HYGIENIC ASPECTS OF BIOSOLIDS REUSE

J.[1] Venglovský, J.[2] Martinez

[1]University of Veterinary Medicine, Komenskeho 73, 040 01 Kosice, Slovak Republic. jan@venglovsky.com

[2]Cemagref Livestock and Municipal Wastes Management Research Unit, 17, avenue de Cucillé, 35044 Rennes Cedex France. jose.martinez@cemagref.fr

Land application of biosolids provides agricultural benefits and presents a cost-effective method of sludge disposal following wastewater treatment. However, reuse of this product causes health concerns that must be addressed and satisfied before land application is an accepted practice. Health concerns include pathogen transmission to food or agricultural workers, contamination of ground water or surface water with faecal material from field run-off, and build-up of heavy metals or organic contaminants. However, manures can contain pathogenic microorganisms which creates the potential for the spread of zoonoses from the farm environment into the food chain or aqueous environment. There is little quantitative information on the fate of manure pathogens during storage and following land application. This makes it difficult to assess whether current manure management guidelines, which are largely focused on reducing nutrient pollution, are appropriate for controlling the risks to food safety and water quality.

Concern has greatly increased about the potential for contamination of water, food, and air by pathogens present in manure, byproducts, and bioaerosols. Effective sanitation of the environment, particularly of some of its special parts, which can be a source of spreading of diseases, plays an important role in prevention of infectious diseases. In this respect special attention should be paid to the disinfection of infected farm animal excrements. Sanitation of excrements should, on the one hand , ensure effective devitalization of infectious agents and, on the other hand, comply with the requirement of preserving the composition of the manure so it can be used in agricultural production.

Pathogenic microorganisms and helminth eggs cannot be detected simply by our senses, however, their presence in the environment presents serious risk to the health of man and animals (Juriš et al., 1989, 1991; Holoda, 1998). From this point of view, excrements of sick animals can be considered important contaminants of the environment. Survival and transport of pathogens from manure to the environment depend on a number of complex phenomena.

Chemical and microbiological changes in the composted substrate are accompanied by an increase in temperature which plays an essential role in ensuring the devitalization of pathogenic germs. Different data were presented about the causative agents of some diseases, such as mycobacteria, with regard to their survival during composting. High resistance of mycobacteria in the outer environment has been observed by Švrcek et al. (1998) who reported that they survive in infected manure for 240 days.

Biowaste is known to contain pathogenic bacteria such as Salmonella and other microorganisms that may be a health risk for both people and animals. The biosecurity risk associated with using digested residues as fertiliser is hard to assess but this risk can not be neglected.

In recent years the fate of human and veterinary therapeutic agents as a potential pollutant of the environment has been paid increased attention. Substantial quantities of these compounds and their metabolites are excreted, flushed down the drain, discarded as waste, or left over in animal feedlots. When they enter the sewer, several of these compounds are not adequately eliminated by the methods that are currently used in sewage treatment. Substantial quantities of biosolids and livestock manure end up on agricultural land.

Four major types of human pathogens can be found in biosolids: bacteria, viruses, protozoa, and helminths. Böhm and co-workers (1999) examined a wide variety of manures, food-processing residues and household wastes for the presence of pathogenic bacteria, fungi and viruses.

The quality of treated sludge should be defined on the basis of risk to human, animal and plant life. The levels of pathogens in the treated sludge should not exceed their ambient levels in the environment. In practice this means that for the purposes of quality control realistic limits of defined pathogens must be set and well-established standard procedures have to be followed.

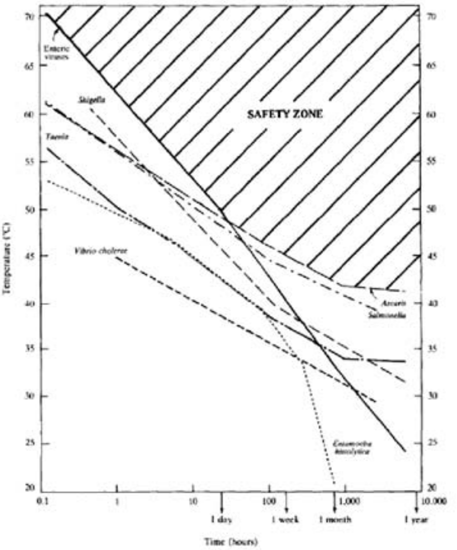
From the variety of bacterial pathogens *Salmonella spp.* are the most relevant since they can infect or contaminate nearly all living vectors from insects to mammals. Multiresistant bacteria are coming more and more into focus since their transmission via environment as well as the introduction of resistance genes into other bacteria may cause tremendous problems in human and veterinary medicine. From the viewpoint of environmental risks viral pathogens such as enteroviruses and rotavirus are the most relevant ones (Metzler et al., 1996). Special attention must be paid to the parasitic pathogens, not only to eggs of round- and tapeworms but to Giardia lamblia and especially Cryptosporidia parvum too, since the latter sometimes occurs in slurry from calves and cattle used in co-digestion. Nearly all gut related pathogens can be found in slaughterhouse effluents. If sludges are of plant origin or if they had been processed by using plant material, they may contain plant-pathogenic viruses, fungi, bacteria, parasites and undesired weeds. This will cause an additional phytohygienic risk if the final product is to be used in agriculture as fertilizer (Böhn 1999 a, b).

