Guelph Research Farm over the past 10 years. A summary of the observations to-date indicate that a) in many cases the requirements for protection from silage are different than from many other materials, and b) there are several types of coatings, both cementitious and liquid, that will do a better job of protecting silo walls than the standard sand/cement mortars commonly used by the silo repair industry. This paper is a follow-up to the one given by H. E. Bellman on the same topic at the 1989 CSAE/ASAE summer meeting in Quebec City (Paper No. 89-4011).

95-206. EXPERIENCES IN ALLOWING THE USE OF UNGRADED LUMBER IN ONTARIO FARM STRUCTURES
J. W. Johnson, Ontario Ministry of Agriculture, Food and Rural Affairs, St. Thomas, ON.

In 1993, the Ontario Building Code was changed to allow the use of ungraded lumber in specific farm building components. This paper outlines the process that brought this about and summarizes design steps for using ungraded lumber.

95-207. A CONCEPT FOR A LIGHT-FRAME BUILDING CENTRE
M. G. Britton and Q. Zhang, Department of Biosystems Engineering, University of Manitoba, Winnipeg, MB.

This paper has been prepared in response to the situation within the specialization that has been known as Structures and Environment. It proposes a concept that might provide a partial response to what the authors see as emerging needs in the light-frame buildings industry. We suggest that our concept has grown from an application of the Engineering Method. As such, it is not THE solution, but rather A solution. We advance the concept for consideration and discussion.

95-208. CORROSION OF ROOF TRUSS GUSSET PLATES IN ONTARIO
J. W. Johnson, Ontario Ministry of Agriculture, Food and Rural Affairs, St. Thomas, ON; and H. Huffman, Ontario Ministry of Agriculture, Food and Rural Affairs, Komoka, ON.

In 1994, the Ontario Ministry of Agriculture, Food and Rural Affairs conducted a field study of livestock buildings that included roof trusses in the environmental air space. This paper outlines the survey method, results, and recommendations for reducing corrosion problems.

95-209. THERMAL AND MECHANICAL PROPERTIES OF STRAW BALES AS THEY RELATE TO A STRAW HOUSE

Straw bales have been used recently as building materials for several houses for human occupation in Nova Scotia. TUNS was asked to investigate three relevant engineering aspects - 1. the potential for biological deterioration in the walls; 2. the insulating properties of the walls, and 3. the strength properties of the bales. To this end, one house was instrumented with thermocouples and humidity sensors inbedded in the walls and wall heat flux plates flush mounted on the walls. The structural strength of the bales was obtained using a 50 tonne industrial press and the measurements of all deformations were made at constant intervals of deformation. The humidity in the walls increased during the summer months, peaking at or just above the threshold level and then decreasing again during the fall. The R value, in FPS units, varied from 30 to 40. The strength (Modulus of Elasticity) of the bales is more dependent on the initial bale density than the bale type. Bales that are exposed to the elements rapidly lose their strength. As expected, the Poisson's ratio for bales is not the same for both lateral directions, but is significantly greater in the direction of the twine.

95-210. EFFECTS OF VENTILATION-HEATING CONTROL STRATEGIES FOR EARLY WEANING PIG BARNS ON ENERGY CONSUMPTION AND 3-D TEMPERATURE DISTRIBUTIONS
Y. Choinière, Les Consultants Yves Choinière, St-Césaire, QC; and B. Laberge, Thevco Electronique Inc., St-Hubert, QC.

A ventilation control chamber has been built at Alfred College, OMAFRA, to study the performance of control systems, ventilation and heating equipment, and recirculation ducts with regard to temperature distribution and energy consumption. The use of the recirculation duct reduced the floor to
ceiling temperature gradients and the energy consumption of the heating system. There was only negligible effect by the "heating offset" control strategy on energy consumption.

95-211. TWO STAGE INFRARED HEATING
R. MacDonald, RDM Engineering, Guelph, ON.
A two stage infra-red type heater was tested for energy use efficiency. The heater is commonly used in industrial, commercial and agricultural operations. An industrial test site evaluation revealed 12% reduction in energy use plus reduced heater cycling (36%) and increased on cycles (43%). Further evaluation of efficiency is being conducted in broiler and swine nursery facilities.

95-212. GAS LEVELS IN PROpane HEATEd BROILER BARNs
D. Allen, Department of Agricultural Engineering, NSAC, Truro, NS; and T. Palmer, F. Jacobs and Associates Consulting Eng., Halifax, NS.
Measurements were made on hourly intervals of selected air quality parameters in a commercial broiler building for one production cycle. The levels of CO₂ were predicted and measured. The concentration of ammonia, relative humidity and temperature were also measured during the test. Samples of the dead birds were taken for a post mortem throughout the test. The broiler building was typical of the industry but utilized a non-vented propane radiant heat source. The production cycle was 42 days in length. Results of the investigation show that carbon dioxide levels exceeded the suggested limit of 5000 ppm for the first week of the cycle peaking at 9400 ppm. The ammonia levels were at or above the TLV of 25 ppm for much of the cycle. Acute Death Syndrome was listed as the cause of death in most cases for the birds examined. There was no identified link to the environment.

95-214. VENTILATION OF DAiRY COWS IN CANADA DURING THE SUMMER
S. Barrington and K. El Moueddeh, Macdonald Campus, McGill University, Ste. Anne de Bellevue, QC; and R. Joncas, Agriculture, Pêcheries et Alimentation Québec, Deschambault, QC.
The effect on dairy cow milk production was examined under Canadian conditions using various summer ventilation systems: 1) ventilation rates of 170 and 454 L s⁻¹ per cow of 450 kg; 2) evaporative pads and a ventilation rate of 454 L s⁻¹ per cow; 3) long blade ceiling fans with ventilation rates of 170 and 454 L s⁻¹ per cow. Each system was tested in sequence for two weeks at a time. As control, the herd was kept outside in an un-shaded yard for 10 days. Milk production was correlated with ambient air temperature, relative humidity and air velocity. Outside, milk production and feed intake dropped by 20 and 10%, respectively. Inside, milk production increased with lower minimum temperatures and smaller differences between minimum and maximum temperatures. Long blade ceiling fans were found ineffective in increasing air velocity as opposed to noisier ceiling vane axial fans which produced velocities of 4.0 to 0.45 m s⁻¹ over a distance of 10 m.

95-215. AIR DISTRIBUTION PATTERNS DUE TO AIR INLETS IN NEGATIVELY PRESSURED LIVESTOCK BUILDINGS
J. R. Ogilvie, School of Engineering, University of Guelph, Guelph, ON.
Livestock building negative ventilation air inlets are much more than just openings for air to enter. These inlets respond to the negative pressure in a predictable or unpredictable way by delivering the same or varying amounts of external air. Air inlets also discharge air in a predictable or unpredictable pattern into the enclosed space. Improvements in air inlets have reduced the pressure loss through the inlet and they can now maintain a constant negative pressure with varying discharge of air. Newer air inlets also generate predictable air distribution patterns. Information is presented on air pattern response characteristics of various air inlets based on the latest research. The effect on the air discharge and patterns from different inlets due to changing ventilation rate is given. Air inlet design will be affected by adoption of a ventilation system performance standard now in drafting stage in ASAE.

95-216. THERMAL PERFORMANCES OF HOT FLOORS BUILT WITH HIGH PERFORMANCES CONCRETE WITH SILICA FUME FOR EARLY WEANING PIGS
Y. Choinière, Alfred College, Ministry of Agriculture, Food and Rural Affairs of Ontario, Alfred, ON; and J.-C. Leduc, Ciment St-Laurent, Longueil, QC.
The use of the hot floor technology in early weaning pig facilities has shown very good results. The advantages of hot floors with high performance concrete are being non-porous and having a good thermal distribution. Two 0.76 X 1.22 m experimental hot floors were built to test: 1) the temperature distribution in the concrete slab; 2) two versus three hot pipes; and 3) the effects of artificial piglets sleeping over the concrete slab. A chart showing the relation between the hot water versus the floor surface temperatures is presented.

