HELMINTHOLOGIA, 42, 3: 137 – 142, 2005

Parasitological and bacteriological risks to animal and human health arising from waste-water treatment plants

N. SASÁKOVÁ, P. JURIŠ[1], I. PAPAJOVÁ[1], M. VARGOVÁ, O. ONDRAŠOVIČOVÁ, M. ONDRAŠOVIČ, A. KAŠKOVÁ, E. SZABOVÁ[1]

University of Veterinary Medicine, Komenského 73, 041 81 Košice; [1]Parasitological Institute of the Slovak Academy of Sciences, Hlinkova 3, 040 01 Košice; E-mail: *nada.sasakova@post.sk*

Summary

Investigations were carried out to evaluate the risk arising from the presence of parasites and bacterial pathogens in sewage sludge and products of aerobic treatment of pig slurry and municipal sewage (WWTP-1 and WWTP-2) with regard to the recipient of the effluent and application of the treated solid wastes to agricultural land. In addition to that, dewatered municipal sludge was treated with quick lime, powdered zeolite and zeolite with lime (3 % by weight each) and observed for 42 days of storage. Parasitological examination showed that no helminth eggs were found in effluents from both plants. The solid fraction from WWTP-1 contained eggs of *Ascaris suum* (12 – 35 eggs. 100 g^{-1}), *Oesophagostomum* spp. (2 – 6 eggs.100 g^{-1}), *Trichuris* spp. (1 – 2 eggs.100 g^{-1}) and *Eimeria* spp. (2 – 12 oocysts.100 g^{-1}). Of 40 samples of sludge from WWTP-2 only two were positive for *Ascaris* spp. and *Trichuris* spp. eggs. Mean efficiency of removal of selected groups of bacteria (mesophilic, coliform, faecal coliform) ranged between 86.5 % (coliforms) and 95.7 % (mesophiles) in WWTP-1 and between 79.8 % (faecal coliforms) and 97.9 % (mesophiles) in WWTP-2. The plate counts decreased mostly by 2 orders except for faecal coliforms in WWTP-2 where faecal coliforms decreased in most cases only by 1 order. Treatment of municipal sludge with lime and lime and zeolite increased pH to 11.8 – 11.9 but only for up to about 12 days. During this period, no coliform or faecal coliform bacteria were detected in sludge and faecal streptococci were lower by two orders. No viable helminth eggs were recovered from samples after 42-day storage.

Key words: helminth eggs; bakteria; waste-water treatment plant; pig slurry solids; municipal pre-treated sludge; quick lime, zeolite

Introduction

Recycling of organic material to agriculture is a desirable aim from the point of view of saving raw materials of limited availability such as phosphorus, but this aim may conflict with both the general aims of environmental protection and the necessity to protect humans, animals and plants from undesired infections (Begon *et al.*, 1997; Valocká *et al.*, 2000; Papajová *et al.*, 2002; Sturhan & Lišková, 2004).

It has been common practice for thousands of years to dispose of human excreta on land. Problems presented by such disposal have been exacerbated recently by the intensification of agriculture, the growth of the human and farm animal population, and the cost of artificial fertilisers which renders materials such as sewage sludge, previously regarded as waste, a valuable commodity.

If diseases are to be spread by raw and processed wastes, the material must become infected with the causative organisms, which must survive treatment or storage, remain capable of causing disease and survive in the material until a human or animal host is encountered. The type of pathogens most commonly found in sewage and sewage sludge depends on the state of health of the population, as well as the presence of hospitals, meat processing plants and abbatoirs in the area (Bruce & Davis, 1983). Sewage sludge may contain a large variety of bacterial and viral pathogens including *Salmonella* sp., *Shigella* sp., *Yersinia* sp., and enteroviruses as well as eggs of parasites such as *Ascaris lumbricoides* and oocysts *Cryptosporidium* spp. and *Giardia* spp. (Reddy *et al.*, 1981; Straub *et al.*, 1993, 1994). Competition and depletion of nutrients combined with increased temperatures and other factors during processing of sludges results in inactivation and destruction of pathogens (Plachý *et al.*, 1997).