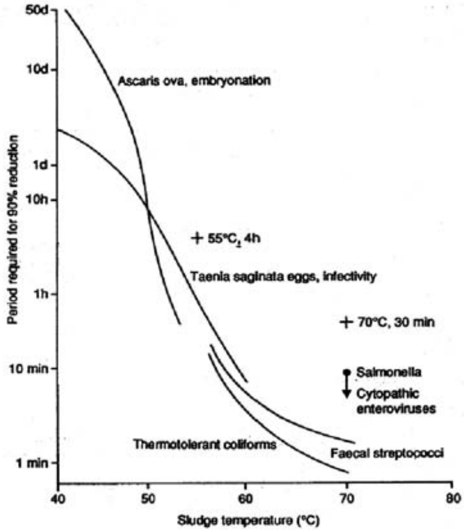
Recycling to agricultural land is an important outlet for sewage sludge and other organic wastes but it must be controlled in order to obtain agricultural benefit from the operation whilst protecting human and animal health and the environment at large. Current practices in Europe are based on the requirements of the 1986 Directive on the use of sewage sludge in agriculture (86/278/EEC). However, since that time new technologies have become available for sludge treatment, more pathogens associated with the food chain have been identified and the concerns of the public relating to acceptable risk have changed.

A wide range of phyla, genera and species are likely to be present in sludges, particularly those that contain large amounts of faecal material. The identity and numbers of pathogens in municipal wastes will be dependent upon the health of the contributing population. According to Davis et al. (2002) *E. coli* counts in treated sewage sludge or sludge from meat processing waste released for land use should not exceed 1000 per gram (dry weight) whereas those of *C. perfingens* spores 3000 per gram (dry weight). A 4 $\log_{10}$ reduction in numbers of added *Salmonella* should be achieved, and *Ascaris* ova should be rendered non-viable.

Of course there are some constraints on the reuse of sludges in agriculture. For example those that may contain the BSE agent should not be applied to land where animals have direct access whereas sludges from paper, vegetable and tannery waste should present no risk after mesophilic digestion or a similar treatment standard. According to Rapp (1995) total bacterial counts as well as the numbers of Enterobacteriaceae, *E.coli* and faecal streptococci remained nearly unaffected under practical conditions (farm storage tanks), and even increased during storage for up to 185 days. The numbers (cfu) of *Salmonellae* in slurry exposed to the slurry in semi-permeable membranes were reduced by more than 10^5. *Yersinia enterocolitica* was completely inactivated within only a few days whereas the eggs of *Ascaris suum* as well as the oocysts of *Cryptosporidium parvum* also lost their viability, although very slowly.

The study by Findlay (1972) showed that *Salmonella dublin* in cattle slurry survived storage for between 19 and 33 weeks. Similarly Larsen and Munch (1986) found that *Salmonella typhimurium* survived in pig and cattle slurry stored at 8^oC for more than 10 weeks with only a small decrease in numbers (from 10^6 to 10^4/ml). *Yersinia enterocolitica* was eradicated by week 6 while *Staphylococcus aureus* was reduced from 10^6 to 10^2/ml in 9 weeks. In the solid fraction of pig slurry, *Salmonella typhimurium* survived for 26 days in summer and 85 days in winter (Placha et al., 2001), and coliforms were reduced by 90% in 35 and 233 days during the summer and winter time, respectively. *Cryptosporidium parvum* oocysts required more than 90 days to become non-viable in cattle slurry stored at 4°C while at 15 and 20°C they were nearly all killed in 30 and 20 days, respectively (Svoboda et al., 1997). In the farmyard, manure stored at temperatures of 4 and 15°C, 30% and 8% of oocysts, respectively, survived longer than 90 days. When composting was encouraged and temperatures in excess of 30°C were achieved, there was no survival of oocysts after 35 days.





The two figures above express the effects of temperature and time on some species of microorganisms. In Figure 1 the *Safety Zone* is the area of the graph where pathogens would not survive, or the sludge would be virtually pathogen free due to a combination of time and temperature. Practical studies indicate that sludge should be held for four hours at 55°C (Fig. 2) or 30 minutes at 70°C to kill at least 99.99% of pathogens (Carrington et al., 1998).

Concluding it can be said that with view to the threats not only of diseases virtually or potentially transmissible to animals and man but also with view to the threats of global terrorism the hygienic aspects of the production and reuse of biosolids are of utmost importance. They present a challenge that requires further sound research and surely also global cooperation and even coordination.

REFERENCES

Böhm, R. 1999 b: Die Bedeutung hygienischer Belange für die Qualität von Produkten der aeroben und anaeroben Bioabfallbehandlung. In: Th. Eikmann, R. Hofmann. Stand von Wissenschaft, Forschung und Technik zu siedlungshygienischen Aspekten der Abfallentsorgung und -verwertung, Schriftenreihe des Vereins für Wasser-, Boden - und Lufthygiene 104, pp. 3-25.