95-217. A PROTOTYPE OF EXPERT VENTILATION DESIGN SYSTEM FOR SWINE BUILDINGS
Y. Chen, R. J. Ford and E. M. Barber, Department of Agricultural & Bioresource Engineering, University of Saskatchewan, Saskatoon, SK.
The Expert Ventilation Design System was developed as a prototype expert system for ventilation and heating design of swine buildings using an expert system tool. This expert system is expected to be able to act as an assistant to the human experts in handling simple calculations, choosing design parameters, evaluating solutions; as an advisor to prompt the designer to consider design alternatives, to use codes, standards, handbooks in an effective way and to help the human experts examine more cases, potentially leading to a better or economical design. A knowledge base, a user interface and a database were created. A hypertext facility is also incorporated in the prototype.

95-218. NATURAL VENTILATION FOR LIVESTOCK HOUSING BY THE CONCENTRATION DECAY METHOD USING A LASER-OPTICAL SYSTEM
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ON; H. Tanaka, University of Ottawa, Civil Engineering Department, Ottawa, ON; and J. A. Munroe, Agriculture and Agri-Food Canada, Ottawa, ON.

Measurements of wind-induced natural ventilation could be done using a tracer gas with the concentration decay method. Measurements were made with a 1/20 scale model of a naturally ventilated livestock building. Tests were performed in the Ottawa NRCC wind tunnel. During a test, smoke was injected inside the scale model and the rate of decay was measured by an optical device (laser and light detector). An attempt was made to calculate an "effective natural ventilation coefficient". The effects of sidewall, ridge and end wall openings on the effective natural ventilation coefficients are presented and discussed.

95-219. MODÉLISATION DES DÉPERDITUONS ÉNERGÉTIQUES DE SERRES MUNIES D'UN SYSTÈME DE CHAUFFAGE RADIANT OU À L'EAU CHAUS ET D'UN ÉCRAN THERMIQUE
S. P. Lemay and A. B. De Vriendt, Génie Mécanique, Université Laval, Sainte-Foy, QC; A. Marquis and L. Gauthier, Génie Rural, Université Laval, Sainte-Foy, QC.

Un modèle a été développé pour simuler les déperditions énergétiques et les températures des composantes de serres de verre en considérant les flux radiatifs, convectifs, conductifs et latents. Des générateurs infrarouges électriques et un chauffage conventionnel à l'eau chaude constituent les systèmes étudiés et le modèle inclut la possibilité d'utiliser un écran thermique. Il utilise la méthode de radiation nette avec des surfaces transparentes pour décrire les échanges radiatifs et une attention particulière est portée sur sa description. Le modèle a été calibré et validé à l'aide de mesures prises dans deux serres de verre équipées des systèmes de chauffage étudiés. Les simulations faites avec le modèle indiquent qu'le chauffage radiant fournit des économies en chauffage de 2 à 7% par rapport au système à l'eau chaude, mais que celles-ci varient en fonction des paramètres climatiques. Entre autres, les économies en pourcentage augmentent lorsque la température extérieure s'élève. L'écran thermique diminue la puissance en chauffage des deux systèmes de 19 à 30%. Avec le chauffage radiant, l'écran réduit la puissance de 2% de plus qu'avec le chauffage à l'eau chaude. L'exploration d'un tel modèle s'avère utile dans l'évaluation d'un équipement comme le chauffage radiant.

95-222. RESPIRATION RATE MODEL FOR BROCCOLI STORED UNDER MODIFIED ATMOSPHERE
M. Ramachandra, G. S. V. Raghava, C. Ratti and Y. Gariépy, Department of Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

The respiration of stored vegetables and fruits should be minimized to extend the storage life. The prediction of respiration rate is of great importance in the design of storage systems. In this study, the respiration rate of broccoli was measured as a function of gas composition and at temperatures of the cold room of 3, 7, 13, and 24°C. The gas composition was measured as a function of time. A model of the type which represents an enzymatic reaction was used to describe the respiration activity of broccoli at these temperatures. An Arrhenius relationship was used in the model to account for the effect of temperature. The model parameters were obtained through non-linear regression. The results of the model were in good agreement with the experimental data. It was demonstrated that there was no significant effect of carbon dioxide concentration on the respiration rate of broccoli for the range studied.

95-223. COLLECTION AND ANALYSIS OF HEADSPACE VOLATILES FOR DISEASE DETECTION IN STORED POTATOES
C. Ratti, Plata Piloto de Ingenieria Quimica, 8000 Bahia Blanca, Argentina; Y. Gariépy and G. S. V. Raghavan, Department of Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste-Anne-de-Bellevue, QC.

The volatiles produced by potatoes infected with the bacteria (Erwinia carotovora) responsible for the disease known as soft rot were analyzed and compared to those produced by healthy potatoes. A dynamic headspace analysis technique was used to simulate, at the laboratory level, conditions usually present in ventilated storage bins. The potatoes were first inoculated with the bacteria and stored in sealed containers at 12°C. For comparison purposes, healthy tubers were also stored under similar conditions. A flow of purified air was passes through the containers and subsequently through tubes filled with a solid absorbent (trap) to capture and concentrate the volatiles. During the experiment, the traps were replaced at 24-hour intervals. The trapped volatile compounds were thermally desorbed and analyzed with a gas chromatograph equipped with a FID detector. In this experiment, it was observed that the total amount of volatile produced by infected potatoes was significantly higher than that of healthy tubers. It was also demonstrated that at least one volatile compound was specific to the disease/potato interaction. In an attempt to identify the volatiles, gas samples were also analyzed with a gas chromatograph equipped with a mass spectrometer. Among the various compounds identified, a furan ester, styrene and phorone, were three compounds that appeared to be specific to the infection. Additional work is required to corroborate these observations.

95-224. HOT WATER THERMAL TREATMENT FOR CONTROL OF POTATO SPROUTS AND NUMERICAL MODELLING OF THERMAL BEHAVIOUR OF POTATOES
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tural and Biosystems Engineering, Macdonald Campus of McGill University, Ste Anne De Bellevue, QC.

The study of hot water dipping as a thermal treatment for control of sprouting of potatoes for short-term storage (3 months) has given good hopes of tuber sprout control. Three temperatures (52, 55 and 57°C) and three dipping durations (10, 20 and 30 min.) were tried in this investigation. The results showed a complete control of potato (cv.Superior) sprouts at temperatures 55°C and 30 min., and 57°C and 20 to 30 minutes dipping time, when stored at 8°C. Complete sprout control could not be achieved in the case of potatoes stored at 18°C temperature. However, the percentage of sprouts were significantly minimum at temperature 55°C and 30 min., and 57°C and 20 to 30 minutes dipping time. The visual observation of tubers showed that there was no physical damage of tubers at the above temperature-time combinations, except a mild browning at 57°C and 20 to 30 minutes dipping duration. The heat transfer phenomena was studied during the hot water thermal treatment and a model was developed to predict the thermal behaviour of potato tubers treated by natural or forced convection in different heat transfer media.

95-225. AN ELECTROLYTIC CELL TO PREVENT NENZYMATIC BROWNING IN LEMON JUICES
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The present study investigated the possibility of using an electrolytic cell to prevent nonenzymatic browning reactions in lemon juices. In this purpose, a single-strength, a double-strength, and a triple-strength lemon juice were subjected to four different current densities (0.116, 0.231, 0.463 and 0.926 A/m²) for 30 minutes using an electrolytic cell. Concentration in dissolved oxygen, oxidation-reduction (redox) potential and pH in juices were monitored. Juice samples were taken at 0, 5, 15 and 30 minutes and then stored at 30°C for one month. After one month of storage, juice samples were assessed for browning and quality alteration. The chemical indices used were the browning index and concentrations in furfural and 5-hydroxymethylfurfural (HMF). Although redox potentials and dissolved oxygen levels were significantly reduced during the electrolytic cell treatment, none of the electrochemical treatments significantly retarded detrimental reactions over the storage period. Initial levels in dissolved oxygen and redox potential do not seem to have any effect on browning or chemical quality deterioration in lemon juices. Thus, this suggests that nonenzymatic browning in lemon juices may be due to factors other than oxidative reactions.

