Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety

# Statement on the use of untreated manure containing raw sewage


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# Contributors

Persons working for VKM, either as appointed members of the Committee or as ad hoc experts, do this by virtue of their scientific expertise, not as representatives for their employers. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

## Acknowledgements

Jørgen Lassen, chair of Panel on biological hazards acknowledges for his valuable contribution to this statement.

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# Summary

The Norwegian department of agriculture decided to re-evaluate the Regulation No. 951 of 4 July 2003 on fertilizers and soil improvers of organic origin. The Norwegian Food Safety Authority (NFSA) requested VKM for a statement on the use of manure from farms where grey water and human waste (sewage) is disposed of directly to the farm manure cellar.

Consideration was given to differences in risk according to the types of domestic wastewater, the species of animal from which the manure derived, the extent and type of sanitary facilities, the crops to which the amended manure is applied, and the effects of storage on infection risk.

According to current legislation, sewage sludge cannot be spread on land where vegetables, potatoes, berries or fruit are grown. Furthermore, sewage cannot be spread on meadows or used for horticultural purposes. In private gardens, parks, playgrounds and similar residential areas, sewage may be used only as a component in a fertiliser, and not applied at the surface. Use of sewage as a fertilizer for the cultivation of grains is permitted. Sewage can also be used when establishing vegetation along roads and embankments.

VKM concludes that manure cellars, to which wastewater, from private household use, and sewage from toilets in the outbuildings are drained, may contain pathogens from humans, in addition to those pathogens originating from animals. The quantity and species of pathogens in this sewage-amended manure would reflect the species and prevalence of pathogens in the population using the facilities. Although the prevalence of intestinal pathogens in the Norwegian human population is relatively low, it should be noted that farms in Norway often provide tourist accommodation, camping facilities, and may house migrant short-term employees during the summer season during which labour requirements are increased. Thus non-Norwegian populations may also use toilet facilities on these farms, and thus when considering the risk of human pathogens, consideration should also be given to people from countries where the prevalence of such pathogens may be higher.

As many viruses and parasites are host-specific, the risk of contamination of produce with human pathogens from such manure is likely to be greater than from manure which has not been amended with untreated sewage.

Pathogen survival is affected by storage, but it should be noted that some pathogens have robust and environmentally resistant transmission stages (e.g. parasite oocysts, cysts and eggs), a proportion of which may survive for prolonged periods in stored manure.

# Sammendrag

I forbindelse med gjennomgang av Forskrift 4. juli 2003 nr 951 om gjødselvarer mv. av organisk opphav (gjødselvareforskriften) har Mattilsynet bedt VKM om en vurdering av sykdomssmitte ved bruk av ubehandlet gjødsel med innhold av sanitært vann. Det ble tatt hensyn til forskjeller i risiko i henhold til hvilke typer sanitært vann gjødselen inneholder, fra hvilket husdyr gjødselen er fra, hvor mye sanitærløsningene blir brukt og på hvilke vekster gjødselen blir brukt.

Etter gjeldende lovgivning kan avløpsslam ikke spres på land hvor grønnsaker, poteter, bær eller frukt er dyrket. Videre kan slam ikke spres på enger eller brukes i gartnerier. I private hager, parker, lekeplasser og lignende boligområder, kan slam bare brukes som en komponent i gjødsel, og ikke spres på overflaten. Bruk av slam som gjødsel er tillat for dyrking av korn, ved etablering av vegetasjon i vegskråninger og lignende.

VKM konkluderer med at gjødselkjellere med innhold av sanitært vann fra privat husholdning og toaletter i uthusene, kan inneholde patogene mikroorganismer fra mennesker, i tillegg til patogene mikroorganismer som stammer fra dyr. Mengden og typer av humanpatogene mikroorganismer i denne typen gjødsel ville gjenspeile typer og mengder av patogene mikroorganismer hos personer som bruker fasiliteter.