Pig excrements frequently contain bacteria of the family Enterobacteriaceae, most of which are of zoonotic character. Bacteria such as *Salmonella* sp., *Escherichia coli*, *Mycobacterium* sp., *Enterococcus* sp., *Streptococcus* sp., *Staphylococcus* sp. pose a potential threat to animal and hu-

man health. In addition to that protozoa (*Isospora* spp., *Balantidium coli*) and eggs or larvae of enteronematodes (*Ascaris suum*, *Oesophagostomum* spp., *Trichuris suis*) are also found in pig faeces. *Ascaris* eggs and coccidial oocysts are hygienically the most hazardous, primarily for their high resistance in the environment (Novák *et al.*, 1998; Krupicer *et al.*, 2000).

The aim of our study was to investigate the parasitological and bacteriological risk arising from sewage sludge and products of aerobic treatment of pig slurry and municipal sewage with regard to the recipient of the effluent and application of wastes to agricultural land with or without additional treatment with quick lime and zeolite.

Material and Methods

The first part of our study was carried out during one year on samples from waste-water treatment plant (WWTP-1) treating approx. 500 $m^3.d^{-1}$ of pig slurry and 320 $m^3.d^{-1}$ of village sewage. In the plant, the solid part is separated on vibrating sieves before biological treatment and is stabilised later by simple storage for different period of time before application to soil. Samples for chemical and bacteriological examination were taken in monthly intervals. Parasite eggs and oocysts were determined in individual stages of the treatment (influent, effluent, solid fraction).

In the second part, investigations were carried out in a waste-water treatment plant (WWTP-2) treating 1300 $l.s^{-1}$ of municipal waste-water. The biological stage in this plant is aerobic and the sewage sludge produced is subjected to anaerobic and aerobic treatment before its dewatering and disposal. Samples for chemical and bacteriological examination were taken in monthly intervals for one year and parasitological examinations for the presence of helminth eggs and oocysts was performed twice during this period.

In the third part, the treated and dewatered sludge was collected and its stabilisation was examined under laboratory conditions after adding quick lime, powdered zeolite and zeolite with lime (3 % by weight each) during 42 days of storage. The results were compared with unamended sludge stored under identical conditions. Commercially available lime (CaO, Carmeuse, Slovakia) was used for this purpose and the powdered zeolite (main fraction 0.125 – 0.250 mm) originated from the Slovak deposit in Nižný Hrabovec and contained 42 – 56 % clinoptilolite.

Of chemical parameters determined in the study we include only pH as one of the most important factors affecting survival of micro-organisms. Additional results of chemical examinations were reported elsewhere (Venglovský *et al.*, 2005).

Bacteriological examination consisted of determination of plate counts of mesophilic, coliform and faecal coliform bacteria (STN 83 0531-4 and STN-ISO 9308-2) on solid cultivation media (Endo agar, Imuna, Slovakia) and faecal streptococci in the municipal sludges (STN-EN ISO 7899-2) on Slanetz-Bartley agar (Biomark, India).

Parasitological examinations of solid samples was carried out by the method of Kazacos (1983). The helminth eggs from liquid samples (influent and effluent) were isolated by a sedimentation-floatation method of Cherepanov (1982), which is a modification of the method of Romanenko (1968) using saturated sacharose solution of specific gravity 1.30.

Results

The results of bacteriological and parasitological analysis of samples from WWTP-1 are presented in Tab. 1 and 2. Mean plate counts of mesophilic bacteria ranged between 9.8 x 10^6 and 9.2 x 10^8 $CFU.ml^{-1}$, of coliform bacteria between 1.0x10^5 and 8.9 x 10^8 $CFU.ml^{-1}$ and of faecal coliform bacteria between 1.0 x 10^5 and 8.3 x 10^7 $CFU.ml^{-1}$. The numbers of selected groups of bacteria (mesophilic, coliform, faecal coliform) in the influent and effluent from WWTP-1 showed that mean efficiency of removal reached 95.7 % for mesophilic bacteria, 86.5 % for coliforms and

