Regulations Related to Land-application of Abattoir Wastewater and Residues

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ABSTRACT

Worldwide, legislations on regulating the disposal of abattoir wastewater and residues are not yet uniform. In Europe and North America, new regulations are being developed to protect soil and water. This provides an opportunity to review the regulations related to land-application of abattoir wastewater and residues. In USA, all states must abide biosolids standards as set out. In Ontario, Canada, a detailed proposal must be submitted to the local Ministry of Environment (MOE) office for review. Biosolids Utilization Committee provides opinion to local MOE office on wastes other than sewage biosolids. There are many minimum land-application restrictions for water and soil protection. According to European Union, overall, land-application of abattoir waste is probably the best practical environmental option for small-scale abattoirs, but is likely to be much less appropriate for modern, large-scale operations. The farmers are generally against the land-application of biosolids in Finland and Luxembourg.

Keywords*:* Abattoir, jurisdiction, legislation, smokehouse, wastewater, land application, biosolids

1. INTRODUCTION

Worldwide, abattoirs are facing the tasks of treating and disposing of wastewater and residues (Munack, 2002; Pereira, 2005). Mittal (2004) has provided an in-depth characterization of the effluent from abattoirs for land-application without treatment. Meat plant wastewater quality and quantity depend on water usage, the type of animal slaughtered, and the amount of rendering or processing that is done on site. Masse and Masse (2000) studied slaughterhouses in Eastern Canada and reported that average of 90 to 140 L of wastewater was produced per hog killed, compared to 200-600 L per hog in Germany (Tritt and Schuchardt, 1992). The Ontario Ministry of Environment (MOE, 1999) reported water consumption at 180-450 L per hog, 800-1700 L per cattle, and 12-55 L per bird for poultry. Other abattoirs, with further processing, produced 1250 L/hog (Masse and Masse, 2000). About 21% of an animal is waste after processing (dependent on animal type), and 80-90% of solid abattoir waste is recycled or reused mainly into feed industry (EU, 2001). Much of

the mass of abattoir waste ends up as a waste water stream from rendering plants. Fertilizer and gelatin industries are using hoof parts and bone meal. Land-application of blood is now less common. Large amounts of nitrogen (N), phosphorus (P) and potassium (K) in waste blood make it a good source of plant nutrients. However, it can cause public nuisance due to odors and environmental concerns. Stomach contents have high levels of N, P and K and in well balanced proportions with N:P:K ratio of about 5:1:1. Wash waters contain lower levels of N, P and K. Thus, excess application of these wastes can cause potential water pollution problems and may be harmful to plants (EU, 2001).

Mittal (2006) had reviewed treatment methods and techniques for wastewater from abattoirs before disposal. In land-application, wastewater and biosolids are directly applied into the land either by injection or by other mechanical means. The materials are biodegradable and provide nutrients to soils. Advantages of land-application are (Masse and Masse, 2000): (i) recovery of wastes, (ii) replacement of chemical fertilizers (N, P, K), and (iii) soil structure improvements. The limitations are: (i) public visual nuisance and odor, (ii) risk of surface and groundwater pollution, (iii) soil contamination due to toxic, heavy metals and organic compounds, and (iv) health hazards to human and animals due to pathogens.

Legislations on regulating the disposal of wastewater and residues are not yet uniform. In the US, the federal government provides guidance while state governments regulate land-application. The U.S. Federal agencies including the Department of Environmental Conservation, Environmental Protection Agency (EPA), and Department of Ecology defer abattoir related questions either to state biosolids rules or to federal regulations. In some states only the federal regulations, governing the beneficial use of biosolids, are applied. This is Title 40 of the Code of Federal Regulations (CFR) Part 503 "Standards for the Use or Disposal of Sewage Sludge", February 1993, as amended February 1994, and October 1995 (often referred to as the "503" or the "Sludge" rule) (US-EPA, 2003). Because of the clean water act, EPA proposed effluent limitation guidelines for the meat and poultry products industry. This includes slaughterhouses (abattoirs) and further processing facilities.

This paper provides an in-depth review of legislations, jurisdictions and regulations related to land-application of abattoir wastewater and residues. Presently, the regulations pertinent to land-application of abattoir wastewater and residues are derived from the municipal biosolids. Therefore, some relevant discussion on municipal biosolids is also included in this review.

2. LEGISLATIONS IN CANADA

2.1 Ontario, Canada

According to Ontario Ministry of Agriculture and Food (OMAF, 1996), a detailed proposal must be submitted to the local Ministry of Environment (MOE) office for review. Biosolids Utilization

Committee (BUC) provides opinion to local MOE office on wastes other than sewage biosolids. After proposal review, recommendations are provided to the MOE on the waste acceptability for agricultural use, appropriate application rates, spreading procedures and soil characteristics. To provide benefits by unfamiliar (unknown) wastes, laboratory testing for nutrients, microbial and chemical analysis, and possibly greenhouse and field testing may be needed. An Organic Waste Management System Certificate will be required by the hauler for waste transport to the land or experimental site. The site must receive a Certificate of Approval for an "Organic Soil Conditioning Site" and meet conditions of Environmental Protection Act and Ontario Regulation 347. The MOE may ask an applicant to provide for a suitable field monitoring program and routine analysis for specific parameters of concern. The waste, before applying to the land, must be treated to minimize the odor potential and reduce pathogens numbers, and other potentially harmful constituents to an acceptable level. The farmer should adjust the waste and fertilizer application based on nutrient concentration information and fertilizer recommendation for the crop. The guidelines are given to restrict the heavy metals amounts applied to soils to limit metal accumulation. The pH of a waste should be between 6.0 and 8.5 when applied to an established crop.

Suggested maximum annual sodium (Na) addition varies from 200 kg/ha for sandy and sandy loam soils to 500 kg/ha for loamy and organic soils (OMAF, 1996). For boron, a limit of 1 kg/ha/yr has been established, and water soluble boron concentration in the soil should be $\leq$ 1 mg/L. Wastes applied to agricultural fields shall contain no foreign non-biodegradable material that may cause human or animal injury or damage to equipment. Up to 1% plastic pieces (<2.36 mm size) and 2% other non-biodegradable material (<2.36 mm size) are allowed (OMAF, 1996).

Guidelines concerning minimum distance between the spreading site and surface watercourse are given in various regulations (OMAF, 2002). These regulations list details on biosolids land-applications regulations in Canada and USA concerning separation distances, waiting periods and soil characteristics when biosolids are applied on the soil. Separation distance can be reduced if wastes are injected directly into the soil. The wastes should never be applied within 10 m of any watercourse. At the time of application, the groundwater table should be >0.9 m from the soil surface. The spacing between the spreading site and individual residence should be 25 m minimum, and 50 m minimum from a residence in a residential area. Application sites should be minimum 15 m away from deep water wells, and 90 m away from all other wells. Liquid wastes should not be spread on frozen or ice covered soil (OMAF, 1996). For storage of wastes, a certificate of approval is needed from MOE. Generally a minimum of 6 months storage will be adequate. The maximum allowable application depth of liquid wastes at any one time is 1.3 cm (OMAF, 1996).

2.2 New Brunswick, Canada

In New Brunswick, land-application of industrial wastes and by-products are prohibited if these have not been previously stabilized, either through lime or aerobic or anaerobic digestion (Guidelines for

Issuing Certificate of Approval for the Utilization as Waste as Soil Additive, 1996). Department of Environmental Management was unable to refer to documentation guiding the abattoir industry towards land-application standards that differed from legislation or guidelines addressing biosolids applications in general.

2.3 British Columbia, Canada

British Columbia has introduced a new Organic Matter Recycling Regulation (B.C. Reg. 18/2002) which addresses biosolids and land-application, but there is no specifics in this document that deal with the land-application of abattoir waste.