95-300. PARTICLE SIZE AND BULK DENSITY EFFECTS ON GRAIN DIELECTRIC PROPERTIES
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The dielectric properties of materials subjected to microwaves are known to be dependent on moisture content, temperature and density of the material as well as the frequency of the microwave field. In this study, linear relationships between roots of the dielectric properties and density found in the literature were confirmed to be valid for pulverized grains tested with the cavity perturbation method. The effect of particle size on dielectric properties of chopped grain is also reported as a quadratic relationship.

95-301. CONTINUOUS FLOW DRYER IN QUÉBEC
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A small scale device was built and tested for studying the process of continuous-flow dryer in Southern Québec. The incoming grain was at around 16% w.b. and at 38-46°C. The grain-flow rate varied between 485 and 756 kg/hour. The air flow was from 9 to 13.5 L·s⁻¹·m⁻³ of grain. Grain samples were taken every half hour. Air and grain temperatures, relative humidities and grain-flow rate were recorded every 15 minutes. The moisture reduction varied between 0.61 and 1.52 depending mainly on the grain-flow rate. The grain was dried and cooled to a safe storage level. A computer simulation program (NATAIR) was modified and will be validated with the data from the 1994 harvest season.

95-302. THIN-LAYER DRYING OF GELATINIZED WHITE YAM CUBES
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Gelatinized white yam cubes were dried using convective air at 40, 50, 60 and 70°C and 10-50% relative humidity. Drying rates proceeded more rapidly at higher temperatures. The drying was found to take place in the falling rate period throughout the drying period hence the mechanism for moisture movement in the material was diffusion. The drying data were found to be accurately predicted by a two-term approximation of the series solution of Fick’s diffusion equation.

95-303. EFFECT OF DRYING AIR TEMPERATURE ON COLOR OF DRIED ALFALFA MEAL
R. T. Patil and S. Sokhansanj, Department of Agricultural & Bioresource Engineering, University of Saskatchewan, Saskatoon, SK.

Color is one of the important parameters of alfalfa which is affected in drying process. Color measurements reported on alfalfa so far are for the apparent color values as seen on the surface of the leaf, stem and chop. In this paper, data has been reported on color of ground meal as effect of drying air temperature and initial moisture content. The alfalfa leaves, stems and chops at four levels of initial moisture content were dried in a thin layer at temperatures ranging from 40 to 250°C up to moisture content of 8%. The color was measured by Hunterlab spectro colorimeter. The results indicated that the stem and leaves discolor at different rates at the same drying temperature. The effect of initial moisture content is more pronounced in case of stems and chops whereas for leaves the initial moisture content had very slight effect. The critical temperature for alfalfa drying based on the meal color is 175°C above which there is drastic reduction in meal color.
95-304. CORRELATION OF PROTEIN AND CAROTENE WITH REFLECTANCE CHARACTERISTICS OF ALFALFA GRIND
R. T. Patil and S. Sokhansanj, Department of Agricultural & Bioresources Engineering, University of Saskatchewan, Saskatoon, SK.

Protein and carotene are important nutritional characteristics of alfalfa products. Color is an important physical characteristic and presumably is a reflection of nutritional characteristics. The reflectance characteristics of ground alfalfa pellets were measured in the range of 400 to 2400 nm. The ground samples had the range of protein content from 15.3% to 22.4% and carotene from 112 to 330 mg/kg. In the visible range (400 to 700 nm) the reflectance was characterized in terms of Hunter "L a b" values. The "a" varied with higher carotene content where "L" and "b" remained more or less the same. The correlation of various color indices was determined with protein and b carotene. The carotene was better correlated with protein (R² = 0.84) than for carotene content (R² = 0.71).

95-306. VARIATIONS IN PHYSICAL PROPERTIES DUE TO DEGRADATION OF TWO TYPES OF PAPER USED IN "PAPER MULCHES"
H. Krishnamurthy, E. Norris and G. S. V. Raghavan, Agricultural and Biosystems Engineering, McGill University, Ste-Anne-de-Bellevue, QC.

One of the problems faced in paper mulching is the early degradation of paper. This is due to variations in temperature, humidity, and solar radiation. Experiments were conducted on two types of paper used for mulching, craft paper and wax coated paper. They were exposed to atmospheric conditions. It was found that the physical properties involved in paper degradation were related to cumulative exposure to solar radiation.

95-307. THE USE OF BINDERS IN PELLETING OF ALFALFA
L. G. Tabil and S. Sokhansanj, Department of Agricultural and Bioresources Engineering, University of Saskatchewan, Saskatoon, SK.

Production of fines and dust from pellets is a major problem of alfalfa products during transport and handling for export. One possible solution to this problem is production of good quality pellets. Durable pellets can be produced by controlling the production process and by using binders. The objective of this experimental work is to determine how durability and hardness of dehydrated alfalfa pellets can be improved with the use of binders. The factors used in the study were dehydrated hay quality, and binder used. alfalfa hay used were of three quality: low, intermediate and high. Five binders were added: lignosulfonate, bentonite, pea starch, collagen protein, and hydrated lime. Results indicate that binders improved the durability of low quality dehy pellets but did not improve the durability of pellets made from high quality alfalfa. Hardness of pellets was also increased by the use of binders. Among the binders studied, hydrated lime produced the most durable and hardest pellets. Pea starch produced the second most durable pellets without necessarily increasing pellet hardness.

95-308. EXPERIMENTAL STUDY OF A PACKED BED OF CLAY-CaCl₂ PARTICLES FOR USE IN AIR DEHUMIDIFICATION AND THERMAL ENERGY STORAGE
B. Casault, N. B. Abdallah and K. C. Watts, Department of Agricultural Engineering, TUNS, Halifax, NS.

Experimental results are presented on the behavior of a packed bed of clay-CaCl₂ particles for use in air dehumidification and thermal energy storage. Operating data of the packed bed are presented for the heat recovery (or discharge) mode. Although preliminary, the results indicate that the rate of moisture sorption is constant for average bed moisture content up to 10%. The rate of moisture sorption increases with the air flow rate (Qₐ) and the specific humidity (Yₐ) of the inlet air. The dew point temperature depression (Tdₚ₋Tdₚₒᵤₜ) is also affected by Qₐ and Yₐ. The heat released upon moisture sorption by the clay-CaCl₂ particles is used to heat the air stream, which is used to heat the air stream, raising the air temperature from 10-12°C for both the solid particles and the air stream.

95-310. DEHULLING AND SPLITTING OF PULSES (PEAS AND LENTILS)
S. Sokhansanj and R. T. Patil, Department of Agricultural & Bioresources Engineering, University of Saskatchewan, Saskatoon, SK.

Pulses are relatively new crops in Canada and their production is on the increase; it about 1.9 million tonnes in 1994 crop year. Dehulling and splitting of some pulses including peas and lentils add to their value as human food and thus this development is important to the agricultural economy. In this paper, the factors involved in dehulling of chickpea, field pea and lentils are covered. The results of experimentation on dehulling these seeds, the methods of evaluating dehulling process, and machines used for processing are described. It is concluded that for efficient dehulling the conditioning of seed and its moisture content are important factors followed by seed shape and uniformity of the product. A generalized flow chart for dehulling and splitting of pulses is proposed and critical areas for improving the quality of product are identified.

95-311. A DISTRIBUTION SYSTEM FOR THE BLEND FEEDING OF GROWING PIGS
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Blend feeding attempts to eliminate the excesses and deficiencies in dietary protein associated with the conventional step feeding of growing pigs (20-105 kg) meeting protein requirements on a daily or weekly basis. An increase in carcass lean percentage and a reduction in feed intake and excreted nitrogen are benefits of blend feeding. In a continuous system the distribution of many unique diets poses a significant engineering problem because age and weight vary between pens. The economics of having n distribution pipelines, where n is the number of diet changes, and the extensive labor involved with manual valves resulted in the idea of using a single distribution pipeline in tandem with feed level sensors. Given the "emptiness" of the feeders on the distribution pipeline by feed level sensors, filling each feeder consecutively eliminates the need for valves. Two feed level sensors, one ultrasonic and the other optoelectronic, were tested with two diets, grower and finisher, for their reliability and accuracy. The optoelectronic feed level sensor had a mean error of 0.61 L and 0.10 L with the grower.
diet and the finisher diet, respectively. The ultrasonic feed level sensor had a mean error of 0.57 L and 0.35 L with the grower diet and the finisher diet, respectively. Both feed level sensors had reliable outputs for 99% of the readings. With improvements in the feed level sensors and the feeder design, the mean error should be reduced further and the reliability increased.