Table 1. Plate counts of selected groups of bacteria in the influent and effluent and the solid fraction from WWTP-1

	Influent ($CFU.ml^{-1}$)	Effluent ($CFU.ml^{-1}$)	Efficiency (%)	Solid fraction ($CFU.kg^{-1}$)
Mesophilic bacteria	9.8 x 10^6 – 9.2 x 10^8	5.2 x 10^4 – 1.2 x 10^7	95.7	3.1 x 10^7 – 3.8 x 10^9
Coliform bacteria	1.0 x 10^5 – 8.9 x 10^8	2.3 x 10^3 – 4.1 x 10^6	86.5	3.5 x 10^5 – 1.6 x 10^8
Faecal coliform bacteria	1.0 x 10^5 – 8.3 x 10^7	4.3 x 10^3 – 6.3 x 10^5	91.4	9.4 x 10^4 – 2.4 x 10^6

Table 2. Parasitological examination of samples from WWTP-1

	Influent (cggs.1000 ml^{-1})	Effluent (cggs.1000 ml^{-1})	Solid fraction (cggs.100g^{-1})
A. suum	28 – 29	0	12 – 35
Oesophagostomum spp.	5 – 19	0	2 – 6
Trichuris spp.	1 – 3	0	1 –2
Hymenolepis spp.	0 – 5	0	0
Isospora spp.	0 – 9*	0*	0*
Eimeria spp.	6 – 34*	0*	2 – 12*

* - oocysts

Table 3. Plate counts of selected groups of bacteria in the influent, effluent and sludge from WWTP-2

	Influent ($CFU.ml^{-1}$)	Effluent ($CFU.ml^{-1}$)	Efficiency (%)	Sludge ($CFU.ml^{-1}$)
Mesophilic bacteria	$1.4 \times 10^4 - 4.5 \times 10^5$	$1.0 \times 10^3 - 5.7 \times 10^4$	97.9	$1.5 \times 10^6 - 8.9 \times 10^7$
Coliform bacteria	$6.5 \times 10^4 - 3.3 \times 10^6$	$1.0 \times 10^2 - 4.4 \times 10^3$	96.6	$2.2.10^6 - 1.3 \times 10^8$
Faecal coliform bacteria	$4.1 \times 10^4 - 7.4 \times 10^5$	$1.1 \times 10^3 - 2.8 \times 10^5$	79.8	$8.6.10^5 - 9.4 \times 10^7$

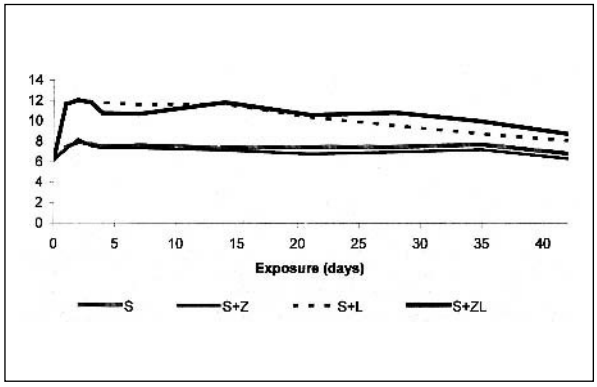

Fig 1. pH levels during 42-day storage of treated sludge (S – sludge; S+Z – sludge amended with zeolite; S+L – sludge amended with quick lime; S+ZL - sludge amended with zeolite and quick lime)

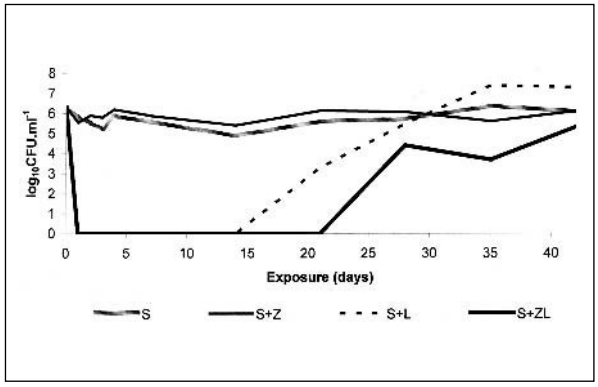

Fig 2. Plate counts of total coliform bacteria during 42-day storage of treated sludge (Legend: See Fig. 1)