Böhm, R., Martens, W., Philipp, W. 1999. Regulations in Germany and results of investigations concerning hygienic safety of processing biowastes in biogas plants. In: *Proceedings of the IEA workshop:*

"Hygienic and environmental aspects of anaerobic digestion: legislation and experiences in Europe." Universität Hohenheim, Stuttgart, Germany. pp. 48-61.

Böhm. R. 1999 a: Hygienic requirements in aerobic and anaerobic treatment of biological wastes. In: J. Martinez and M. N. Mauded (eds) *Proceedings of the 8th International Conference on the FAO ESCORENA Network on recycling of agricultural, municipal and industrial residues in agriculture (formerly animal waste management)*. Rennes, France, 26-29 May 1998 Ramiran 98, FAO and CEMA-GREF, Vol 2, pp. 371 – 378.

Böhm. R. 2002. Hygienic Safety In Organic Waste Management. In: J. Venglovsky, G. Greserova. (eds.) *Proceedings of 10th International Conference of the European Research Network on Recycling of Agricultural, Municipal and Industrial Residues in Agriculture "RAMIRAN 2002"*, May 14-18, Strbske Pleso, Slovak Republic, pp. 17 - 30.

Davis et al., 2002. Evaluation of Treatment Processes for the Control of Pathogens in Organic Wastes. J. Venglovsky, G. Greserova. (eds.). *Proceedings of 10th International Conference of the European Research Network on Recycling of Agricultural, Municipal and Industrial Residues in Agriculture "RAMIRAN 2002"*, May 14-18, Strbske Pleso, Slovak Republic, pp. 37 - 40.

Feachem, R.G., D.J. Bradley, H. Garelick, D.D. Mara. 1983. Sanitation and disease: Health aspects of excreta and wastewater management, John Wiley and Sons, New York. p. 501.

Findlay CR (1972). The persistence of Salmonella dublin in slurry in tanks and on pasture. The Veterinary Record, Sep., 2: 233-235.

Holoda E., Mikula I. 1998. Comparison of DNA of some Salmonella strains by the PEGE_method (In Slovak). In : Hygienical and ecological problems in relation to veterinary medicine. Copycenter spol. s.r.o, pp. 335-337. Venglovský, J. (ed.).

Juriš P., Breza M., Schmidtová D., Venglovský J. 1991. Dissemination and survival of endoparasitic germs in the environment (In Slovak). Vet. Med. (Czech), 36: 665-671.

Juriš P., Venglovský J. 1989. Disinfectation of the environment in intensive animal production (In Slovak). Veterinárství, 39: 123-124

Larsen, H.E., Munch, B. 1986. Pathogenic bacteria in extra-animal environments. Occurrence, survival, and hygienic significance with special reference to farm animal waste management. Danish J. Agronomy, Special Issue, March, 57-66.

Metzler, A., Regli, W., Leisinger, M., Heider, H., Schweizer, K., Tabisch, A. 1996. Viren und Parasiten im Trinkwasser: Risiken und Prävention. Mitt. Gebiete Lebensm. Hyg., 87: 55-72.

Novák P. 1994. Dynamics of indicator microorganisms in the course of composting of agricultural wastes (In Czech). In : *Proc. of int. conf. "Ecology and Veterinary Medicine"*, Košice, pp. 69-72

Philipp W., Roth S. 1994. Microbial content of biowaste and compost. *Proc. 8 th. Inter. Cong., Animal Hygiene*, St. Paul, Minesota, USA, pp. 36-40

Pike, E.B., Carrington, E.G. 1986. Stabilization of sludge by conventional and novel processes - a healthy future. In: *Proceedings of symposium: The agricultural use of sewage sludge - Is there a future?* Doncaster. The Institute of Water Pollution Control, Maidston, pp. 1-43.

Placha, I., Venglovsky, J., Sasakova, N., Svoboda, I.F. 2001. The effect of summer and winter season on the survival of Salmonella typhimurium and indicator microorganisms during the storage of solid fraction of pig slurry. J. Appl. Microbiol., 91: 1-8.

Rapp, A. 1995. Hygienisch- mikrobiologische Untersuchungen zum Verhalten von ausgewählten Bakterien und Viren während der längerfristigen Speicherung von Flüssigmist in Güllegemeinschaftsanlagen. Dissertation an der Uni Hohenheim.

Strauch, D. 1991. Microbiological treatment of municipal sewage waste and reuse as a means of disinfection prior to recycling in agriculture. Studies Environ. Sci., 42: 121-136.

Strauch, D. 1998. Pathogenic micro-organisms in sludge. Anaerobic digestion and disinfection methods to make sludge usable as a fertiliser. Eur. Water Manag., 1: 12-26.

Strauch, D. 1994. Composting of source separated waste to prevent spread of salmonella. German regulations. *Proc. 8 th. Inter. Cong., Animal Hygiene*, St. Paul, Minesota, USA, pp. 21-23