2.4 Quebec, Canada

In Quebec during 1999, about 700 000 tons of biosolids were land-spread, of which about 10% came from abattoirs. About 2% of farmland received residuals. Presently, short term accumulation of trace elements in soils is non-existent or negligible. A certificate of approval (CA), issued by MENV (Ministry of Environment), is generally required for land-application. High-quality residuals can be spread without a CA if certified by a commercial quality control organization (Bureau de Normalisation du Quebec, BNQ). About 10% of the waste land-spread now has this certification (MENV, 2002). An agro-environmental reclamation plan (AERP) for land-application of wastes must be prepared according to the latest agronomic standards and provide the following information: (i) residual's source and description, (ii) residual classification, (iii) location map showing lot numbers, sensitive zones and crops, (iv) soil analysis, (v) agronomic recommendations, (vi) total N available for growing season or post harvest application, (vii) rationale for selecting N and P availability, (viii) compliance with environmental constraints, (ix) order and delivery slips, (x) practices to limit leaching and runoff of N and P, (xi) commitment for two verification visits by a professional, and (xii) sound and dust control measures. Land-application of wastes is subjected to farm regulations that limit the amount of N and P that can be applied to the land. These land application requirements are similar to those in Ontario and Europe. Quebec introduced legislation in November 2002 that based land-application standards around an odor classification system, which is more stringent than criteria in the U.S. (MENV, 2002).

Criteria regarding the land-application of biosolids are based on three factors, i.e., the levels of organic and inorganic contaminants (categories C1 or C2, details in Table 10), pathogens (categories P1, P2 and P3), and odors (categories O1, O2 and O3). Exception of these is for the use of C2 residuals in high amounts for the revegetation of degraded sites. Biosolids that do not meet minimum requirements (C2-P3-O3) cannot be land-spread. Odor problems have caused the greatest concern with land-application of biosolids. Odor scores are divided into 4 categories based on (MENV, 2002) the olfactomery test results and surveys of the perception of odors:
O2: Mean odor score of solid dairy cattle manure: 4.1 $\pm$ 1.7 (s.d.), i.e. odor score >2.4 and $\leq$ 5.8

O1: Odor score < the lower bound of O2, i.e. odor score > 0 and ≤ 2.4
O3: Odor score > the upper bound of O2, but #liquid hog manure, i.e. odor score > 5.8 and ≤ 8.3
Out-of category: Odor score > liquid hog manure. It is no longer permitted to use residuals in agriculture as they are too malodorous.

Table 1 indicates that untreated abattoir waste falls into the out-of-category range. Abattoir wastes that are limed generally fall into O2 or O3 class. Quebec's C1 and C2 criteria were mainly derived from the Canadian guidelines for compost quality. Residuals classified O2 and O3 are subject to numerous application requirements. Categories are subject to specific requirements which include application prohibition times, separation distances, communication plan requirements, restricted public access, incorporation requirements, and application heights, etc. (MENV, 2002). Odor measuring equipment are now available (Yuwono and Lammers, 2004a,b) and should be used to quantify the problems.

There are additional constraints for malodorous residuals classified as O2 or O3 depending on their odor levels. The constraints are the same as or harsher than those currently in force in the U.S (SOLINOV, 2002). The application of O3 waste is prohibited on Saturday, Sunday and public holidays. Untreated abattoir waste that had not been limed or stabilized attained odor scores higher than liquid hog manure. These were designated as "out-of-category" and were not to be land-applied.

The preventive approach of restricting unique loading to 22 t ds (dry solids)/ha/5 yr for the C2 category simplifies the management and control of activities. There are many minimum land-application restrictions for water and soil protection. There are additional restrictions for category C2 fertilizing residuals (MENV, 2002). In Ontario (Canada) and the US, soil metal analyses are required and load limits vary from one metal to another. If current agronomic and forestry rules are rigorously applied, the risks of N and P contamination are strongly reduced. For biosolids and abattoir residuals, the following parameters have to be analyzed: Dry matter, total N, NH_4-N, P_2O_5, K_2O, organic matter, C/N, pH and neutralizing value for wastes treated with lime, and Al analysis for wastes treated with aluminum salts. Land-application of unmixed abattoir manure does not currently require a CA. If the residual maximum value exceeds 20% of the C2 criteria, one of the following measures must be implemented: (i) all batches or portions of batches of one type of residual that exceed the C2 requirements must be stored separately and not apply, and (ii) all batches or portions of batches of one type of residual that exceed 20% of the C2 requirements must be uniformly mixed with other batches before application. A calculation must show that the final mixture content meets C2 requirements. If the residual generator or professional suspects, that unanalyzed contaminants may exceed C1 criteria, or that specific contaminants or undesirable objects are present, remedial measures must be proposed (MENV, 2002).

Populations of *E. coli* and *Salmonella* are determined to establish the presence of faecal

contamination. Constraints for the land-application of categories P1, P2, and P3 (Goyer *et al*., 2001) are based on U.S regulations for sewage sludge (US-EPA, 2000a).

Table 1. Residual/fertilizer type and odor score/type used to apply biosolids to land in Quebec, Canada (adapted from Goyer et al., 2001)

Fertilizer residue or farm fertilizer	Odor score	Odor category[1]
Chemical fertilizers	1.2	
Lime mud	1.3	O1
Fertilizing residuals compost (manure)	1.7	O1
Manure compost (manure)	2.1	O1
Municipal biosolids, aerated lagoons	2.5	O2
Beef cattle manure	3.8	
Dairy cattle manure	4.1	
Municipal biosolids, limed or heat dried	4.4	O2
Municipal biosolids, biological treatment in a plant	5.3	O3
Boiler hen manure	5.4	
Beef cattle manure, liquid	5.9	
Dairy cattle manure, liquid	6.2	
Milkhouse wastewater	6.6	
Potato wastes	7.1	O3
Abattoir biosolids, limed	7.4	O2 or O3[2]
Laying hen manure, liquid	7.7	O3
Milk calf manure, liquid	8.1	
Hog manure, liquid (feeders)	8.3	
Abattoir biosolids, untreated	10.1	Out of category

[1]Only substances classified as fertilizing residuals are assigned odor classes
[2]Odor category depends on the liming process

For wastes of "excellent environmental quality" B Class C1-P1-O1, utilization constraints are minimal due to low environmental risk. Wastes of "good environmental quality" are subjected to additional restrictions. Wastes that do not meet the minimal quality standards (C2-P3-O3) including abattoir waste cannot be land-applied under the new legislation, unless they are stabilized. MENV

now requires that lime treatment be done directly at the abattoirs. The application of liquid biosolids by air-spraying is prohibited in Quebec (Canada) (SOLINOV, 2002).

Constraints are greater for malodorous biosolids or those containing human pathogens. These constraints are mainly separation distance (residences, residential zones, property boundaries, roads, etc.), a restricted period of one year to limit public access to application sites, the obligation to incorporate the biosolids into the soil after application and the obligation to spread (aero-aspersion) liquid waste at a height less than 1 m above the ground to avoid spreading particles through air. The separation distance from an adjacent residence (Table 2) is at least 90 m for P2 and P3 wastes and this distance increases to 500 m for the "very malodorous category" O3 (MENV, 2002). Other constraints are required for malodorous wastes, such as setting up a communications plan. At the abattoir, the wastewater should be kept in aerobic conditions, and liming at the plant <6 h following withdrawal of the biosolids, or 6 h following drying. During storage: mixed with other types of residues is not permitted, and pH must be ≥10 at all times (MENV, 2002). Table 3 lists maximum annual loading of metals in biosolids applied to land in the US and Ontario, Canada.

Table 2. Separation distances for land-application of different categories of biosolids in Quebec, Canada (adapted from Goyer et al., 2001)

Category and applicable limits for biosolids		Required distance (m) from an adjacent residence
P1	Faecal coliforms <1000 MPN/g (dry basis, db) and *Salmonella* <3 MPN/4 g (db) and other requirements equivalent to the US EPA's Class A	__
P2	Faecal coliforms < 2 x 10^6 MPN/g (db) and other requirements equivalent to the US EPA's Class B.	90*
P3	Faecal coliforms < 2 x 10^6 MPN/g (db) and biological treatment with a 20 d equivalent retention time for sludge	90*
O1	Odor level < than solid dairy manure	__
O2	Odor level similar to solid dairy manure	75
O3	Odor level > than solid dairy manure and < than pig slurry	500

*500 m from a residential zone.