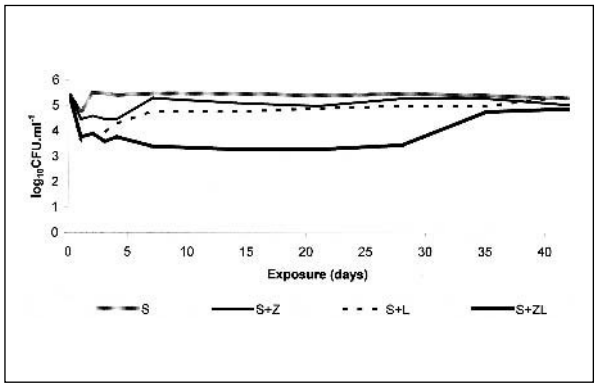

Fig 3. Plate counts of faecal coliform bacteria during 42-day storage of treated sludge (Legend: See Fig. 1)

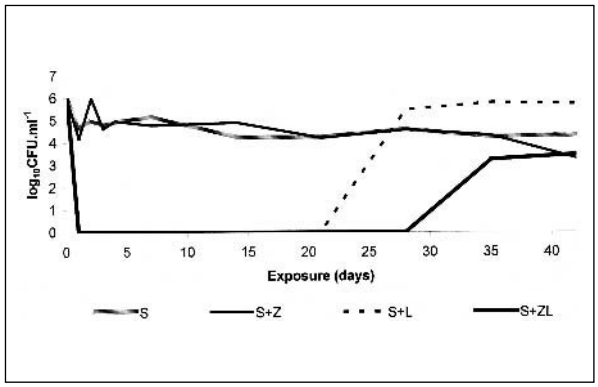

Fig 4. Plate counts of faecal streptococci during 42-day storage of treated sludge (Legend: See Fig. 1)

91.4 % for faecal coliform bacteria. This resulted from the decrease in plate counts by approximately two orders of magnitude in most samplings and corresponded to the technology used. Better efficiency was reached in the warmer period (May – October) as the flocculation of activated sludge may be supported by higher temperatures. The plate counts in the solid fraction ($9.4x10^4$ – $3.8.10^9$ $CFU.ml^{-1}$) indicate high population of this substrate with the bacteria of interest.

Parasitological examination show-ed that no helminth eggs were found in effluents from both plants despite their presence in the influent. The solid fraction from WWTP-1 contained eggs of *A. suum* (12 – 35 eggs. $100g^{-1}$), *Oesophagostomum* spp. (2 – 6 $eggs.100g^{-1}$), *Trichuris* spp. (1 – 2 $eggs.100g^{-1}$) and *Eimeria* spp. (2 – 12 $oocystes.100g^{-1}$). Neither *Hymenolepis* spp. nor *Isospora* spp. were recovered from the samples.

Bacteriological examination of samples from WWTP-2 provided results that differed from those of WWTP-1 (Tab. 3). The plate counts of investigated bacteria in the influent were lower due to considerable dilution of human faeces and other contaminated materials. Mean plate counts of mesophilic bacteria ranged between 1.4×10^4 and 4.5×10^5 $CFU.ml^{-1}$, of coliform bacteria between 6.5×10^4 and 3.3×10^6 $CFU.ml^{-1}$ and of faecal coliform bacteria between 4.1×10^4 and 7.4×10^5 $CFU.ml^{-1}$. The mean efficiency of remo-

val reached 97.9 % for mesophilic bacteria, 96.6 % for coliforms and 79.8 % for faecal coliform bacteria. The plate counts of mesophilic bacteria decreased mostly by 1 order while those of faecal coliforms decreased less and the efficiency of removal of these bacteria was the lowest. Better removal was observed with coliform bacteria (mostly by 3 orders of magnitute).