95-405. SYSTEM TO SEPARATE ROCKS FROM SOD CLODS DURING ROCK PICKING OPERATIONS
J. Martineau and C. Laguë, Département de génie rural, Université Laval, Sainte-Foy, QC.
Some soils contain large amounts of stones which, if left loose on the surface, can reduce the efficiency at field. Actual rock picking equipment can't differentiate between stones and sod clods of the same dimensions. The use of a system that separates stones from sod clods would increase the field performances of rock picker and would reduce nutrients and organic matter losses. The tested separation principle uses the differences in energy restitution coefficient for products to be separated. Preliminary trials have been done to select the best configuration among variables such as: rotation speed and diameter of the cylinder, fall point and separation point of material. Large scale trials on a modified rock picker have been conducted on plots having 3 levels of stones and 3 levels of sod clods densities. Separation rates have reached 84% for sod clods and 74% for stones.

95-406. STATISTICAL COMPARISON OF A FULL FACTORIAL DESIGN AND A CENTRAL COMPOSITE DESIGN FOR SPRAY DROPLET DEPOSITION
H. Philion and R. Thériault, Département de génie rural, Université Laval, Cité Universitaire, QC; B. Panneton, Centre de Recherche Horticole, Agriculture et Agro-Alimentaire Canada, St-Jean-sur-Richelieu, QC; and P. Dutilleul, Department of Plant Science, McGill University, Macdonald Campus, St-Anne de Bellevue, QC.
The comparison of a 33 factorial design and a Central Composite Design in the quality of model fitting and the statistical significance of the coefficient estimates is described. Spray droplet deposition experiments were conducted in a controlled environment spray chamber. An air-assisted spraying boom was used on broccoli and potatoes. The independent variables studied were air speed, air flow and spraying angle. Kromekote cards were used to collect the fluorescent dye Blankophor BA liquid 80% used as spraying liquid. The area covered by the spray droplets was measured by image analysis. Applying a single threshold as in Panneton et al. (1991) yielded a binary image of good quality. Comparative results are similar for both designs on the potato, while the factorial design seems to perform better in the broccoli experiment. Overall, the Central Composite Design is more conservative than the factorial.

95-407. FORAGE MACERATION AND ITS IMPACT ON LIVESTOCK PRODUCTION AND ALFALFA DEHYDRATION: A REVIEW
M. Roberge, Département de génie rural, Université Laval, Sainte-Foy, QC; and P. Savoie, Agriculture Canada Research Station, Université Laval, Sainte-Foy, QC.
Maceration, also known as intensive conditioning, super-conditioning or mat making, has been experimented over the last fifteen years at several sites in North America and Europe. It modifies the physical characteristics of freshly mowed forage, the forage fibres are lacerated longitudinally, the field drying rate is enhanced and the feed value of forages fed to ruminants is sometimes increased. Three experimental mowersmacerators have been developed in Québec since 1990 by Université Laval and Agriculture and Agri-Food Canada. The paper provides a review of the experimental prototypes. They have generally increased the field drying rate of forage by 60 to
100% without causing more losses than conventional conditioning and handling systems. Recent feeding studies have shown that maceration can improve forage intake by 5 to 15% and weight gains or milk production by similar amounts. For the alfalfa dehydration industry, maceration could be beneficial by reducing the amount of water remaining in the crop for artificial drying, thereby saving about 30% of the natural gas currently used.

95-408. A PROCEDURE TO QUANTIFY THE DEGREE OF MECHANICAL FORAGE CONDITIONING
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Greater mechanical conditioning is known to increase the drying rate, the digestibility of fibre, and the susceptibility to losses. It is important to quantify the degree of conditioning to distinguish different mechanical devices and predict their impact in the field and with animals. An extensive study was carried out in 1994 to measure the compressibility of forage subjected to pressures in the range of 3 to 45 kPa. Timothy and alfalfa were treated at 8 different levels of mechanical conditioning over a 4-week period to consider the effect of maturity. The more intensively forage was conditioned, the more easily it compressed. The wet density varied between 68 and 895 kg/m³, increasing almost linearly with the degree of mechanical conditioning. An intermediate pressure of 6.5 kPa in a 200 mm diameter cylinder provided the highest and most regular slope to distinguish conditioning treatments. The method is rapid, can be used in situ and provides an index or ratio of densities when compared to a non-conditioned control. A standard method to use the procedure is proposed so researchers from various areas can report the relative conditioning degree with some consistency.

95-410. DESIGN AND COMMISSIONING OF A TESTING FACILITY FOR BIODIESEL FUEL
K. C. Watts, C. Allen and E. Ferguson, Technical University of Nova Scotia, Halifax, NS.

A survey of work to date in this field indicates that there is a proliferation of papers on different types of fuels, including the same type of fuel, but from different places in the world. Thus a facility has been designed to test common components of biofuels, with a view to generating an algorithm that can predict the performance of an unknown biofuel based on its component compositions. Some previous work is discussed. The facility is made up of two identical, single cylinder diesel engines, except that one is direct injection and one is indirect injection. The load is applied using electric generators wired to resistance elements. Instrumentation includes optical speed sensors, temperature sensors, and fuel gauges and exhaust component instrumentation. The instrumentation is controlled and data collected by computer. Preliminary results using diesel fuel are shown.

95-411. AN INTELLIGENT PARALLEL STRUCTURED ROBOT FOR AGRICULTURAL APPLICATIONS

Although agricultural operations such as harvesting, sorting, and packaging have been identified in many discussion papers as being prime candidates for robotic applications, few robots are in use in today's agriculture. This is in part due to the expense and complexity of robotic systems. This paper describes a three-degree-of-freedom parallel structured robot which is simple in mechanical design and electronics/computing architecture, thereby making it relatively inexpensive and hence suitable for many agricultural applications. Sensors mounted in the end-effector provide intelligence which added to the robots inherently high speed provide further impetus for its use in the often unstructured agricultural environment. The application of this robotic technology is discussed in detail in relation to the harvesting of strawberries.

95-500. WATER QUALITY MONITORING FOR THREE CROP PRODUCTION PRACTICES
A. Mandani and P. Brenton, Agricultural Engineering Department, Nova Scotia Agricultural College, Truro, NS; L. Cochrane, Extension Engineering, Nova Scotia Department of Agriculture & Marketing, Truro, NS; J. van Roestel and B. Thomas, Plant Industry Branch, Nova Scotia Department of Agriculture & Marketing, Truro, NS; and K. Webb, Agriculture & Agri-Food Canada, Truro, NS.

Four sites are being monitored to determine the impact of several nutrient management practices on subsurface and surface drainage water quality. The sites are located in central Nova Scotia on soils with course loamy surface material underlain by compact subsoil. All sites have systematic subsurface drainage installed and one site also has ditches to collect surface runoff. Water samples are being collected manually from tile outlets and surface inlets and analyzed for nutrient content. Nutrient management practices that meet crop nutrient requirements have the potential to produce nitrate concentrations in surface and subsurface drainage water that do not exceed the Canadian drinking water standard of 10 mg/L. The potential for higher nitrate levels in drainage water increases if outflow and runoff occur soon after nutrient application.