3. LEGISLATIONS IN THE UNITED STATES

BioCycle's 2000 survey of state biosolids coordinators collected overall data on land- application of

biosolids, but did not collect specifics on abattoir wastes. For the annual survey, BioCycle sends a questionnaire to biosolids coordinators in all states. The study did reveal that 16 U.S. states do have one or more counties and/or towns with restrictions, bans or ordinances on land-application of biosolids. California (16), New Hampshire (40) and Virginia (29) have the greatest number. State law in New Jersey preempts any local bans (BioCycle, The State of Biosolids in America, December 2002, p 50).

Table 3. Biosolids land application jurisdictional scan B maximum annual loading (kg/ha) (from various US and Canadian sources)

	Ar	Cd	Co	Cr	Cu	Hg	Mo	Ni	Pb	Se	Zn
Ontario	0.28	0.05		4.7	2.7	0.02		0.7	1.8		6.7
US-EPA	2	1.9			75	0.85		21	15	5	140
New York		0.5			17			67			34
Maximum cumulative loading (kg/ha)											
Ontario	1.4	1.6	30	210	150	0.8	4	32	90	2	330
Alberta		0.8-1.5		50-100	100-200	0.2-0.5		12-25	50-100		150-300
US-EPA*	41	39			1500	17		420	300		2800
New York		3.4		337	84.3			34	337		169

* same for MI, MN, NJ, OH, OR, and PA states

In the USA, sewage sludge is applied to approximate 0.1% of available agricultural land (US-EPA, 2002). This land-application is regulated by "Code of Federal Regulations, Title 40 (part 503), under section 405(d) of clean water act" established by EPA in 1993. Biosolids is referred to treated sludge of municipal, industrial and agricultural origins to meet the land-application standards in the part 503 rule. Presently in biosolids, 9 inorganic chemicals are regulated, and now considering to include "dioxins" in the list. Generally blood is not collected from very small operations even if they have rendering services available. Most of it is applied on the land or buried.

Revised "Biosolids Management Guidelines for Washington State" (Publication #93-80, Revised July 2000) of the Washington State Department of Ecology did not include specifics around the land-application of abattoir waste that would distinguish its treatment from other biosolids. The Maine Department of Agriculture (DAFFR) and Environment Protection Department have been involved in developing a Compost Pilot Program.

Table 4 provides summary of the jurisdictional review related to land-application of abattoir wastewater in Canada, US and EU. Table 5 summarizes the regulation requirements in various

States for land-application of biosolids describing various factors. There are some differences in these regulations applied to different States and countries. Table 6 lists maximum permissible metal concentrations. According to EU data on metals in abattoir wastes varies as (mg/kg solids) (Mittal, 2004): Cd (0.1 to 6), Cr (0.1 to 71), Cu (0.3 to 210), Hg (0.01 to 10), Ni (1 to 36), Pb (0.1 to 54), and Zn (0.1 to 1426). Thus, only Hg concentration (10 mg/kg ds in blood) is near to the maximum allowed for New York State. Rest of metal levels is very low compared to permissible limits, and can

Table 4. Summary of jurisdictional review and land application of abattoir wastewater and biosolids for Canada, US and EU. All are regulated under State=s law (adapted from NRC, 2002)

State	Regulation	Comments
California	Water Quality Control Board & Local Enforcement Agency.	On a case by case basis - no composting of blood.
Colorado	Discharge Permit Regulation, 5CCR1002-61, Specifically 61.3 & 6CCR1007-2, Part B, Sec. 14 - Solid Waste Composting.	--
Iowa	Iowa Administrative Code Title 567, Chapter 121.	Permit exemption up to 2 tons/acre/year.
Kansas	Department of Health & Environment, Division of Environ., Bureau of Waste Management, Kansas Statutes 65-3407.	--
Minnesota	General Permit Authorization to Land Apply Wastes Generated from Food and Beverage Processing Facilities, State Disposal System (SDS) Permit MN G960000.	Minnesota Pollution Control Agency - discourages direct land-application of undiluted blood - permit required.
Nebraska	Title 132, Chapter 3; >1000 cubic yards required to operate in accordance with Title 132, Chapter 2 003.02.	One-time land-application allowed with approval from Department of Environmental Quality.
NC	North Carolina Solid Waste Management Regulations.	Case by case basis.
PA	Title 25, Chapter 291 of PA Code, PA DEP, 254-5400-100.	--
Wisconsin	Code NR214- Land Treatment of Industrial Liquid Wastes, By-Product Solids and Sludges & NR518-Land-application of Solid Waste.	No whole blood to land.
USA – Federal	Title 40 of the Code of Federal Regulations (CFR) Part 503 - Standards for the Use or Disposal of Sewage Sludge.	--
Quebec	Provisional criteria for land application of fertilizing residuals.	Odor categories, limed abattoir waste acceptable.
EU	Waste Framework Directive (75/442/EEC as amended 91/156/EEC).	--
Scotland	Waste Management Licensing Regulations WMLR94.	--

USA - blood and blood/water mixtures fall under the definition of solid waste according to EPA.

Table 5. Requirements for land application plans for biosolids in selected States of the USA (adapted from Abt Associates, Inc., 2002)

State 6	CA	CO	IA	MN	NE	NC	PA	WI
Waste parameters	x	x	x	x	x	x	x	x
Total solids, pH			x	x				x
Total volatile solids, P			x	x				
Total Kjeldahl/Ammonia N			x	x			x	x
Total K			x					x
Total Na, Cl				x				
Salt content, microbial number								x
Metal content			x			x		x
Chem. Comp., physical characteristics			x			x	x	
Soil characteristics			x	x	x	x	x	x
Depth							x	
Texture				x	x		x	
Color, structure, matrix			x		x		x	
Bulk density, total N			x					
pH			x	x	x		x	x
Organic matter, Exchangeable K			x	x				x
Exchangeable P			x	x			x	x
Metals			x				x	
Ion-exchange properties			x		x			
Waste application rate	x		x	x	x	x	x	x
Site limitations, ground/surface water risks	x	x	x	x	x	x	x	x
Crop characteristics				x		x	x	x
Nuisance control	x	x			x	x	x	
Adequate storage				x			x	x
Sampling requirements		x	x	x	x	x	x	x
Financial assurance		x					x	
Closure plan		x	x		x		x	x

Table 6. Maximum permissible (ceiling) metal concentrations (mg/kg ds) in biosolids for land application in Canada and the USA (compiled from MENV, 2002, Anon., 1998)

	Quebec-C1	Quebec - C2	Ont.	EPA	MI	MN	WI, OH, PA, IN	NY
Ar	13	75	170	75	75	75	75	-
Cd	3	10	34	85	8	85	85	25
Co	34	150	340	-	-	-	-	-
Cr	210	1060	2800	3000	-	-	-	1000
Cu	100	757	1700	4300	4300	4300	4300	1000
Hg	0.8	5	11	57	57	57	57	10
Mo	5	20	94	75	75	75	75	-
Ni	62	180	420	420	420	420	420	200
Pb	150	500	1100	840	840	840	840	1000
Se	2	14	34	100	100	100	100	-
Zn	500	1850	4200	7500	7500	7500	7500	2500
Dioxin ng/kg	17	50	100	-	-	10-50 ppt	-	-
Furan, ng/kg	17	50	100	-	-	-	-	-

easily be applied to land. However, accumulations of these metals have to be controlled by limiting waste loading rate. Only animal stomach waste (Mittal, 2004) contains maximum levels of toxic

chemicals (mg/kg ds), i.e.: PCB (0.2), Fluoranthene (0.5), Benzo fluoranthene (0.4), and Benzo pyrene (0.6). These levels are also much below the maximum permitted levels for land-application.

According to the Clean Water Act, direct dischargers (effluent is discharged directly into navigable waters) must comply with effluent limitation guidelines and new source performance standards in National Pollutant Discharge Elimination System (NPDES) permits; indirect dischargers (effluent is discharged to publicly owned treatment works) must comply with pretreatment standards (US-EPA, 2002). The Pollution Prevention Act (of 1990) describes that "pollution that can not be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and disposal or release into the environment should be employed only as a last resort..." (US-EPA, 2002). Small meat and poultry products (MPP) facilities are excluded from the proposed effluent regulation as (i) these discharge <3% of the conventional pollutants, <1% of toxic pollutants, <4% of the nutrients and <1.5% of pathogens of the entire MPP industry, and (ii) by improved treatments only a limited amount of loading removal would be possible (US-EPA, 2002).