Samples of influent, effluent and activated sludge, taken on two occasions at WWTP-2 and examined for the presence of helminth eggs provided surprising results. None of the samples (n = 10) of influent, effluent and activated sludge allowed us to recover helminth eggs. One of the factors may be the considerable dilution of human faeces in these waste-waters. Out of 40 samples of sludge only two samples were positive, one contained one egg of *Ascaris* spp. and the other one egg of *Trichuris* spp. These were the samples of sludge which was subjected to laboratory experiments (treatment with quick lime, zeolite and combination of lime and zeolitu). No helminth eggs were detected in the sludge after 42 days of storage with the materials mentioned.

Results obtained in the third part of experiment, involving observation of the effect of lime and zeolite amendment, are shown in Fig. 1 – 4. The materials used affected most of the parameters determined including the chemical ones, particularly pH (Fig.1). pH values in substrates amended with lime and lime with zeolite increased to 11.8 – 11.9 but only for up to about 12 days when they began to decrease as the storage processed. The final values ranged between 8.1 and 8.8 compared to the control (6.8) and substrate amended with zeolite (6.4). During the period of low pH, the neither total coliform nor faecal coliform bacteria were recovered from the respective substrates up to days 14 – 21 (total coliform) and 21 – 27 (faecal coliforms) of the storage. After this period we detected them again and their plate counts gradually increased, in one case even above the original level (Fig. 2). Plate counts of faecal streptococci showed a decrease by about two orders for up to 27 days of storage only in the substrate amended with lime and zeolite (Fig. 4).

Discussion

Pathogens may survive for a remarkable period of time in excrements, sludges and the environment. This is the basis for the resulting epidemiological risk. The direct and indirect transmission of zoonotic agents to farm animals is generally regarded as the most relevant risk factor of agricultural utilization of untreated or insufficiently treated sludge and wastes of animal origin (Jurič *et al.*, 1992; Jurič *et al.*, 2000). Multiresistant bacteria are becoming increasingly important since their transmission via the environment as well as the introduction of resistance genes into other bacteria may cause tremendous problems in human and veterinary medicine (Tschäpe, 1996). Effluents from WWTP are discharged into surface waters where they increase the counts of coliform and faecal coliform bacteria and faecal streptococci. Evaluation of quality of our surface waters shows that particularly due to microbiological parameters many rivers belong to lower quality classes (SAŽP, 2004). The organisms used to monitor the effectiveness of sanitation treatment of organic wastes were *E. coli*, faecal streptococci and *Salmonella* sp. According to Hays *et al.* (1977) considerable number of bacteria and viruses entering the WWTP is devitalised by the treatment but endoparasite developmental stages may remain viable. With regard to their relatively high specific weight they tend to sediment and concentrate in the solid fraction together with undissolved substances and in this manner may be returned into the environment (Jones, 1980; U. S. Environmental Protection Agency, 1992). While the pathogenic viruses and bacteria may survive in the environment for hours or days, protozoan cysts remain viable for months and eggs of helminths even for years (Sorber & Moor, 1986; Sobsey & Shields, 1987) because of the presence of stabilising proteins, lipids and chitin in the wall of nematode eggs (Bruňanská, 1989; Eckert, 2000). In their fully-developed, second-stage larval form, eggs of *Ascaris* spp. are highly resistant and have been frequently used as indicator organisms for water and sewage treatment processes. They may also be an good indicator for the effectiveness of composting to reduce parasites (Mara & Cairncross, 1999; Mizgajska, 1993; Roepstorf & Murrel, 1997).

Our results showed that the efficiency of removal of selected groups of bacteria in both treatment plants corresponded to the technology used. In general, the plate counts decreased by one to two orders of magnitude. Better results were reached in the summer season which can be associated with better floculation of the activated sludge and therefore also higher entrapment of bacteria in the sludge flocs.