95-501. HERBICIDE LOSSES IN SUBSURFACE TILE EFFLUENT FROM CORN FIELDS UNDER CONVENTIONAL AND NO TILLAGE
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The effects of no tillage (NT) and conventional tillage (CT) on tile drain flow, and on concentration and loss of atrazine, deethylatrazine, and methylchlor in tile effluent was evaluated in clay loam, 3 ha, corn fields in eastern Ontario. Over the four crop-year study period (90-91 to 93-94), flow was significantly higher under NT than CT. Atrazine and its degradation product deethylatrazine were almost always present in tile effluent. Concentrations of atrazine were mostly below the USEPA advisory of 3 μg/L while concentrations of atrazine plus deethylatrazine were generally below 5 μg/L, the Canadian Interim Maximum Acceptable Concentration (IMAC) for the sum of atrazine and its metabolites. Under both treatments, concentrations exceeding these limits were mainly observed during rainfall-induced flow events within a few days or weeks.
after herbicide application. Over the study duration, flow-weighted average concentrations of atrazine during flow events were significantly higher under NT than CT. Metolachlor was detected in relatively few flow events at concentrations well below the Canadian IMAC of 50 μg/L. Annual loss in tile water depended more on total flow than on concentration.

**95-503. INVESTIGATING METHODS OF INTEGRATING LIQUID MANURES INTO CONSERVATION TILLAGE CROPPING SYSTEMS**

Y. Chen, R. Samson, Resource Efficient Agricultural Production Canada, Ste. Anne de Bellevue, QC; and G. Schell, Ecological Services for Planning, Guelph ON.

This on-farm research project aimed at evaluating the influence of liquid manure application techniques on corn growth and soil nutrient content in conservation tillage systems. Experiments were established on no tillage and reduced tillage corn fields in the spring of 1994. The sites locate at four farms, one dairy farm and three hog farms, in southern Ontario. The treatments of nitrogen source were inorganic fertilizer, manure and combination of inorganic fertilizer and manure. The nitrogen application time included preplant and sidedress. Manure was surface-applied with or without incorporation. The incorporation was realised by an AerWay implement or a disc incorporator. Regardless of the application time (either preplant or sidedress), weed pressure in no-tilled manure plots could result in a deduction of corn yield. To the contrary, an increase in corn yield was also found using manure as a fertilizer source or combining manure with inorganic fertilizer when there were no weed problems. Incorporating manure into soil slightly increased corn yields.

**95-504. EVALUATION OF AN ON-FARM POLLUTION CONTROL SYSTEM FOR REDUCING PESTICIDE AND FERTILIZER POLLUTION**

A. Liaghat, S. O. Prasher and R. S. Broughton, Department of Agricultural and Biosystems Engineering, McGill University, Ste Anne de Bellevue, QC.

This paper reports the development of an on-farm pollution control system using soil as a biological filter, for trapping herbicide and fertilizer residues. A field site with four shallow surface ditches, under-lain with four perforated drain pipes, was used to carry-out field measurements. Polluted water with concentration levels of about 100 μg/L was applied to the ditches for 10 days continuously (actual application lasted for four hours daily); and no water was applied for the following ten days. Water samples were collected both before application and after the water came out of the drains, in an observation chamber. Herbicide levels were reduced significantly in drainage water in comparison to the 100 μg/L level in applied water. Bio-degradation of herbicides was found to occur between water applications; thus it is proposed that the system could be self-sustainable in the long term.

**95-505. GROUNDWATER CONTAMINATION DUE TO SEPTIC TANK LEACHING BEDS: FIELD EXPERIMENTS IN SOUTHERN ONTARIO**

D. Joy, N. Burnham, H. Whiteley and S. Zelin, School of Engineering; and H. Lee, Environmental Biology, University of Guelph, Guelph, ON.

Groundwater is the principle water source for many Canadian communities. As such, its contamination is a serious concern. Numerous reports indicate that leaching beds are a source of groundwater contamination in Canada and the United States. Leaching bed tracer experiments have been conducted for three years at an instrumented site in Elora, Ontario. In Ontario, microbiological objectives for drinking water require routine testing of source wells for total coliforms and Escherichia coli (E. coli), indicators of fecal contamination. In three experiments, a strain of E. coli resistant to the antibiotic naladixic acid was used as a biotracer to show the extent of bacterial transport from the leaching bed. The leaching bed was unable to treat the bacteria and they easily entered the groundwater. Transport patterns were very different depending on the way the biotracer was introduced and were also different from transport patterns of a conservative tracer (indicative of nitrates) under the same field conditions. These findings suggest performance based standards must consider more than one contaminant type if the standards are to be effective.

**95-506. A SYSTEM FOR STUDYING THE EFFECTS OF LOW TEMPERATURE CONDITIONS ON MANURE COMPOSTING**

J. Franke, J. Leonard and J. Feddes, Agricultural, Food and Nutritional Sciences; R. Janzen and W. McGill, Renewable Resources, University of Alberta, Edmonton, AB.

Six 170 L insulated plastic barrels were used as compost vessels to study the effects of low temperature on composting a 3:1 ratio of dairy manure and barley straw. All vessels were filled with the same mixture and allowed to reach thermophilic temperature. Four barrels were situated in a coldroom and were constantly ventilated at a rate of 3 L min⁻¹: two with coldroom air and two with outside air. The remaining two barrels were kept outside the coldroom as controls and were constantly ventilated with ambient air at a rate of 3 L min⁻¹. The flow rate for all barrels was increased to 33 L min⁻¹ if the mean temperature of the compost exceeded +55°C. Average temperatures of the cold room and ambient air were -19.5°C and +16.2°C respectively. Levels of ammonia (NH₃), oxygen (O₂), carbon dioxide (CO₂) and temperature in each vessel were continuously monitored and recorded. The contents of each vessel were mixed to reinitiate microbial activity if temperature and gas concentrations indicated that the composting process had stopped. Periods between mixing ranged from four to 10 days but became shorter as the compost grew older. The temperature in the two vessels receiving a constant flow of cold air decreased at a rate slightly quicker than that in the cold room vessels receiving ambient air. The mean maximum average temperature for the four vessels in the cold room was 66.5°C. While the coldroom vessels cooled, the temperature in the control vessels remained in the thermophilic range (mean temperature of 64.0°C) indicating constant microbial activity. For all barrels, peak O₂ consumption and CO₂ production were reached between 12 to 36 hours after mixing, depending on the initial temperature of compost. NH₃ production was only noticeable in significant amounts in the early stages of composting. The data and results produced from the trial runs were very satisfactory and there appears little doubt this system and method of analysis can be further work in this area.
95-507. INFLUENCE ZONE OF AERATION PIPES AND TEMPERATURE VARIATIONS IN PASSIVELY AERATED COMPOSTING OF MANURE SLURRIES L. Fernandes, M. Sartaj, Civil Engineering Department, University of Ottawa, Ottawa, ON; and N.K. Patni, Centre for Food and Animal Research, Agriculture and Agri-Food Canada, Ottawa, ON.

Three modes of aeration for composting of poultry manure slurries under high moisture condition (76%) using peat as the bulking agent were studied. Forced aeration (FA), passive aeration (PA), and natural aeration (NA) modes were examined. A total of 9 piles, 3 replicates for each treatment, were built in trapezoidal shape with an initial volume of 5.03 m$^3$ each and monitored for a period of 90 days. The influence zones of passive and forced aeration were determined by statistical comparison of temperature profiles of 59 thermocouples distributed inside each pile. The influence zone of passive aeration pipes included the interior part of the pile bottom half, while for forced aeration treatment the influence zone included the interior of the pile. In both PA and FA, air diffusion was the predominant aeration mechanism at locations near the pile surface and they had the same performance as the natural aeration pile. These results were verified by applying Cluster analysis. Comparison of the three treatments showed that under initial conditions of this study, passive aeration composting performs better than forced and natural aeration composting in terms of temperature development and process sanitation capabilities. The end product looked like peat and was rich in phosphorus and nitrogen.

95-508. EARTHEN HOG MANURE LAGOONS; PART I: FLUX REDUCTION DUE TO SEALING T.A. Fonstad, UMA Engineering Ltd., Saskatoon, SK; and C.P. Maulé, Agricultural & Bioresource Engineering, University of Saskatchewan, Saskatoon, SK.