Selv om utbredelsen av patogene mikroorganismer hos den norske befolkningen er relativt lav, det er viktig å nevne at gårder i Norge ofte tilbyr turistovernatting, camping fasiliteter og ansetter utenlandsk arbeidskraft i sommersesongen når behov for arbeidskraft er økt. I og med at denne ikke-norsk populasjon bruker også toaletter på gårdene bør det også, når det vurderes risikoen for humanpatogener, tas hensyn til mennesker fra land der forekomsten av slike patogener kan være høyere.

Mange virus og parasitter er vertsspesifikke, dermed er risikoen for forurensing av produkter med humanpatogener fra slik gjødsel trolig større enn fra husdyrgjødsel som ikke er blitt tilfløt ubehandlet slam. Overlevelse av patogener påvirkes av lagring, men det bør også nevnes at enkelte patogene mikroorganismer har robuste overføringsstadier (f.eks. parasitt oocyster, cyster og egg) hvor en andel kan overleve i lengre perioder i lagret gjødsel.

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# Background

VKM has received following request from Mattilsynet.

In connection with the review of Regulation No. 951, 4 July 2003, on fertilizers and soil improvers of organic origin, the Norwegian Food Safety Authority (NFSA) has been asked about the use of sanitary facilities in agricultural settings where grey water and human waste are disposed of directly into the farm manure cellar (slurry tank).

Such sanitary facilities and provision are not illegal according to Regulation No. 951, 4 July 2003, but according to some local regulations may be banned when establishing new agricultural buildings or when new water and wastewater plumbing are fitted in existing farm buildings. However, Regulation No. 951 4 July 2003 sets requirements for sanitation of manure if mixed with sludge. NFSA's impression is that these requirements are not always followed.

The sanitary facilities described above might be used either regularly or infrequently, and may range from a simple sink to a lavatory and shower. Such sanitary facilities may be used sporadically and only by household members or may be used to provide regular toilet services for temporary staff and other visitors. In the older literature, it is noted that some councils accept that all household sanitary water is piped to the manure cellar (slurry tank) (Warberg 2005).

The Norwegian Department of Agriculture has decided that the regulation regarding fertilisers and soil improvers of organic origin should be re-evaluated. NFSA has therefore requested VKM provides a statement on the use of manure from farms with this kind of sanitation situation.

**Data**

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# Terms of reference

NFSA asks VKM for a statement regarding the hygienic aspects of the use of raw manure containing domestic waste water.

It is requested to consider whether there is difference in risk according to the types of domestic waste water disposed of to manure cellar (slurry tank), from which type of animal the manure is originating, how much sanitary solutions are used and in which crops fertilizer are used and how storage affects the risk.

# Introduction

Some farms have sanitary facilities where wastewater and sewage from the household and from toilets in the outbuildings are drained to manure cellar. Despite containing sewage, when it is stored in a manure cellar, it is referred to as manure. Faecal-oral disease transmission from human faeces is documented, but scientific evidence of human or animal infection associated with use the of human sewage as a component of manure is relatively scant.

# Microorganisms

In the report from 2011, VKM described in detail the pathogenic microorganisms that represent a public health risk from sewage (Lassen et al. 2011). A short overview of the major points is provided here:

## Bacteria

Pathogenic bacteria that represent a health risk from sewage are *Salmonella* spp., *Shigella* spp., the ETEC group in *E. coli*, *Campylobacter* spp and *Vibrio cholerae*. In addition, it must be assumed that *Yersinia enterocolitica*, *Listeria monocytogenes* and the intestinal pathogen *E. coli* may represent a risk of infection through the sewage. There is no endemic level of *Shigella* spp., ETEC group and *Vibrio cholera* in Norway, but there is a low level of *S*. Typhimurium, mostly associated with hedgehogs and small birds but not Norwegian livestock. The endemic level of *Campylobacter* spp. is associated with a wide range of mammals and birds, both domestic and wild species. For *Y. enterocolitica* pigs are the only animal reservoir. *L. monocytogenes* and anaerobic gram-positive spores like *Clostridium perfringens*, *C. tetani* and *C. botulinum* are found naturally in the environment, including water, soil, vegetation, and decaying plant material, but also in the intestine of a wide range of animals.