According to federal guidance (US-EPA, 2002), blood is classified as nonhazardous due to low concentration of toxic metals in it. Blood comes under the definition of solid waste as specified by the U.S. Environmental Protection Agency (EPA) through Resource Conservation and Recovery Act (RCRA).

3.1 State Regulations

All the states, studied in the report, require a permit for land-application of solid waste. A land-application plan has to be submitted. The land-application plan provides the information on the type of waste proposed for application, the proposed method, location, frequency of application, and an impact assessment of the surrounding environment. Some states (OMAF, 2002) regulate land-application more strictly than other states. MN and PA require very specific data in the site plan while other states, such as CA, ask applicants to prove the benefits of land-application, and it should not pose any environmental risks.

In **California** the composting of blood and other animal material from mammals is prohibited. For poultry processors, on-site composting may be excluded from regulations if the compost produced is sold or given to the agricultural source from where the feedstock was purchased. Composting regulations are given in Title 14, California Code of Regulations, Chapter 3.1, Composting Operations Regulatory Requirements (http://www.ciwmb.ca.gov/ Regulations/Title14/ch31.htm).

Land-application permits are handled case-by-case basis on the regional level. For this, a processor has to contact its Regional Water Quality Control Board for specific requirements, and it has to submit a comprehensive site plan, including waste, soil and surrounding water environment. It also

has to submit odor and vector control measures to the Board and Local Enforcement Agency (LEA). Then, the Board and LEA review the case and issue a permit, and establishes the waste discharge requirements. Due to the ban on composting, rendering is a viable option in California. California has the largest number of rendering plants and generally the plants charge a fee of $0.03/lb of blood (for small quantities). There are also a small number of blood spray drying plants that pay processors for blood (Abt Associates, Inc., 2002).

In **Colorado**, composting feedstock is classified in three categories. The type 2 contains animal and food wastes in which the meat processing wastes also falls. Composting facilities are classified into four classes and meat processing waste facilities fall under Class II. A certificate of designation is required for a Class II facility, for the approval of which a Design and Operation Plan has to be submitted. Local governing bodies issue this certificate. Specific requirements for all classes of composting facilities are laid down by Colorado regulations. Composting state regulations cover the land-application. But a ground water discharge permit from the Colorado Discharge Permit System Regulation (5 CCR 1002-61, specifically Regulation 61.3) might be required for the application of blood and blood-water mixture on land (Abt Associates, Inc., 2002).

In **Iowa**, composting is regarded as the best viable method for disposing of blood from small meat processing units. It becomes more viable because land-application is not recommended during the time when the ground is frozen or when crops are growing. Iowa Department of Natural Resources (DNR) regulates composting. The composting facilities are required to state and specify the types of waste they are unable to accept. No permit is required for on-site composting. Only the requirements as mentioned in the Iowa Administrative Code 567 B Chapter 105.9 must be met. Some requirements are: incorporation of blood into the composting process within 24 h, prevention of run-off and leachate, odor and vermin controls, and storage time limits (Abt Associates, Inc., 2002).

For land-application purposes, a land-application plan has to be submitted in accordance to the Iowa Administrative Code (Title 567, Chapter 121). This plan must include soil, waste and site analyses. Permit is not required, if the amount applied for, does not exceed 2 t/(acre.yr) (Abt Associates, Inc. 2002). For the permit, periodic sampling, record-keeping and site closure plans are required (Table 5). Site limitations are enforced to protect water (ground, surface) and other environmentally sensitive areas. Environmental hazards and human contact are restricted through site limitation. For financial assurance, the applicant has to assure the government that it will be able to cover closure costs (Abt Associates, Inc., 2002).

Waste parameters and soil characteristics (Abt Associates, Inc., 2002): The waste parameters for the analysis of the waste materials, and soil characteristics are mentioned as per state requirements.
Crop characteristics (Abt Associates, Inc., 2002): Pathogens or toxins present in the waste can have a detrimental effect on the plant growth. Different states regulate crop characteristics so as to prevent

destruction of plants by pathogens.

Groundwater and surface water risks (Abt Associates, Inc., 2002): Groundwater and surface water run a risk of being polluted due to leaching, runoff and other means. The groundwater table and surface waters on or near the land-application site are required to be analyzed in some states.

Adequate storage (Abt Associates, Inc., 2002): Waste storage planning is another criteria which is given consideration due to the fact that waste production does not undergo any stoppage even when the conditions are not suitable for its application on land e.g. when ground is frozen or during rainfall.

Waste application rate (Abt Associates, Inc., 2002): The type of crop to be grown determines the optimal waste application rate. The waste application rate must provide the requisite amount of nitrogen for the plant's need. This need must guarantee the proper yield as well as minimize the amount of nitrogen seeping below the root zone of the vegetation to the groundwater.

4. LEGISLATIONS IN EU

A report prepared by the European Commission (EU, 2001), presents information on the land-application of wastes in the 15 Member States of the European Union (EU). The objectives of the study were: (i) review current practices for land-application of organic wastes including abattoir waste, but excluding sewage sludge and compost, (ii) provide a better understanding of the associated risks of land-application, and (iii) suggest actions which would help ensure a high level of environmental protection from land-application. Currently Waste Framework Directive (75/442/EEC as amended 91/156/EEC), sets out the principles of the necessary controls where waste materials are to be recycled to land. However, there is a case for introducing more specific controls to ensure a high level of environmental protection. Recommendations are made for registration, record-keeping and cost-effective controls on land-application. It would allow for each member state to build a national database comprising the registers of designated wastes and land-application permits from which all relevant information about land-application could be derived. Summary data could then be provided to the European Commission as required, to present a synopsis of land-application across the EU. There were considerable differences between member states concerning land-application and availability of information about the practice.

It is estimated that 5-10% of abattoir waste in the EU is land-spread after composting, or without treatment. This is mainly gut contents, consisting primarily of partly digested feed or vegetable matter. The wash water from holding areas and vehicles is also typically land applied or discharged to sewer. Application of blood to land is now less common. Overall, land-application of abattoir waste is probably the best practical environmental option for small-scale abattoirs, but is likely to be

much less appropriate for modern, large-scale operations. Land-application of blood and gut contents from abattoirs is liable to cause public nuisance due to odors and environmental concerns, and, that if applied on the soil surface it is unsightly and there is potential for disease transmission. Thus, these wastes be dealt as untreated sewage sludge and applied to the land by subsurface injection or else incorporated as soon as possible after application on the surface of arable land or into grassland. In addition, land-use restrictions as for untreated sewage should apply, and that the rate of application of the waste should be in accordance with agronomic rate (EU, 2001).

To minimize odor nuisance, the wastes should be applied by sub-surface injection into grassland or immediately incorporated into arable land. Public nuisance can be reduced by avoidance of application in fields close to and upwind of residential areas. Storage should be avoided where possible. It would be beneficial to treat abattoir waste by a stabilization process before land-application. There are few waste treatment plants installed at abattoirs across Europe. Treatment plants are more popular in Scandinavia, with some having aerobic or anaerobic digestion facilities that also produce biogas (EU, 2001).

Some EU countries have developed more stringent legislations concerning land-application than other developed countries.

Scottish recommendations suggest that land-application of abattoir waste be deemed appropriate, blood and intestinal contents should be diluted at least 1:1 with water before application. In **Belgium**, the stomach content of cattle is mainly composted before being reused in agriculture or in any other beneficial route. In **Denmark**, sludge, etc. from meat processing can not be used for agricultural purposes if it is not stabilized using one of the following treatments: anaerobic digestion, aeration, composting without temperature control, addition of lime, or 6 months storage. Stabilized sludge, etc., from meat processing must be worked into the soil within 12 h after application and cannot be used for gardening (EU, 2001).