Research was initiated to determine the suitability of Saskatchewan soils for the construction of earthen liquid hog manure storages. Field investigations involved installation of a groundwater monitor well adjacent to 19 existing hog manure storages. Soil and water analyses were conducted at each site. Although evidence was not conclusive, in general, groundwater mounding and NO$_3$, Cl$^-$, K$^+$ levels higher than typical background levels were observed. Four of these storages were chosen for further investigation. Soil sampling below each lagoon as well as ground water monitoring well installations were completed at each site. Results indicate significant contamination migration in sandy soils and minimal migration in clay till. Laboratory investigations involved the construction of soil columns which were subjected to hydraulic conductivity tests using both water and fresh hog manure. Seven soil gradations were used which ranged from 9% to 33% clay content. After manure application, final hydraulic conductivities for all columns approached values of 10$^{-6}$ to 10$^{-7}$ mm/s regardless of soil type. This represents a decrease in hydraulic conductivity of 1 to 3 orders of magnitude. Even though the soil appeared to seal, chemical analysis of exfiltrates indicated high levels of anions within 60 to 90 days.

95-509. EARTHEN HOG MANURE LAGOONS; PART II: ION TRANSPORT IN SOIL MATERIALS C.P. Maulé, Agricultural and Bioresource Engineering, University of Saskatchewan, Saskatoon, SK; and T.A. Fonstad, UMA Engineering Ltd., Saskatoon, SK.

The rate of ion transport in saturated soil systems is affected by the ion type, adsorption, clay content and type, compaction, seepage rate, and the effect of the solution upon the movement and adsorption of ions from animal manure are presented. The objective of the study reported in this paper is to enable estimates of ion travel time within soil liners of earthen hog manure lagoons in Saskatchewan. Seven soils of different textures were packed into acrylic columns and then manure ponded on them. Flux and ion concentrations of the exfiltrate solution were monitored with time. The test duration will be two years. The results reported here are after 200 days. A general approximation of ion travel time for a hypothetical lagoon is simulated from the preliminary data collected to date.

95-510. ZEOLITE AS FEED ADDITIVE TO CONTROL SWINE MANURE ODORS AND TO IMPROVE ANIMAL GROWTH PERFORMANCE S. Barrington and K. El Moueddeb, Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

Zeolite is a tektosilicate found in volcanic deposits and capable of exhibiting a cation retention capacity (CEC) of 400 meq/100 g. Alberta zeolite was used as feed additive to test its capability in improving feed conversion and reducing manure odor level. Observations were made on 27 grower hogs fed 5% zeolite pelleted feed and compared in growth performance to a control group of 27 other grower hogs. Initially, the hogs weighed 18.6 kg (8.2 kg of standard deviation for both groups) and the results reported were taken after four weeks of testing. The zeolite ration improved feed conversion by 0.47 kg of feed per kg of body gain and rate of gain by 0.4 kg of body mass per week, as compared to the control feed. Furthermore, a noticeable improvement in air quality and ammonia level was observed.

95-511. DYNAMIC MODEL FOR THE SIMULATION OF NITROGEN VOLATILIZATION AND MINERALIZATION IN MANURE-AMENDED SOILS S. Hengnirun, S. Barrington and S. Prasher, Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

The volatilization and mineralization processes in manure-amended soils were simulated using a dynamic approach as part of an overall nitrogen management-oriented model called MANIMEA. Both processes are considered to take place simultaneously in the two separate components, the applied manure layer and the soil. In the soil component, the simulation depth is divided into zones of incorporation and beyond incorporation. The volatilization submodel takes into account temperature, cation exchange capacity, and air movement. The mineralization submodel considers the effect of pH of the applied manure and the soil, and the variation and distribution of temperature and moisture content in the soil profile. The influence of waste management and farming practices on the availability of nitrogen at the time of application is also considered in the model. The simulated results indicated good agreement with the results from analytical methods. Taking into account the interaction of volatilization and mineralization provides a better estimation for the applica-
tion rates of sufficient amount of manuriel nitrogen for plant growth with minimal environmental pollution.

95-512. PLUGGING TILE DRAINS TO REDUCE MA- 
NURE CONTAMINATION
R.J. Fleming and M.C. MacAlpine, Ridgetown College, 
Ridgetown, ON.

The second phase of an experiment was performed to assess the feasibility of plugging a drainage outlet to reduce or elimi-
nate any harmful impacts to surface water after application of 
liquid manure on farmland. Two flat fields were divided so 
that, in each, two separate drains could be monitored. At one 
farm, observation wells were installed on the header tile to 
monitor flow and water quality. Manure was spread and one of 
the drains was blocked. Seven days after manure application 
the blocked drain was released. In the other field, one of the 
outlet pipes was blocked for a shorter period. Total loadings of 
nitrate, ammonium, coliform bacteria, phosphorous and potas-
sium were compared.

95-513. MILKING CENTRE WASTE MANAGEMENT 
IN ONTARIO
H.E. Cuthbertson and L. Senyshyn, Ontario Ministry of 
Agriculture, Food and Rural Affairs, Resources and Regula-
tions Branch, Guelph, ON; and S. Koppen-Train, Rural 
Development Secretariat, Inter-ministry Coordination Unit, 
Ontario Ministry of Agriculture, Food and Rural Affairs, 
Toronto, ON.

Watershed studies conducted in the late 1980's indicated 
that up to 80% of dairy operations were disposing of milking 
centre waste by means of direct discharge to natural and 
artificial drainage systems. Concern had also been expressed 
about the storage of manure and polluted runoff from yards 
and solid manure storages. A provincial survey found that 50% 
of the producers were disposing of their milking centre waste in 
an environmentally acceptable manner, 25% in a manner 
that had the potential to pollute at some times during the year 
and 25% in an unacceptable manner via direct discharge. 
Manure storage structures were present on 75% of the farms. 
Sixty eight percent of the liquid manure storages were prop-
erly sized, while only 36% of the solid manure storages had 
sufficient capacity and most did not contain runoff. The num-
ber of milking cows was found to be a fair predictor of total 
milking centre water usage, but a poor predictor of water usage 
per milking cow. The mean water usage in litres per milking 
cow per week was 99.6 for the sample, 111.0 for the farms with 
parlour systems and 97.5 for the tie stall systems. Water use 
per milking cow did not decrease substantially as cow numbers 
increased.

95-514. DEVELOPMENT AND UTILIZATION OF 
OMAFRA NUTRIENT MANAGEMENT COMPUTER 
PROGRAM (MNanpc)
D. Hilborn and C. Brown, Ontario Ministry of Agriculture, 
Food and Rural Affairs, Woodstock, ON.

The OMAFRA Nutrient Management Computer Program 
(MNanpc) has been developed as a tool to assist farmers, 
contractors and advisors to generate a nutrient management 
plan for farms using livestock manure. This user-friendly pro-
gram combines existing pieces of information from many 
published sources and data bases into one step by step package.

One of the challenges related to the program is interpreting 
output information using environmental, economic, and com-
mon sense parameters. The program is especially of interest as 
a planning tool for large livestock or poultry operations with 
large volumes of manure to handle.

95-515. SELLING THE PUBLIC ON LARGE HOG 
FARMS - A SUCCESS STORY
M.E. Jorgenson, Confinement Engineering Ltd., Humboldt, 
SK; K. McKnight, Saskatchewan Agriculture and Food, 
Saskatoon, SK; and I. Stomp, Stomp Pork Farm, Leroy, SK.

A 1200 sow farrow to finish swine barn was "welcomed 
with open arms" to a community barely a stone's throw from 
others that have been embroiled in controversy. This paper 
demonstrates the practical application of the public involve-
ment process using principles of renowned rural sociologist, 
Dr. Desmond Connor. Presented as a successful case study, a 
step by step public process is developed which is applicable to 
any environmentally sensitive project.

95-600. THE AGRICULTURAL ENGINEER AND THE 
INTERNET
J.-A. Landry, Agricultural and Biosystems Engineering, 
Macdonald Campus, McGill University, Ste. Anne de 
Bellevue, QC.

Lately, the words Internet, Cyberspace, Electronic High-
way, and several others with similar flavors have been on 
everyone's lips. The concept of distributed, universally avail-
able information offers great promises and draws great 
e excitations. Millions of internet clients are surfing the sev-
eral thousand sites that now provide material of all natures. 
Unfortunately, most of this material is of questionable interest, 
when not simply of questionable quality. Several hours, even 
days, can be spent searching for usable information. Numerous 
mechanisms are available to help browsing more efficiently 
through Cyberspace and several sites provide access to spe-
cialized information in a well organized manner. This paper 
presents some of the available searching procedures, essential 
tools for surfing the internet. Several sites, particularly attrac-
tive to Agricultural Engineers, are also presented. The 
discussion mainly focuses on sites proposing a comprehensive 
access to a wide variety of material related to Agricultural and 
Biosystems Engineering.