Results of parasitological analysis showed that eggs of several helminths were present in the influent to WWTP-1 while all effluent samples were negative. Examination of the solid fraction indicated that considerable number of them passed to the solid fraction and therefore this substrate requires further processing before application to agricultural land. This indicates that there is a need for additional treatment of this material especially because it is almost exclusively used for agricultural purposes. Composting may be recommended as a most suitable way of treatment as it inactivates most of the agents, provided that temperatures above 55°C are maintained for sufficient period of time. However, some authors reported that resistant organisms such as *Clostridium perfringens*, *C. botulinum* and the cysts and eggs of protozoan and helminth parasites may survive. There is also a danger that *E. coli* and *Salmonella* sp. may grow in the final compost if the process has been inefficient and the organic matter remains poorly stabilised. According to Day and Shaw (2000) the temperature of 55°C is sufficient to devitalise *A. lumbricoides* in 60 min and *Entamoeba histolytica* cysts in 1 sec. Thermophilic stabilisation (48.5°C) was sufficient to destroy eggs of *A. suum* in the study by Plachá and Venglovský (2002). Stern (1974) reported that *A. lumbricoides* eggs were devitalised in 60 min at 50°C and in 7 min at 55°C while devitalization

of *Taenia saginata* required 5 min at 70°C. Burge (1983) observed that 10-fold reduction in *Ascaris* spp. ova was reached within 1.3 min at 60°C. All the above data indicate that composting at temperatures above 55°C for at least 3 days should be sufficient to eliminate or at least minimise the problem.

The samples of influent and effluent from WWTP-2 were negative at helminthological examinations. Of the 40 samples of sludge from this plant only two were positive, namely those of the sludge which was subjected to liming and amendment by zeolite. Treatment of sewage sludge by lime was investigated by a number of authors also with regard to viability of *A. suum* eggs (Eriksen *et al.*, 1996; Bujoczek *et al.*, 2002; Capizzi-Banas *et al.*, 2004). Their inactivation was observed by all the mentioned authors and was associated also with increased pH. Our results showed that quick lime and lime with zeolite devitalised total and faecal coliforms but the effect was evident only for 14 – 21 days with total coliforms and 21 – 26 with faecal coliforms and after this plate counts started to increase gradually to the initial or even higher level. The biggest decrease (by about two orders) in faecal streptococci was observed after addition of lime and zeolite and persisted up to day 27 of storage. Helminth eggs were not recovered from the samples after 42-day storage. The pH in the sludge amended with lime and lime and zeolite increased to 11.8 – 11.9 which was probably one of the principal factors that affected survival of selected groups of micro-organisms and, potentially, also of helminth eggs (Allievi *et al.*, 1994).

Acknowledgement

The study was supported financially by the grants VEGA No. 1/0620/03 and 2/4178/04.

References

ALLIEVI, L., COLOMBI, A., CALCATERRA, E., FERRARI, A. (1994): Inactivation of fecal bacteria in sewage sludge by alkaline treatment. *Biores. Technol.*, 49: 25 – 30

BEGON, M., HARPER, J. L., TOWNSEND, C. R. (1997): *Ecology: individuals, population and community* (In Czech). Publ. House of Palacky Univ. Press, Olomouc

BRUCE, A. M., DAVIS, R. D. (1983): Utilization of sewage sludge in agriculture. Maximising benefits and minimising risks. In Proceeding of the International Symposium: *Biological reclamation and land utilisation of urban wastes.* Naples: 121 – 142

BRUŇANSKÁ, M. (1989): Histochemical topography of succinate dehydrogenase in the reproductive system of *Ascaris suum* females. *Helminthologia*, 26: 43 – 49

BUJOCZEK, G., OLESZKIEWICZ, J. A., DANESH, S., SPARLING, R. R. (2002): Co-processing of organic fraction of municipal solid waste and primary sludge - stabilization and disinfection. *Envir. Techn.*, 23: 227 – 241

BURGE, W. D. (1983): Monitoring pathogen destruction. *Biocycle*, 24: 48 – 50

CAPIZZI-BANAS, S., DELOGE, M., REMY, M., SCHWARTZBROD, J. (2004): Liming as an advanced treatment for sludge sanitisation: helminth eggs elimination - *Ascaris suum* eggs as model. *Water Res.*, 38: 3251 – 3258