An EU Animal By-products Regulation that is expected to come into force soon will cover how to deal with blood and gut contents from abattoirs and will require treatment of blood, or mixtures of blood and gut contents (by either rendering, incineration or composting) before applying on land (EU, 2001). Gut contents from animals is not proposed for treatment under the Regulation, but will be required to be spread on arable land (i.e, not on land to which grazing livestock have access). A statutory requirement for blood from abattoirs to be treated prior to final disposal is now introduced as part of the EU controls on animal by-products (SMHCC, 2001). According to the European Commission, more than 90% of the waste spread on land is farm waste and predominantly animal manure.

Tables 7 and 8 summarize limit values for heavy metals in biosolids, limit values of these metals that

can be added annually to the soil, limit values of heavy metals in soil where biosolids are applied, and maximum permissible levels of trace organic compounds in waste or effluent, respectively. Compared to North American regulations, the limits for Cd and Hg are lower in EU regulations. Table 9 provides a summary of legislations in various regions and countries of EU for land-application of abattoir wastes. Thus, considerable data have been collected and summarized on pollution created by land-application of abattoirs wastes and other biosolids. Specific legislations have been developed in various countries of the World between 1998 and 2001 (EU, 2001).

4.1 Scotland

Presently, no nutrient management plan and requirements for qualifications of contractors are required for waste land-application. There is no monitoring of exempt waste for microbiological quality. It is recommended that the wastes should not be (i) injected on lands with field tiles, and (ii) applied outside daylight hours. The maximum recommended land-application of waste is 50 m^3/ha. Land-application of abattoir wastes should not cause any health risk which should be ensured by the farmer. The waste should be soil injected to prevent odor problems (EU, 2000).

Table 7. European Union limit values for amounts of heavy metals that may be added annually to soil, based on a 10-year average (compiled from NRC, 2002, EU, 2000)

	Limit values (g/ha/yr)	
Elements	Directive 86/278/EEC	Proposed
Cd	150	30
Cr	-	3,000
Cu	12,000	3,000
Hg	100	30
Ni	3,000	900
Pb	15,000	2,250
Zn	30,000	7,500

The competent authority may decide to allow an increase in the loading rate for Cu and Zn on a case-by-case basis for those plots of land that are Cu- or Zn-deficient and if it has been proved by

qualified expert advice that there is a specific agronomic need for the crops.

Strategic review of land-application of organic waste has been under taken by Scottish Environment Protection Agency (SEPA) (SEPA, 1998). Exempt industrial waste application on land comprises only 3% of the total land-application. Agricultural waste contributes 96% of land-application.

Table 8. European Union limit values for heavy metals in soil, mg/kg ds (compiled from NRC, 2002, EU, 2001)

Directive	Cd	Cr	Cu	Hg	Ni	Pb	Zn
86/278/EEC (6<pH<7)	1-3	--	50-140	1-1.5	30-75	50-300	150-300
Austria	0.5-2	50-100	40-100	0.2-1	30-70	50-100	10-300
Belgium (Fl)	0.9	46	49	1.3	18	56	170
Belgium (Wa)	2	100	50	1	50	100	200
Denmark	0.5	30	40	0.5	15	40	100
Finland	0.5	200	100	0.2	60	60	150
France	2	150	100	1	50	100	300
Germany	1.5	100	60	1	50	100	200
Greece	1-3	--	50-140	1-1.5	30-75	50-300	150-300
Ireland	1	--	50	3	30	50	150
Italy	1.5	--	100	1	75	100	300
Luxembourg	1-3	100-200	50-140	1-1.5	30-75	50-300	150-300
Netherlands	0.8	100	36	0.3	35	85	140
Portugal							
soil pH<5.5	1	50	50	1	30	50	150
5.5<soil pH<7	3	200	100	1.5	75	300	300
soil pH>7	4	300	200	2	110	450	450
Spain							
soil pH<7	1	100	50	1	30	50	150
soil pH>7	3	150	210	1.5	112	300	450
Sweden	0.4	60	40	0.3	30	40	100-150
UK							
5<soil pH<5.5	3	--	80	1	50	300	200
5.5<soil pH<6	3	--	100	1	60	300	250
6<soil pH<7	3	--	135	1	75	300	300

soil pH>7	3	--	200	1	110	300	450
Estonia	3	100	50	1.5	50	100	300
Latvia	0.3-1	15-30	10-25	0.1-.15	8-30	15-30	35-100
Poland	1-3	50-100	25-75	08-1.5	20-50	40-80	80-180

Fl = Flanders, Wa = Wallon, limits of As = 22 in Belgium (Fl), Mo = 10 and Co = 50 mg/kg ds in Austria only.

Table 9. Legislations in various regions and countries of EU for land-application of abattoir wastes (complied from EU, 2001)

	Title	Number/specifications	Purpose
EU	The Waste Framework Directive.	75/442/EEC as amended 91/156/EEC.	Control principles of recycling waste materials to the land.
EU	Specific controls for land-application wastes.	86/278/EEC;91/676/EEC.	Land-application of sewage sludge; water protection against nitrites from agriculture.
Austria	Waste Management Act 1990; Fertilizer Act 1994; Soil Protection Laws of States.	Came into force on July 1, 1990.	Legal framework for the avoidance, utilization and disposal of waste.
Belgium	Regional regulations to recycle industrial waste to land.	VLAREA II/AGW of 12/01/95; The Royal Decree of January 7, 1998.	Controls the quality of any materials used in agriculture or spread on land.
Belgium	Other indirect regulations.	Nitrates EC Directive; Protection of Surface and Groundwater.	Indirectly affect the industrial waste disposal.
Denmark	Application of Waste Products for Agricultural Purposes.	Statutory Order 49 of January 20, 2000 (SO 2000/49).	Controls on the land-application of industrial waste.
Finland	Waste Act and Decree.	Act 1072/1993 and Decree 1390/1993.	Implemented 75/442/EEC directives. No regulation for waste quality for application.
France	(i) Regulation on registered installations (ii) Nitrates directives (iii) Water legislation.	(i) Law No. 663 of July 19, 1976 (ii) Decree 93-1038 and 96-163 (iii) Decree 93-743, 92-742, 97-1133.	A system of integrated permit for the most polluting activities. Protecting water from nitrates of agriculture origin. Control of land-application.
Germany	(i) Bio-Waste Ordinance (ii) Fertilizer Law and Ordinance	(i) BioAbfV 1998, (ii) DMG 1977 amended 1994; DuMV 1991 (iii) BboSchG 1998.	Regulating application of biological waste on soils, quality of fertilizer and application, and protection of soil quality.

	(iii) Soil Protection Law.		
Greece	No specific regulation.		
Ireland	Waste Management Act.	SI 1998/146.	Implements the EC Waste Directive.
Italy	Land-application of industrial waste.	Decree 22/97.	Waste is applied after composting.
Nether-lands	(i) Decrees of Manure and Fertilizers, (ii) Mineral Accounting System.	(i) Decree 86/1998, 765/1997 (ii) MINAS 1998.	(i) Land-application of other organic fertilizers; implementation of loss-making standards, (ii) Farmers keep record of nutrient application and depletion.
Portugal	No specific regulation.	--	--
Spain	(i) Land-application of industrial waste, (ii) Fertilizers and Derivatives Act	(i) Macro Law 10/1998 (ii) May 28, 1998	(i) Ensures transcription of European Directive 91/156/EEC, (ii) Lists fertilizers and derivatives regulations.
Sweden	No legal requirements for organic wastes spread on land.	Voluntary quality certification scheme was accepted in 2000 for land-application.	--
UK	Control on industrial waste land-application.	Part II of Environmental Protection Act 1990; Waste Management Licensing Regulations (WMLR) 1994; Groundwater regulation 1998; Protection of Water Against Agricultural Nitrate Pollution Regulations 1996; Animal By-	Licensing of waste recovery, disposal and treatment operations.

product Order 1992; Bovine Material Order (SI 1996 No. 1192).