95-601. MODULES D'AUTO-APPRENTISSAGE AS-
SISTÉ PAR ORDINATEUR (AAO) POUR LES COURS 
DE GENIE RURAL À L'UNIVERSITÉ LAVAL
R. Thériault, D. Désilets et R. Boily, Département de génie 
rural, Université Laval, Sainte-Foy, QC.

Une structure commune a été élaborée afin de produire des 
modules d'ALLO complémentaires de la formation théorique 
et des expériences de laboratoire déjà réalisés par les étudiants 
dans le cadre des cours de génie rural. Cette structure fait appel 
au logiciel Director de Macromedia pour Macintosh. Les mod-
ules développés peuvent être exploités sans licence et ils 
puissent aussi être traduits en version PC. La structure prend la 
forme d'un logiciel interface qui simplifie et accélère le 
développement des modules avec Director. Elle intègre les 
textes, les dessins, les photos CD, la génération de courbes, 
surfaces et graphiques, ainsi que l'animation et la simulation. 
Elle comprend des formats standardisés pour la page de
présentation, le menu, la navigation, l'aide contextuelle, le format des textes, le glossaire, l'évaluation formative et l'évaluation sommative. Les trois premiers modules portent sur: 1) les composantes et le fonctionnement des sémoirs; 2) les interactions entre les paramètres de la traction exercée par les tracteurs agricoles; 3) la simulation des procédés de congélation. Cinq autres modules viendront compléter les types d'applications possibles de la structure commune.

95-602. THE ENGINEERING OF AUTONOMOUS BIOSYSTEMS: THE ECOCYBORG PROJECT
R. Kok, L. Parrott and G. Clark, Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

We are investigating how to engineer autonomous systems that will be able to persist for extended periods. Initially, we are working with a hypothetical cyborged ecosystem which we call the EcoCyborg. We are using a modelling and simulation approach to investigate how the EcoCyborg will behave in response to various levels of cognition and consciousness being present in its control system. The EcoCyborg is described with a composite model consisting of three modules respectively representing the ecosystem and the two extrinsic controllers (Pavlovian and cognitive). In the ecosystem module the biological community can be modelled with up to 100,000 components in an object-oriented manner. The cognitive controller module uses neural networks to create a limited artificial consciousness. The simulation approach under OS/2 allows the simultaneous use of different languages and packages for the various parts of the model. Results will be used to clarify genotype/phenotype relationships.

95-603. COSTS OF OPERATION OF GRAIN DRYING AND STORAGE CENTERS
G. Duruvage and D. Désilets, Département de génie rural, Université Laval, Sainte-Foy, QC.

A computer program was developed to compute the costs of operation and the inventories of grain drying and storage centers and to follow utilization of the equipment. The flow diagram is fed into the computer along with the characteristics of each component of the system. The electrical rates under different loads, the fuel cost, the investment, the interest rate, and the insurance costs are also needed. All these can be modified whenever desired. The daily inputs consist of the weight, moisture content and grain type of each load received as well as the duration of each operation and the flow channel (equipment) in use. The outputs can be presented daily, monthly or yearly. They contain the following: quantities received and shipped; quantities dried, cleaned and handled; costs of fuel and electricity; fixed costs; inventory of each silo; hours of operation of each component; and cost of operation of each operation. The system is already installed in both large and small centers.

95-604. STRUCTURE OF THE ECOCYBORG SIMULATION UNDER OS/2
R. Molenaar, R. Kok and R. Lacroix, Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

A simulation structure for an EcoCyborg is being developed and implemented with the IBM OS/2 operating system. The structure is composed of seven processes. Each process is constructed independently and various software products are being used for that task. The resulting structure will be used for simulation to gain a better understanding of how to design, create and control biosystems. This paper gives an overview of the overall simulation structure and its implementation under OS/2. Preliminary results are also presented.

95-605. APPLICATION OF GIS AND WATER QUALITY MODELS TO WATERSHED MANAGEMENT
M.H. Moussavizadeh, F. Papineau, P. Enright and C.A. Madramootoo, Agricultural and Biosystems Engineering, Macdonald Campus, McGill University, Ste. Anne de Bellevue, QC.

Nonpoint source pollution is site specific and is a long term environmental problem. Computer models and GIS can be used to make management decisions. GIS has become increasingly important in solving problems related to water resource management, soil and water contamination, environmental remediation and other applications in natural resource management. This paper describes the application of SPANS/GIS to hydrologic and nonpoint source pollution modelling, to identify the best management practices for the 26.1 km² Saint Esprit watershed in Quebec.

95-606. THE STUDY OF ECOSYSTEM DYNAMICS USING SIMULATION
O.G. Clark and R. Kok, Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

As part of an effort to investigate the engineering of autonomous biosystems, a case study is being carried out which focuses on modelling a configurable cyborged ecosystem. As part of this project, it is necessary to quantitatively and qualitatively characterise the system's dynamical behaviour as it results from varying structural configurations and initial and environmental conditions. The characterisation of complex systems such as ecosystems can be achieved using both traditional statistical and ecological techniques (e.g. mean values, measures of variability, diversity and stability), as well as more modern tools (e.g. dynamic simulation, state space descriptions, measures of chaoticity). The resulting values can then be used to compose "fingerprint" vectors which describe aspects of interest. Several vectors can be constructed describing the same systems from the viewpoint of different paradigms, if this adds useful information. Some of these techniques have been applied to preliminary simulation results.

95-607. USING OBJECT-ORIENTED DATABASES MANAGEMENT TECHNOLOGY IN AGRICULTURAL DECISION SUPPORT SOFTWARE
L. Gauthier and T. Néel, Agricultural Engineering Department, Laval University, Sainte-Foy, QC.

The object-oriented paradigm has been receiving considerable attention in the past few years. Most of this attention has been devoted to the use of object-oriented programming languages and methodologies. More recently, the use of object-oriented databases management systems (OODBMS) has also received considerable attention. It allows the storage and management of objects possessing the same semantics as
the objects processed by the programming language. OODBMS technology can be used to extend the object model used in an application to the persistent data store. In other words, an OODBMS supports the storage of semantically rich data (i.e. objects). The SAGE application framework makes use of such technology. It is built with a Smalltalk-based OODBMS and is designed to support decision making processes in areas such as plant protection and soil fertility management. We present how SAGE makes use of OODB technology and analyze the impact of this technology on the functionality of the supported software.

95-608. SIMPORC: A MODEL OF PIG GROWTH UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

L. Chénard, A. Marquis, L. Gauthier, Département de génie rural, Université Laval, Sainte-Foy, QC; and C. Pomar, Agriculture and Agri-Food Canada, Lennoxville, QC.

A steady state model was developed to simulate swine production under different indoor conditions for Quebec’s climate using the Object Oriented Programming language Smalltalk. Three winter management strategies are compared. They are: humidity control with heating, humidity control without heating, and temperature control without humidity control. For each of them, we adapted an animal growth model based on the results of Pomar (1991, 1992, 1994). In this model, the pigs are fed ad libitum and variations on feed intake and zootechnical performances of the pigs are taken into account. The thermoregulation relationships come from Wittemore (1983). Feeding and heating costs are included in the model. The model also incorporates a health module for identifying the frequency at which selected animal health risk factors may occur under a given management strategy for a fattening period from 20 to 105 kg. The software built from this model, SimPorc, is intended to assist in the selection of optimum economical and sanitary management choices for swine production. Parameters such as the building insulation, the date at which the fattening period starts, the costs of feed, weaned pigs, building, labor, veterinary interventions, heating and also mortality can be determined by the users for a given simulation and any correctly formatted weather database can be used.