DAY, M., SHAW, K. (2000): Biological, chemical and physical processes of composting. In STOFELLA, P. J., KAHN, B. A. (Eds): *Compost utilisation in horticultural cropping systems.* Lewis Publishers, Boca Raton: 17 – 50

ECKERT, J. (2000): Parasitenstadien als umwelthygienisches Problem. In ROMMEL, M., ECKERT, J., KUTZER, E., KÖRTING, W., SCHNIEDER, T. (Eds.): *Veterinärmedizinische Parasitologie*, 5. Aufl., Berlin, Blackwell Wissenschafts-Verlag: 94 – 119

ERIKSEN, L., ANDREASEN, P., ILSOE, B. (1996): Inactivation of *Ascaris suum* eggs during storage in lime treated sewage sludge. *Water Res.*, 30: 1026 – 1029

HAYS, B. D. (1977): Potential for parasitic disease transmision with land application of sewage plant effluents and sludges. *Water Res.*, 11: 583 – 595

CHEREPANOV, A. A. (1982): *Methods of laboratory centrals of cleaning plants on farms.* Publ. House Kolos, Moscow

JONES, P. W. (1980): Health hazards associated with the handling of animal wastes. *Veter. Rec.*, 106: 4 – 7

JURIŠ, P., PLACHÝ, P., TÓTH, F., VENGLOVSKÝ, J. (1992): Effect of biofermentation on *Ascaris suum* eggs. *Helminthologia*, 29: 155 – 159

JURIŠ, P., PAPAJOVÁ, I., RATAJ, D., LAUKOVÁ, A. (2000): Properties and fertilizing value of pig slurry. In DUBINSKÝ, P., JURIŠ, P., MONCOL, D. J. (Eds.): *Environmental protection against the spread of pathogenic agents of diseases through the wastes of animal production in the Slovak Republic.* Halequine, Ltd., Košice: 95 – 126

KAZACOS, K. R. (1983): Improved method for recovering ascarid and other helminth eggs from soil associated with epizootics and during survey studies. *Amer. J. Vet. Res.*, 44: 896 – 900

KRUPICER, I., VALOCKÁ, B., VASILKOVÁ, Z., SABOVÁ, M., PAPAJOVÁ, I., DUBINSKÝ, P. (2000): IN DUBINSKÝ, P., JURIŠ, P., MONCOL, D. J. (Eds.): *Environmental protection against the spread of pathogenic agents of diseases through the wastes of animal production in the Slovak Republic.* Harlequin, Ltd., Košice: 79 – 93

MARA, D. D., CAIRNCROSS, S. (1999): *Guidelines for the safe use of waste water and excreta in agriculture and aquaculture.* WHO in collaboration with the UN Environmental Programme: 41 – 62

MIZGAJSKA, H. (1993): The distribution and survival of eggs of *Ascaris suum* in six different natural soil profiles. *Acta Parasit.*, 38: 170 – 174

NOVÁK, P., LUKEŠOVÁ, D., ČÍŽEK, A., ZABLOUDIL, F. (1998): Hygienic-ecological aspects of treatment of farm animal excrements. In VENGLOVSKÝ, J., ONDRAŠOVIČ, M., SOKOL, J., JURIŠ, P., KRAJŇÁK, M. (Eds.): *Hygienic and ecological problems in relation to veterinary medicine.* Copycenter, Košice: 73 – 80