Exempt industrial wastes for land-application include blood and gut content from abattoirs. Most exempt wastes are not pre-treated or stored at the point of source. This leads to odor problems, and the possibility of not being applied at the time most beneficial to the land or the crop. There is only limited data concerning fate and impacts of nutrients, and pathogens in the exempt wastes. Risks of pathogens associated with exempt and agricultural wastes are not fully understood or quantified.

The SEPA (1998) first called for a ban on the application of abattoir waste, including animal blood and gut contents on land. According to the Report, the present approach to the regulation and management of organic wastes to land was inadequate, inconsistent, leading to practices which posed a risk to the public, to the environment and to animal and plant health. A range of measures were suggested, including a consistent legislative framework, enforceable Codes of Practice, land management plans for farmland, and the prohibition of certain application activities, such as untreated abattoir waste, to ensure that future land-application was carried out responsibly and effectively. In 1987, the total amount of blood and guts recycled to land from abattoirs in Scotland was estimated at 26,000 t (maximum) or 3% of total wastes applied to lands. SEPA is the enforcing authority in Scotland for the Waste Management Regulations. Waste is currently applied to land throughout the year and often during adverse weather conditions as a result of a lack of storage facilities. Wastes have also been applied with little regard for weather conditions. Exempt wastes are occasionally spread at night (SEPA, 1998).

The Final Report of the Task Force on *E. coli* O157 (SHMCC, 2001) addressed the issue of land-application of blood and gut contents from abattoirs. Blood could be a good culture for growing bacteria, such as *E. coli* O157, with the critical factors being temperature and time. Blood, if managed properly before land disposal, should pose no significant risk of infection from *E. coli* O157. Storage at 15^{o}C or below would be a sensible precaution and that where storage is not practicable, consideration should be given to more frequent removal from the abattoir i.e. daily. Gut contents could be regarded as similar or less in hazard to excretions direct to land from animals in the field. Solid layer of dung on cattle hides could lead to higher carcass microbial contamination.

In March 2001, SEPA notified relevant waste disposal contractors that the application of abattoir waste on agricultural land, as opposed to sub-soil injection was illegal. SEPA took this action following the directive by the Scottish Executive of "controls" for the disposal of abattoir waste as a result of the national hoof and mouth disease outbreak. Incorrect or over application of waste on land has the potential for non-point source or diffuse pollution of waste streams (EU, 2001).

Many recommendations were made based on the study conducted after surveying land-application practices and waste characterization. These are: (i) Land-application of all organic wastes should be regulated by a consistent legislative frame work, (ii) the legislation should cover mixed waste streams and put standards for safe acceptable amounts for various wastes on different soil types, and

(iii) prohibition is needed to inject waste into land with field drains, applying in designated heritage sites, and applying out with daylight hours. For exempt wastes, 6 month pre-notification system does not provide sufficient level of information, and it is not required to include the information into any farm plans. Faecal-containing materials such as abattoir waste pose high risk (EU, 2001).

The Scottish Waste Management Licensing Regulations (WMLR94) under the Scottish EPA identify a number of non-agriculture wastes, often referred to as industrial wastes, have been allowed to be applied to agricultural land with legal exemptions from licensing. These wastes include blood and gut content from abattoirs (also include septic tank sludges, distillery waste, dredgings from inland waters, etc.). There was no government Code of Practice covering the application of wastes in accordance with the exemptions, however SAC Technical Note (T459) provides guidance, and the PEPFAA (Prevention of Environmental Pollution from Agricultural Activity) Code of Practice should be followed, although this was not statutory. Overall, the Report recommended that the land-application of blood and gut contents from abattoirs undergo suitable pre-treatment (EU, 2001).

4.2 Other EU Countries

Austria (EU, 2001): Solid waste from food industry is mainly converted to compost, and liquid wastes are treated. The residues of the treatment are the part of wastewater treatment sludge.

Belgium (EU, 2001): Land-application of waste is carried out by contractors who report to different administrators. Soft approach is taken on the recycling operation by the administration. The waste producer reports the following to the administration before recycling waste in agriculture: (i) annual waste production, (ii) waste quality, and (iii) waste production process description including raw materials and their analysis. The waste license is issued by Regional Administration specifying the land-application conditions. The sludge is mainly applied on land. The stomach content is mainly composted before applied on land (SEPA, 1998).

Denmark (EU, 2001): A farmer's Nutrient Management Plan is changed if industrial waste is spread on land. Overall responsibility for enforcing Sludge Order is with Danish EPA. The sludge from wastewater treatment plants at abattoirs is exempted from authorization under the Sludge Order. The waste producer is liable or responsible for waste land-application even when a subcontractor is hired to execute the actual land-application. This liability/responsibility is generally transferred to the farmer from the waste producer after application. A detailed annual fertilizer budgets are maintained by the farmers to ensure a balance of inputs and outputs. Application of liquid waste during winter is prohibited since 1999 through a legislation. Due to the increase in growing of organic foods, some farmers are not accepting industrial waste.

Waste application must not: (i) cause groundwater pollution, (ii) cause significant unsanitary conditions, and (iii) applied in such a way so that by sudden thaw and rainfall wastes are likely to runoff to water courses or drain. Sludge Order 2000/49 has put the following limits for nutrients quantities recycled to land from waste application: total N (170 kg/ha/yr), total P (30 kg/ha/yr) and dry matter (7 t/yr). The followings are limit values (mg/kg ds) for xenobiotic substances: linear alkybenzene sulphonates (LAS): 1300, polycyclic aromic hydrocarbons (PAH): 3, nonylphenol + ethoxylates (NPE): 10, and di-ethylhexyl phthalate (DEPH): 50. Untreated sludge from meat production is not allowed for agricultural purposes. Land-application of waste should also comply with the requirements on heavy metal content, xenobiotic compound content and microbiological quality. A minimum of 5 samples from a waste must be taken and at least 75% must comply with the limit values and no sample must exceed by 50% of the limit values. A nutrient management plan is needed as waste applied to land must be used for fertilizer purposes. The animal blood is collected and reused. During 1998, about 12% of untreated wastes from meat plants were applied to land, and about 87% waste was pasteurized under controlled conditions before application. The waste from the animal was about 21% (w/w) of total waste from meat plants or 17471 t (EU, 2001).

About 80-90% of organic material from abattoirs without flotation tanks is disposed to the municipal wastewater treatment plants. About 80% of organic material from abattoirs with flotation tanks is retained in the grates and the flotation tanks. There is an increasing trend in treating abattoir wastes by anaerobic digestion before land-application. Only small concentrations of environmentally undesirable substances are supposed to contain in abattoir wastes and by-products. Land-application of industrial wastes accounts for <1% of the N applied from fertilizers and farm waste while P accounts for 1-5% (EU, 2001).

Finland (EU, 2001): Land-application activities are licensed. If the quantities of waste recycled to land is <500 t, then a permit for land-application is issued by the local municipalities otherwise by the regional council. The MOE controls and supervises the implementation of waste legislation. There is no specific regulation specifying quality requirements for waste land-application. Composted organic waste used as soil improver is controlled by Fertilizer Act 232/1993.

France (EU, 2001): The decree of 1998 01 08 specifies the technical regulations governing the sludge application on land under the provision of decree No. 97-1133, issued on 1997 12 08, related to the distribution of the sludge produced by wastewater treatment. The sanitized sludge is the sludge that has been treated so that pathogens are no longer detectable (*Salmonella* < 8 most probable number (MPN)/10 g ds) . Industrial waste is applied to land by authorized professional contractors who are required to have a written agreement from the farmer owning the land. The cost of wastes land-application depends on (i) length of haul of wastes, (ii) waste liming, (iii) importance of the considered deposits, and (iv) nuisances caused by land-application. Thus, the cost of land-application of industrial effluent is Euro 1 to 4 per m^3 and of sludge is Euro 15-23/t. In future, a tax

will be paid by the farmer that will be proportional to the farm size and to a residual pollution level based on nitrogen. In the abattoir and rendering industry, there are a few on-site effluent treatment facilities. Often some pre-treatment (sieving, straining and degreasing) is conducted. Many abattoirs dispose the effluent to communal sewer system. Abattoirs processing beef only produce manure waste. The solid manure amount is decreasing in comparison to liquid manure. Stomach contents are generally land-spread. About 3% of this goes to abattoir effluent. Meat industry sludge generally contains high levels of organic and nitrogen-bearing materials. Blood is the worst source of pollution.