## Viruses

Viruses that may represent a public health risk from sewage sludge are those with a faecal-oral transmission route. Whether different viruses will be infectious in manure, and could be infectious when manure is used, depends on the animal source as well as management and storage conditions. Most viruses are species-specific, meaning that in general there will be a higher risk for transmission of human diseases from manure containing sewage.

## Parasites

Parasites that may represent a hazard in manure and sludge are those with a faecal-oral transmission route. Some parasites are host specific and are thus infectious only for a specific host, while other parasites have limited host specificity, or are infectious for many different hosts. Parasites with a faecal-oral transmission route often have robust and environmentally resistant stages (oocysts, cysts and eggs) improving the chances of long-term survival in the environment. Whether these intermediate stages will survive in manure, and continue to be infectious when manure is used, will depend on the processing and storage conditions. Experiments have shown that some parasites (e.g. *Cryptosporidium*) have significantly longer survival in liquid livestock waste than bacteria. In addition, the spread of protozoa via runoff from agricultural land fertilized with cattle and pig manure has been confirmed in controlled studies. There are a large number of different parasites in humans, and especially in animals, in Norway, the transmission stages of which can occur in manure or sewage. It should be noted that the prevalence of human parasitic infections is relatively low in Norway.

# Antimicrobial resistance

In 2009, The Norwegian Food Safety Authority (NSFA) asked VKM to undertake a risk assessment concerning the health risk from the spreading of slurry under Norwegian conditions. In the report from 2010, VKM described in detail antimicrobial resistance against various antimicrobials. It was concluded that antimicrobial resistance was not widespread in isolates from Norwegian animals. The same is true for enteropathogenic microbes in humans, but it was observed that *Campylobacter* strains isolated from patients infected outside Norway are more resistant than strains from patients infected domestically (Lassen et al. 2009).

It is unlikely that antibacterial resistance will be promoted in sewage treatment plant effluent, in the sludge, or in the soil following application of sewage as fertilizer. An exception may be for the fluoroquinolone ciprofloxacin in soil, due to persistence and limited mobility of fluoroquinolones into the subsoil (Eriksen et al. 2009).

# Survival of pathogens during storage of manure and in the environment

This topic was addressed in detail in the VKM rapport (Lassen et al. 2011) and the main points are reiterated below:

- The ability of pathogenic microbes to survive during storage of manure and in the environment varies between organisms.
- Survival will depend on physical factors such as temperature, sunlight, humidity, etc. The availability of nutrients, predation and background flora is also important.
- In general, parasite eggs, cysts, oocysts and spore-forming bacteria are robust to most environmental factors, but cysts / oocysts are quite sensitive to direct sunlight and dehydration. Ubiquitous bacteria (normally present in the environment), e.g. *L. monocytogenes*, are also robust and survive very well.
- Bacteria adapted to warm-blooded animals (including humans) e.g. *Salmonella*, *Campylobacter* and *E. coli*, are usually far more sensitive to various environmental factors and are decimated relatively quickly. VTEC however, is a sub-group of *E. coli* that can withstand relatively severe environmental stresses. They are relatively sensitive to higher temperatures (no growth above 42°C), but can withstand low temperatures, low pH and dehydration. *Campylobacter* spp. are very sensitive to dehydration and grow only in a microaerophilic atmosphere. This means that, as long as *Campylobacter* spp. are in a humid environment, they survive relatively well, but will die relatively rapidly if they are exposed to direct sunlight.

A British survey looked at the reduction of various zoonotic agents in liquid manure during storage. The survey studied *Salmonella*, *E. coli* O157, *Campylobacter jejuni*, *Listeria monocytogenes* and *Cryptosporidium parvum*. Liquid manure from various animal species and with different dry matter content was used. The results indicated that D-value (1 log10 unit decrease) for bacteria ranged from six to 44 days. *C. jejuni* had the fastest decrease, while *E. coli* O157 showed the slowest reduction. D-value of *C. parvum* ranged from 133 to 345 days.