PAPAJOVÁ, I., JURIŠ, P., LAUKOVÁ, A., RATAJ, D., VASILKOVÁ, Z., ILAVSKÁ, I. (2002): Transport of *Ascaris suum* eggs, bacteria and chemical pollutants from livestock slur-

ry through the soil horizon. *Helminthologia*, 39: 77 – 85
PLACHÁ, I., VENGLOVSKÝ, J. (2002): Influence of sludge aerobic exothermic stabilization on the viability of *Ascaris suum* eggs. In *Proceedingds of 10th International Conference RAMIRAN*, High Tatras: 361 – 364
PLACHÝ, P., PLACHÁ, I., JURIŠ, P. (1997): Effect of anaerobic stabilization of sewage sludges on the survival of *Ascaris suum* eggs under laboratory conditions. *Helminthologia*, 34: 229 – 234
REDDY, K. R., KHALEEL, R., OVERCASH, M. R. (1981): Behavior and transport of microbial pathogens and indicator organisms in soil trated with organic wastes. *J. Environ. Qual.*, 10: 255
ROEPSTORFF, A., MURRELL, K. D. (1997): Transmission dynamics of helminth parasites of pig on continuous pasture: *Ascaris suum* and *Trichuris suis*. *Int. J. Parasitol.*, 27: 563 – 572
ROMANENKO, N. A. (1968): Methods for the examination of soil and sediment of wastewater on helminth eggs (in Russian). *Med. Parazit. Parazit. Bolez.* 6: 723 – 729
SAŽP (2004): *Environment in the Slovak Republic (Decade of the care about environment in SR)* (In Slovak). Centre of environmental science and information technologies in Banská Bystrica: 1 – 15
SOBSEY, M. D., SHIELDS, P. A. (1987): Survival and transport of viruses in soils: Model studies. In RAO, V. C., MELNICK, J. L. (Eds.): *Human viruses in sediments, sludges and soils*. Boca Raton, FL, CRC Press: 155 – 177
SORBER, C. A., MOORE, B. E. (1986): *Survival and transport of pathogens in sludge amended soil, a critical literature review*. Report No. EPA/600/2-87/028. Cincinnati, Office of Research and Development: 65 – 88
STERN, G. (1974): Pasteurisation of liquid digested sludge. *In Proceedings of the National conference on composting municipal sludge management*. Information Transfer, Inc., Silver Spring, Maryland: 25 – 36
STN-EN ISO 7899-2: Determination of intestinal enterococci (In Slovak)
STN-ISO 9308-2: Determination of coliform and thermotolerant coliform bacteria (In Slovak)
STN 83 0531-4: Microbiological analysis of surface water (In Slovak)
STRAUB, T. M., PEPPER, I. L., GERBA, CH. P. (1993): Hazards from pathogenic microorganisms in land-disposed sewage sludge. *Rev. Environ. Contam. Toxicol.*, 132: 55 – 91
STRAUB, T. M., PEPPER, I. L., GERBA, CH. P. (1994): Detection of naturally occuring enteroviruses and hepatitis A virus in undigested and anaerobically digested sludge using the polymerase chain reaction. *Can. J. Microbiol.*, 40: 884 – 888
STURHAN, D., LIŠKOVÁ, M. (2004): Cyst Nematodes in the Slovak Republic. *Helminthologia*, 41: 217-219
TSCHÄPE, H. (1996): Die Verbreitung antibiotikaresistenter Keime in der Umwelt mit besonderer Beachtung der Salmonellen. *Dtsch. Tierärztl. Wschr.* 103: 273 – 277
U. S. ENVIRONMENTAL PROTECTION AGENCY (1992): *Environmental regulations and technology. Control of pathogens and vector attraction in sewage sludge (including domestic septage)*.Under 40 CFR Part 503: 1 – 34
VALOCKÁ, B., DUBINSKÝ, P., PAPAJOVÁ, I., SABOVÁ, M. (2000): Effect of anaerobically digested pig slurry from lagoon on soil and plant nematode communities in experimental conditions. *Helminthologia*, 37: 53 – 57
VENGLOVSKÝ, J., SASÁKOVÁ, N., VARGOVÁ, M., PAČAJOVÁ, Z., PLACHÁ, I., PETROVSKÝ, M., HARICHOVÁ, D. (2005): Evolution of temperature and chemical parameters during composting of the pig slurry solid fraction amended with natural zeolite. *Biores. Technol.*, 96: 181 – 189

RECEIVED APRIL 15, 2005

ACCEPTED AUGUST 22, 2005