Germany (EU, 2001): Priority is being placed on more and better advisory bodies to assist farmers concerning current practices.

Ireland (EU, 2001): A waste license is not required for the recovery of sludge from blood of animal or poultry origin. Waste application is only permitted on land with phosphorous level of ≤15 mg/L of waste. An application agreement is needed between the industry and land-owner. Waste application rate to the land is determined by: (i) P requirement of the crop, (ii) permissible rate of the N under the Nitrates Directive (250 kg N/ha), and (iii) a maximum hydraulic loading of 23 m^3/ha on limestone soils or 50 m^3/ha on other soils. Waste treatment process includes biogas generation, composting, and waste fired power stations.

Italy (EU, 2001): Industrial waste can be recycled to land according to Fertilizer Act requirements. Land for waste application is classified based on geology, soil characteristics and water pollution risk. Abattoir wastes are recycled to land without or with treatment by the fertilizer industry (about 20%), rest of the wastes is reused in other industries mainly the feed industry. Sludge is generally spread on land, and some is composted before application on land.

Spain (EU, 2001): Waste characteristics must demonstrate its agronomic benefit and innocuous nature. Heavy metals, pH, dry solids, organic matter, conductivity, N, P, K, Ca, and Fe are checked. Soil of the application site must be analyzed, and an application program is required. Destination and monitoring sheets are also required.

Macro law: The waste management organizations handling the recycling must be authorized and registered. Each region in Spain controls the granting of such authorizations. Control is strict in some regions and lacking in others.

Sweden (EU, 2001): There is no central governing body to regulate land-application of waste. Voluntary regulatory and quality certification scheme initiated since 2003. Untreated organic waste is no longer applied to land due to the opposition of public, farmers and dairy industry. Waste is treated in anaerobic digesters or composting plants before applying to land.

UK (EU, 2001): Abattoir wastes, particularly blood can (i) contain beneficial levels of nutrients such as nitrogen, (ii) have high conductivity and fat content, and (iii) be potentially odorous. Exempted wastes are blood and gut contents. Dissolved air flotation (DAF) treatment has been used to separate solids from liquid waste materials.

Except for land-application of sewage sludge, there is no regulatory requirement or control on the waste or soil quality. Mostly contractors are applying industrial wastes to land. However, there is no specific minimum standard for waste storage. Certain wastes for land-application are exempted from licensing such as blood and gut contents from abattoirs. For this, contractors have to inform regulatory agencies of the type and maximum quantity of waste, and location of land-application. The land-application must be beneficial for agriculture or ecological improvements. Maximum of 250 t/ha/yr can be spread on the land. Strict procedures are now implemented at abattoirs and renders for the purposes of removing, separate disposal, carcass components which might contain Bovine *Spongiform encephalopathy* (BSE) prions (EU, 2001).

Three weeks notification will be required by the agency before the land-application takes place. Secure and appropriate methods and location of waste storage should be used prior to application. Agency is concerned about the presence of blood and gut contents in abattoir wastes due to the risk of transmitting pathogens into the food chain. The Agency has recommended that exempt list should include only treated abattoir wastes (EU, 2001).

Portugal (EU, 2001)**:** No specific regulation exists.

Greece (EU, 2001): No specific legislation exists to the recycling of organic wastes.

Maximum quantities of biosolids land-application have been set from 1 t by Netherlands for grasslands to 10 t by Denmark per ha per year. The opinion on biosolids recycling and disposal varies in intensity and resolution throughout the EC. Almost all application of biosolids on agricultural land has been prevented by regulations in the Netherlands and Flanders regions of Belgium since 1991 and 1999, respectively. In Germany, public opinion is in favor of agricultural land-application. The farmers are generally against the land-application of biosolids in Finland and Luxembourg. The Swedish Federation of Farmers has recommended against the land-application of biosolids because of quality concerns. Similarly, farmers unions in Austria, France, and the Walloon region of Belgium have asked for a ban on biosolids because current methods of land-application of biosolids are not addressing the perceived risks. New regulations, in Denmark and UK, will be strict to reduce risks to an acceptable level and providing for additional restrictions on the land-application of biosolids. Farmers have supported the agricultural land-application of biosolids in Ireland and Portugal for economic and agronomic reasons (EU, 2001).

5. REGULATIONS RELATED TO NITROGEN AND PHOSPHORUS

In most of cases, the application rate of biosolids for nitrogen (N) and phosphorus (P) on land is determined from agronomic rate, i.e. the amount required by a crop for required yield. Some countries have placed additional guidelines. In Ontario, Canada, the maximum rate for N is 135 kg N per ha over a 5 year period (Anon., 1998). For P, the acid soluble P content of biosolids must be determined (OMAF, 1996). About 40% of the applied P is available to plants. Quebec (MENV, 2002) and the USA (40CFR503, US-EPA, 2002), the biosolids application rate should be ≥ the amount of N required by a crop. EPA is silent about how to take other N source into account. However, in WI and Quebec, all sources of N (manure and mineral fertilizer) should be taken into account when calculating biosolids application rate. In MN, the maximum N application rate is based on realistic yield goals, soil organic matter content, and previously grown crops. In MI and IL, P application is based on agronomic rate.

The application of manure in European countries varies from >200 kg N/ha and >100 kg P/ha in the Netherlands to <40 kg N/ha and <20 kg P/ha in southern Europe (EU, 2001). In Denmark, the maximum quantity of N and P recycled to land from land-application of biosolids is 170 kg N/ha/yr and 30 kg P/ha/yr, respectively. In France, N application from biosolids is limited to 350 kg/ha on grassland and 200 kg/ha on other arable land. In Ireland and UK, the waste application rate is determined by maximum application of 250 kg N/ha and P is based on requirement of the crop to which it is applied. However, in UK, the N limit is lowered to 170 kg/ha in nitrate vulnerable zones set up by the government.

6. REGULATIONS RELATED TO PATHOGENS

Pathogens (P-criteria): Criteria developed in the US for municipal biosolids are used in Quebec (MENV, 2002). In USA, current federal environment regulations do not consider pathogen from animal manure directly. Although the Clean Water Act (40CFR122) covers pollutants from point sources, especially concentrated feed lots, under the national pollutant discharge elimination system (NPDES) permit program (US-EPA, 2003). Although the regulations applicable to manure are those applicable for nutrients; pathogens have recently become an issue since several disease outbreaks have been traced to livestock. Pathogens involved in this are: *E. coli* O157:H7, *Salmonella* species, *Listeria monocytogenes*, *Mycobacterium paratuberculosis,* etc. There are no regulations related to pathogen content of soil, although human sewage sludge must be treated to reduce the pathogen content prior to use on fields (Clean Water Act 40CFR503). In Canada, packaged manures must not be detrimental to plants, animals or public health (OMAF, 1996).

Part 503 rule (US-EPA, 2003) indicates that public risk is reduced by a combination of treatment to

reduce pathogen levels and good management practices to minimize the potential for exposure to pathogens. Options to restrict potential movement of pathogens include the use of appropriate buffers or filter strips, divert storm-water, the use of storage pads or lagoons, enclosure of long term storage, restriction of public access to field storage sites, and isolating runoff from fruit or vegetable crops.