In 2002 a study unintentionally found *E. coli* O157: H7 in cattle manure used to fertilize vegetables. By taking samples of fertilized soil, manure and animals over a period of time, *E. coli* was isolated from the fertilized soil only one week after fertilization, ie in July, from the manure cellar in September (it was first isolated in late June 2002). The bacterium was also isolated from six cows and two sheep in September. In the samples taken later (until May 2003) there were no *E. coli* O157: H7 isolates from any of the samples. In a Norwegian experiment *E. coli* O157: H7 was added to fresh cattle manure and was isolated from the fertilized soil eight weeks after fertilization, but not after 12 weeks. In this experiment a reduction in numbers of *E. coli* (fecal indicator) eight weeks after fertilization was seen, suggesting that *E. coli* would disappear or be present in only a very small number after some time in the soil.

In the UK, several experiments spreading manure, added various pathogenic microorganisms, on the pasture and on the soil were conducted. Various types of manure (liquid manure from dairy cattle, beef cattle and pig) were inoculated with different types of *Salmonella*, *E. coli* O157, *C. jejuni*, *L. monocytogenes*, and *C. parvum*. The results of these experiments show that the typical intestinal bacteria (*E. coli*, *Salmonella* and *Campylobacter*) generally have lower rate of survival in soil and on the pasture than *L. monocytogenes* which is a ubiquitous bacterium found in nature but also in the faeces of animals. However, there was still considerable variation. For instance, *Salmonella* from soil samples was isolated 63, 32 and 16 days after the spreading of liquid manure from, respectively, dairy cattle, beef cattle and pigs, whereas *E. coli* O157 showed the longest survival period of 32 days for the same manure types. D-values (90% reduction, 1 log10 unit) varied between about one and a half to almost three days. D-value of oocysts of *C. parvum* ranged between 8 and 31 days indicating that protozoa are significantly more resilient than bacteria. It was possible to isolate the oocysts from *C. parvum* from the surface of grassland 63 days after injection of liquid manure from pigs. When intestinal bacteria were spread on the soil, the time before manure was incorporated into the soil played a major role in the survival of bacteria from manure. The reduction in the numbers of added intestinal bacteria was faster when fertilizer was lying on top of the soil than when the fertilizer was incorporated within 2 hours. The authors explain this by variations in temperature, UV radiation from the sun, the effect of wind, etc. They argue however that this is not necessarily the best practice because manure left on the surface represents a risk of spreading to the environment.

Little is known about the persistence of various viruses in different matrices, but some experiments indicate that a proportion of rotavirus may persist in slurry, manure and fresh water for several days.

# Discussion

Sewage is known to contain pathogens and the types and concentrations of pathogens in sewage influent reflect the infection situation in the relevant population. To our knowledge, there are no studies that investigate the occurrence of human pathogens in manure that contains wastewater and sewage from private households and from the toilets in farm outbuildings. However, it is safe to assume that manure originating from such sources would also contain human pathogens. Higher levels are expected in the manure containing sewage than in the manure containing only wastewater from hand washing basins or showers. Some human pathogens, particularly some viruses and parasites, may be less likely to occur in manure of only animal origin, due to the host-specificity of many viruses and some parasites. Most intestinal parasites are transferred from host to host via environmentally robust eggs, cysts, and oocysts that can contaminate produce by inadequately sanitised manure (Amundsen et al. 2001).

A case has been described in Norway in which metacestodes of the human tapeworm, *Taenia saginata*, were detected in meat from cattle at slaughter. The cattle had been infected by ingestion of the tapeworm eggs in the faeces from a non-Norwegian, temporary farm worker (Press, (2012). It should be noted that if the parasite had not been identified in the meat, then there was a very real potential for infection of subsequent consumers of the meat. This parasite is very rare in Norwegian livestock, but its prevalence in humans and cattle is quite common in some developing countries.