95-609. CREATION OF AN ECOSYSTEM MODEL: STRUCTURE AND COMPOSITION

L. Parrott and R. Kok, Agricultural and Biosystems Engineering, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

As a part of the EcoCyborg Project, an object-oriented model of an artificial ecosystem has been formulated. The model can accommodate up to 100,000 individuals representing 1000 different species whose characteristics partially mimic those of terrestrial life forms. Each individual organism or collection of organisms is encapsulated in an object which contains information about how it interacts with other objects. Individuals are spatially distributed and are subject of environmental influences. A procedure has been developed in which object classes can be created and defined outside of an object-oriented programming language environment. The model is structured so that the behaviour of the system given various initial conditions can be observed through a multi-process simulation in OS/2.

95-610. APPLICATIONS OF ARTIFICIAL NEURAL NETWORKS TO LAND DRAINAGE ENGINEERING

C.-C. Yang, S.O. Prasher, Agricultural and Biosystems Engineering; and R. Lacroix, Department of Animal Science, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

This paper describes the use of artificial neural networks (ANNs) which model the performance of a subsurface drainage system. The ANN model was developed and trained by using the simulated midspan watertable depths from DRAINMOD, a conventional watertable management model. Compared to DRAINMOD, the model is very simple to run and requires only a small amount of data, such as precipitation, evapotranspiration and initial midspan watertable depth. The results indicate that the ANN model can make predictions similar to DRAINMOD, doing this significantly faster and with fewer input data. Thus, with adequate training, an ANN model is able to simulate the fluctuations of watertable depths under a surface drainage system.

95-611. THE EFFECT OF DATA PREPROCESSING ON THE LEARNING ABILITY OF ARTIFICIAL NEURAL NETWORKS

R. Lacroix, X.Z. Yang and K.M. Wade, Department of Animal Science, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

The objective of this research was to investigate the effect of data preprocessing on the learning ability of artificial neural networks, specifically with regard to the impact of distributing the vectors uniformly with respect to the output categories found in the training data set. The analyses were done for neural networks dedicated 1) to classification and 2) to prediction. From the results obtained in this study, it can be concluded that the distribution of outputs influence the learning process of neural networks for both types of application. For example, less frequent events were not learned very well by neural nets unless data preprocessing was performed. The types of output distribution required for ANN training may depend on the specificities of each problem.

95-612. KNOWLEDGE ENGINEERING FOR FUZZY DECISION-SUPPORT SYSTEMS

M. Strasser, R. Lacroix, Department of Animal Science; R. Kok, Agricultural and Biosystems Engineering; and K.M. Wade, Department of Animal Science, Macdonald Campus of McGill University, Ste. Anne de Bellevue, QC.

A research project is currently under development with the objective of creating a global decision-support system (DSS) for dairy cattle breeding decisions. The DSS will be constructed using expert systems and fuzzy logic. To establish a framework for the development of this DSS, a first generation prototype fuzzy DSS was developed with the goal of providing dairy cattle culling decisions. An analysis of this prototype has been performed resulting in the establishment of a framework for the elicitation and implementation of expert knowledge in a fuzzy decision-support system. This framework will be used for the implementation of a second generation fuzzy DSS currently under construction.
NOTES TO CONTRIBUTORS

The Editorial Board will assess suitability and essential detail of papers submitted for publication in Canadian Agricultural Engineering. One or more reviewers will be used. Their comments and suggestions will be compiled and submitted to the author. The review will ensure that:

1. A research paper presents a piece of research carried to a well-defined stage of advancement and the conclusions are adequately supported by the experimental results.

2. A technical paper presents a clear, concise, and factual outline and interpretation of the development, design, test, or analysis under consideration and that it is a contribution in the field of agricultural engineering.

3. A general paper on education, research, or extension is pertinent to major changes in curriculum, research, or extension or to forward-looking developments in these areas.

4. A technical note on equipment development, technique of measurement, or method of analysis will have an application for other workers in the field of agricultural engineering.

MANUSCRIPT

The manuscript should be typed double-spaced on paper 216 x 279 mm (8.5" x 11") with margins not less than 30 mm. The first page should contain only the title, authors’ names, addresses (including postal codes), and contribution number where applicable. The telephone number and FAX number of the corresponding author should also be included. Tables and captions for illustrations should be on separate pages, placed after the text. Manuscript paper with numbered lines is required. Six copies must be submitted. After a paper has been accepted for publication, the author will be expected to provide a copy of the paper on floppy disk in a format compatible with MS-DOS or Macintosh systems.

The title of the paper should give an accurate description of the article, using key words that can be used for computer-indexing.

ORGANIZATION

The paper should be organized to conform with present Journal practice. All papers must include a short abstract section of about 200 words. Authors are encouraged to submit the abstract in both English and French. There will be a charge for translation services that must be provided by the Journal.

Major headings - Center on the page with all words in capital letters.

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Technical and detailed information should be included only in the form of description, table, graph, chart or photograph. In general, follow the style used in a recent issue of the Journal, or the style used in Transactions of the ASAE.

References

List references alphabetically by authors at the end. Follow the format set by the American Society of Agricultural Engineers, but do not abbreviate journal names. Material in press, with the name of the journal, may be used as a reference. Private communications and unpublished reports should be referred to in parentheses in the text. Private communications should include the person’s title and address. Avoid the use of footnotes. Use the author-date system in the manuscript when referring to articles in the Reference section.

Tables

Designate tables at the top by table number (Roman numerals) and title, in upper and lower case letters. All headings and other information in tables are to be in lower case except first letter of first word. Keep the table compact and place it across the page wherever possible. Do not use vertical lines.

Measurements

Only metric system (SI) units are to be used.

Equations

Equations and formulas must be set up clearly. Use capitals for symbols as much as possible and lower case for superscripts and subscripts. Greek and other characters should be identified clearly. Equations should be numbered on the right-hand margin and appear on the center of the equation.

Abbreviations

Abbreviate units of measure only when used with numerals. Use correct SI unit abbreviations. Do not use abbreviations in the title.

ILLUSTRATIONS

Either original drawings or glossy photographs are acceptable for illustrations. An illustration should be planned to fit, after reduction, into a space 90 mm wide (one column) or 183 mm wide (two columns). The original should be not more than three times the size of the final figure. For identification, the figure number and author’s name should be written on the lower left corner with soft pencil.

Line drawings should be machine produced on white drawing paper or tracing paper. Authors are encouraged to produce drawings using one of the commonly used computer packages. Letters, numerals, labels and axis captions should have only the first word capitalized. Axis captions should be followed by a comma, the symbol in italics, and the units in parentheses [i.e. Acceleration of particle, $A_p \text{ (m/s}^2 \text{)}$]. If a symbol is not used omit the comma. Letters and numerals must be at least 1.5 mm high and preferably 2 mm high in final form. Curves on graphs must be 0.3 mm wide after reduction. Axes and grid lines should be clearly visible but inconspicuous; a width of 0.2 mm after reduction is suggested. Figure numbers and captions should be typed on a separate page, not on the original illustrations. When a paper is submitted for publication, the original illustrations need not be provided so long as the copies are of such quality that reviewers can understand them. Original drawings must be provided when the paper is accepted for publication. If a drawing has been produced by a computer package, a copy of the file should be submitted on disk at the time that the manuscript is submitted on disk.

DISCUSSIONS

Discussions may be submitted on any paper or technical note published in the Journal for a period of not more than four months following publication. Discussion of a paper or technical note is open only to anyone who has significant comments or questions about the content of the paper/technical note. A discussion will not be accepted for publication if it contains material readily found elsewhere, is purely speculative, introduces personalities, or otherwise falls below the standards of a technical paper in a professional journal. Authors will be given an opportunity to reply to discussions.

The format for discussions differs from those of papers in that figures are to be identified by capital letters to avoid confusion with the original paper. The discussor should refer to him/herself as “the writer” or “I” and to the author of the original paper as “the author.” The first page shows the title of the original paper with a footnote to identify the author, volume, page and date. Name and address of the writer of the discussion follow the title.

Discussions will be reviewed by the Editorial Board and possibly the reviewers of the original paper. The length of a discussion is restricted to one journal page. Lengthy discussions will be returned for shortening, or the writer may be encouraged to submit a paper of technical note.