Tables 10 to 12 provide regulations related to acceptable pathogens levels in biosolids and wastewater for land-application. Limited data are available on pathogen content of abattoir wastes

Table 10. Biosolids jurisdictional scan B pathogens general quality in Canada and the USA (adapted from OMAF, 2002)

	Faecal coliform	Treatment methods	Field management practices
Ontario			Yes
BC	<2 million MPN/g	Same as US-EPA	Yes
Quebec C1	<2 million MPN/g	P2:Liming; faecal coliform <2 M/g + aerobic biological treatment; US-EPA class B; faecal coliform <2 M/g + *Salmonella* <3; P3: faecal coliform <2 M/g + biological treatment >20 h	Yes
Quebec C2	<2 million MPN/g	P2:Liming; faecal coliform < 2 M/g + aerobic biological treatment; US-EPA class B; faecal coliform <2 M/g + *Salmonella* <3; P3: faecal coliform<2 M/g + biological treatment >20 h	Yes
US-EPA*	<2 million MPN/g	3 alternatives plus 5 processes to significantly reduce pathogens	--

Pathogens Higher Quality

	Salmonella	Faecal coliform	Treatment methods
Ontario			Must be stabilized.
Alberta			Digestion and wastewater lagoon.
BC		<1000 MPN/g	Same as US-EPA
Quebec C1	P1:<3 MPN/4 g	P1:<1000 MPN/g	P1: must also meet drying at 80^{o}C and dryness >90%; or same as US-EPA
Quebec C2	P1:<3 MPN/4 g	P1:<1000 MPN/g	P1: must also meet drying at 80^{o}C and dryness >90%; or same as US-EPA
USEPA*	<3MPN/4 g	<1000 MPN/g	6 alternatives plus 5 processes to significantly reduce pathogens

* same for MI, MN, NJ, OH, OR, NY and PA states; MPN = most probable number

Table 11. European limit values for pathogens concentrations in biosolids (compiled from NRC, 2002, EU, 2001)

Country	Pathogen limit	Other microbes
France	8 MPN/10 g of ds	Enterovirus: 3 MPCN/10 g of ds Helminths eggs: 3/10 g of ds
Italy	1000 MPN/g of ds	
Luxembourg		Enterobacteria: 100/g No egg of worm likely to be contagious
Poland	Biosolids cannot be used in agriculture if it contains *Salmonella*	Parasites: 10/kg of ds

ds = dry solids; MPN = most probable number; MPCN = most probable cytophatic number.

Table 12. Threshold values for pathogens in abattoir wastes for land-application (adapted from EU, 2001)

Country/Region	*Salmonella*	Faecal *Streptococci*	Total *Enterobacteria*	*E. coli*
Spain	None in 25 g of treated waste	1000 MPN/g	1000 cfu/g	<1000 MPN/g of treated waste
Sweden	None in 5 samples of 25 g	--	≤10/g in 3 of 5 samples; 10-300/g in 2 of 5 samples	--
Quebec-P1,P2 fertilizer use, compost.	<3 MPN/4 g ds.	<1000 MPN/g ds faecal coliforms.	--	--
Quebec-P3 fertilizer use	--	$<2x10^6$ MPN/g ds faecal	--	--

coliforms

MPN = most probable number, cfu = colony forming units

(Mittal, 2004). Sludge age is not sufficiently correlated with pathogen reduction (MENV, 2002). Meat plant wastewater might acquire pathogens naturally from the hides and digestive tracts of the slaughtered animals. *Campylobacter jejuni* are found in the gastro-intestinal tracts of healthy cattle, sheep, pig, chickens and turkeys. *Listeria monocytogenes* are found in the intestinal tracts of sheep, cattle, pigs and chickens. *E. coli* O157:H7 is shed in the feces of cattle. Thus, land-application of biosolids must meet pathogen reduction criteria for either class A or class B according to part 503 rules (US-EPA, 2000b). Pathogen standards are not risk based concentration limits for individual pathogens, but at reducing the pathogens presence by treatment or a combination of treatment and use restrictions. In the USA, for class A sludge, the pathogens must be reduced to below detectable levels, and for class B, pathogens are adequately reduced in density as faecal coliform density of $2x10^6$ MPN/g ds (US-EPA, 2000b).

Class A (US-EPA 2000b): These biosolids are treated to further reduce pathogens using processes such as advanced alkaline treatment, composting, drying, heat treatment, pasteurization to meet the pathogen density limits in part 503, so that biosolids will not pose a risk of infections disease transmission through contact.

EQ (Exceptional Quality): Class A biosolids, satisfying one of part 503 VAR options 1-8 (Table 8) and meet the metals limits (US-EPA, 2003), are EQ class. These have no site restrictions, and may be generally marketed and distributed.

Class B (US-EPA, 2000b): These biosolids are treated to significantly reduce pathogens using processes such as aerobic digestion, anaerobic digestion, air drying, and lime stabilization. Class B biosolids contain some pathogens but at significantly reduce level. Due to this, site and crop harvesting restrictions are implemented for public health protection.

According to US-EPA (2000b) (EPA / 832-B-00-007), the treated sludge quality is based on the risk to human, animal and plant life. The pathogens level in the waste should not exceed the ambient levels in the environment. It is recommended that *E. coli* population should be < 1000/g ds, and tentatively spores of *C. perfringens* should be < 3000/g ds.

For new plants and treatment processes: At least 4 log reductions of added *Salmonella* and the viability inactivation of *Ascaris ova* are recommended for treating sewage sludge or animal wastes by advanced processes. Conventional treatment processes should demonstrate at least 2 log reductions in pathogen population based on *E. coli* (US-EPA, 2000b).

According to EU guidelines, abattoir wastes can pose environmental concerns by *Salmonella* and other zoonotic pathogens. *Cryptosporidum parum* may occur in gut contents. Wastes containing animal fats should be incorporated into the soil. Due to the problems of odor and environmental

concerns, it is better to treat wastes before land-application by a stabilization process. To avoid further development of odors, the wastes should be stored for minimum time (US-EPA, 2000b).

The European Commission conducted a study (EU, 2001) on proposed pathogen treatments for numerous sludges that would render them suitable for unrestricted use. These sludges are treated such that the levels of pathogens in material applied to land do not exceed the levels already in the environment. This study looked at treatment needs to produce pathogen-free sludges, as the DG Environment Waste Management Unit is considering revisions to the Directive relating to the land-application of sludges (EC, 1986), and pathogen reduction treatments and related limits. Sludges, in this study, included those from abattoirs and related establishments (which generate material from slaughter and initial dressing of carcasses), and from butchery activities (that reduce carcasses to manageable pieces). The study indicates that there is little published evidence relating to the range and concentrations of pathogens in abattoir sludges. Two key conclusions from this study are: (i) sludges that may contain BSE agent should not be applied to land where animals have direct access, and (ii) planting, grazing or harvesting constraints will have to be applied to land that has received meat processing sludge which has not been hygienized.

7. DISCUSSION

There are wide variations in limits for heavy metals allowed to be land-applied. For example, the limit of Cu and Zn in Quebec is 100-757 and 500-1850 mg/kg ds, while in the USA, EPA allowed these at the rate of 4300 and 7500 mg/kg ds, respectively (Table 6). In European countries, Cu limit is from 10-25 mg/kg ds in Latvia to 50-210 mg/kg ds in Spain, and Zn limit is 35-100 mg/kg ds in Latvia and 300 mg/kg ds in Estonia (Table 8). Similarly the pathogen limit in France is 8 MPN/10 g ds where in Italy this limit is 1000 MPN/g ds (Table 11). Thus it is difficult to compare the regulations of various countries. The limits for various heavy metals, toxic chemicals, pathogens, N and P are based on the types of biosolids from various industries, traditional use, soil type, crop type, nutrient and chemical profile of the soil, danger of chemicals flowing to river or lakes through runoff, ground water contamination chances, public opinion and pressure, etc. There is no uniform standard or regulation even in Europe. The data collected in this review will assist in developing a uniform regulation for various countries. Environmental protection initiatives worldwide will also assist in developing such regulation. Presently many States in the USA have prepared their own regulations where different limits for various contaminants have been set up compared to EPA guidelines (Table 6).

8. CONCLUSIONS

Specific information on the land-application of abattoir wastes is significantly limited. Generally existing biosolids legislations and guidelines are used which are not dealing specifically to abattoir

wastes. The application of abattoir wastes could be a potential source of bioaerosols. Studies are being conducted in different countries on the analysis of risks specific to pathogens from the abattoir wastes applied on the land. The current regulations and approaches of land-application of abattoir wastes are inadequate and inconsistent. These practices might pose a potential risk to the environment, plant, animal and public. Recording of nutrients inputs to the land is now being implemented in various countries. More research is required related to the pathogens content of wastes and changes in pathogen levels, and organic and inorganic contaminants in soil after repeated application of the wastes.

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