An association between field workers' personal hygiene and produce contamination with generic *E. coli* at the preharvest level has been described by Park et al. (2013). Their findings support the practice of good personal hygiene and other good farm management practices (GAP), like the use of portable toilets and the use of hand-washing stations may reduce produce contamination with generic *E. coli* at the preharvest level.

Livestock manure can be spread only on approved areas, i.e. cultivated soil. Manure that contains wastewater and sewage from private households and from the toilets in farm outbuildings should be considered as sewage. Considerations for possible use of such manure, areas and application methods should be based on assessment of risk for survival of pathogens and potential impact on human health (Lassen et al. 2011).

Currently, Regulation 4 July 2003 No. 951 on fertilizers and soil improvers of organic origin require that stabilization and sanitation processes are conducted, but these requirements do not apply to manure used on own or rented land. According to the same regulation sewage cannot be spread on land where vegetables, potatoes, berries or fruit are grown, and cannot be spread on meadows or land used for horticultural purposes. In private gardens, parks, playgrounds and the like, sewage sludge may be used only as a component of a fertilizer, and should not be applied at the soil surface Use of sewage sludge for cultivation of grains is permitted. Sewage sludge can also be used when establishing vegetation along roadsides and embankments (Lassen et al. 2011).

It is difficult to assess the risks of transmission of infectious diseases related to the use of sewage, as the microbial risks are poorly investigated. In evaluations of previous studies it has been established that the evidence that sewage causes disease and evidence that sewage does not cause disease are both lacking (NRC 2002). The absence of documented disease events associated with the use of sewage as a component of manure does not demonstrate that the use of sewage on soil is free of risks.

Transmission of disease can occur through handling of sewage or through the environment, as following land application the pathogens in sewage will either end up in the soil or may be transported to water. Crops fertilised with sewage constitute another potential route of transmission. Zoonotic agents can survive on the surface of fruits and vegetables and it is also shown that the bacteria can be internalized inside such products. In Norway manure is usually spread either in the spring or autumn. Although manure is rarely or never used on a salad fields during the growing season, there is still a risk of accidental contamination of fruits and vegetables close to the harvest (Lassen et al. 2009). Through vectors (birds, insects, rodents etc.) a further spread of pathogens in the environment is possible. When assessing the risks different microbial groups need to be considered. For bacteria, *Salmonella, Campylobacter* and EHEC probably constitute the largest risks. All of these are zoonotic agents. *Giardia* and *Cryptosporidium* are the protozoa that are often most persistent, with prolonged survival in the environment. Helminth eggs, such as *Ascaris* spp. eggs and *Taenia* spp. eggs, are also highly robust. Various of these parasites have zoonotic potential, whereas enteric viruses are generally considered to be transmitted more host species-specific.

# Data gaps

The prevalence of human pathogens in manure containing wastewater and sewage from private households and from toilets in farm outbuildings is lacking.

# Conclusion

Manure cellars, to which wastewater and sewage from private households and from toilets in outbuildings are also drained, are likely to contain human-specific pathogens, in addition to zoonotic pathogens originating from animals. This means that humans and animals in contact with this manure are exposed to a greater range of pathogens. Although the prevalence of enteropathogenic microbes in Norway is relatively low among animals as well as humans, there will probably be a greater risk for contamination with human pathogens from such mixed manure regardless off the animal origin of the manure. This is particularly true for parasites and viruses. The risk is expected to be very low where only wastewater from hand washing basins or showers is drained to manure cellar.

Furthermore, it should be noted that tourists, visitors, and employees from other countries, may often stay at farms in Norway, particularly during the summer. People from other countries bring with them their enteric pathogens, providing the opportunity for contamination with pathogens that are less common in the local Norwegian population.

As the main risk for human health is increased prevalence of specific human pathogens the animal origin of the manure is not significant.

The storage of manure affects the survival of pathogens, but several pathogens, particularly intestinal parasites, have robust and environmentally resistant stages (oocysts, cysts and eggs) and a proportion of these may survive storage.

Manure that contains wastewater and sewage from private households and from the toilets in farm outbuildings should be considered as sewage.

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