DOES HORSE MANURE POSE A SIGNIFICANT RISK TO HUMAN HEALTH?

Abstract

Questions periodically arise during park and open space Master Planning processes, trail planning/development, and other public meetings whether horse manure poses significant health risks to humans. The following paper was developed to help provide information for non-scientists about laws and regulations defining toxic and hazardous wastes, the chemical and pathologic contents of horse manure, and some thoughts about the potential risks to humans exposed to horse manure.

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Contents

What Type Waste is Horse Manure?

Horse manure is a solid waste excluded from federal regulation because it neither contains significant amounts of listed hazardous components, nor exhibits hazardous properties. See definitions below:

Issue	Definition
Waste	Loss through breaking down of bodily tissue; damaged, defective or superfluous material produced by a manufacturing process - Webster's Dictionary
Solid Waste	Any discarded material that is not excluded in Section 261.4 of the Code of Federal Regulations (CFR). Domestic sewage (261.4aii) and animal manure (261.4b2ii) are specifically EXCLUDED from Federal regulations
Hazardous Waste	Solid wastes which are either: A. Listed: literally a list of organic compounds and inorganics (metals & metal compounds) which may pose a substantial hazard to human health. The federal government maintains this list. B. Characteristic: [1] 1. Fails one or more test for: a. *Ignitability*: flash point 140° F or spontaneously combustible b. *Corrosivity*: pH <2 or >12.5 c. *Reactivity*: generally sulfide & cyanide compounds d. *Toxicity*: fails Toxicity Characteristic Leachate Procedures (TCLP) tests (See Table 1) 2. Is fatal to humans in low doses or lab animals at specified threshold levels 3. Contains toxic constituents (See Table 1)

What Chemicals Comprise Horse Manure and Are They Toxic?

Toxicity Definition: Relating to or caused by a poison - Webster's Dictionary
Everything is toxic to something at some level (although not necessarily every substance to every species). Toxicity may be acute, chronic or bioaccumulative. Toxins come into the body by being ingested, inhaled or dermally absorbed. The sixteenth century Swiss physician, Paracelsus, first pointed out the fact that ALL substances are toxic and that the difference between a remedy and a poison is simply the amount that is taken into the body. "The dose makes the poison". Many chemicals that are essential to good health, like sodium chloride, are toxic at high levels, but dysfunctions can result when they are present at levels that are too low.2

The human body has the remarkable ability to function unaffected by exposures to toxics. UC Berkeley biologist Dr. Bruce Ames has said, "Every day we are ingesting in our diet at least 10,000 times more by weight of natural pesticides than of man-made"- from bacon, peanut butter, mustard, basil, tea, and wine, among others.3 The number of organic chemical compounds that have been synthesized since the turn of the century now exceeds half a million, and some 10,000 new compounds are added each year.4 Many of these new products are toxic to humans. Thus, the body is constantly being exposed to a variety of toxic chemicals.

As you can see in Table 2, the primary chemical constituents of horse manure are about the same as harmless household and agricultural fertilizer. In fact, animal manure is a valuable agricultural amendment and has been used for millennia to help grow our food supplies. Current mushroom culture relies heavily on horse manure, while other crops have been developed with human sewage sludges in order to recycle our own prolific wastes. Thus, based on its chemical constituents, horse manure should not be considered toxic.

Pathogens of Concern

Commercial livestock intestinal microflora has been studied in depth, but not horses. Very few statistics are available on horses. According to Dr. Deanne Meyer, Livestock Management Specialist at UC Davis (1997), it is difficult to find data on horses because it is seldom that more than 50 horses are kept in a single facility. You must have a sufficient mass of animals for study, before data can be considered representative. While the US Department of Agriculture keeps extensive data on commercial livestock operations, it keeps no data on horses. The Council for Agricultural and Science Technology (CAST) estimates livestock volume in units as follows:

Cows	104 million
Swine	60 million
Sheep	8 million
Poultry	7790 billion[5]

The mere 6.9 million horses6 thought to populate the United States have been of little concern until recently when increased attention began to be given to the Clean Water Act.

"Human pathogens are rarely a concern in farm-generated wastes" (NRAES 54). Pathogens are organisms (fungus, helminths, virus, protozoa, bacteria) capable of producing infectious disease. Fungi are usually considered to be of minimal health risk (Straub et al 1993). *C. tetani* is reportedly found in equine manure, but does not represent a source of significant public health risk (NCSU 2000). Many common equine helminths (worms, bots, etc.) are pathogenic to domestic animals but are not pathogenic to man (Straub et al, 1993). Generally speaking, horse guts do not contain the 120 viruses and constituents of concern in human, dog and cat feces (carnivores and omnivores) (Atwill 1998, Putnam 1983, Davis et al 1996, Rugg 1998). Most viruses with zoonotic potential (animals infecting humans) are not found in horse wastes.7

As a result of intensive studies on commercial livestock, some protozoa and bacteria have been identified that can survive in horse guts. (See Table 3) Pathogens of primary concern are waterborne microorganisms that usually follow ingestion pathways into the body. Transmission can also occur through direct oral-fecal exposure. These include *Cryptosporidium parvum , Giardia duodenalis, Campylocbacter spp, Salmonella spp., pathogenic strains of E. coli,* and *Yersinia spp.* By far, C. parvum and Giardia are the two of most concern because they have very low thresholds of infectious dose. People infected by these organisms may exhibit a range of symptoms from mild abdominal discomfort to death, especially among the very young, elderly, and people with immunologically suppressed systems. Neither of these organisms can be destroyed easily with traditional water treatment processes. With recent large-scale waterborne outbreaks of Cryptosporidiodosis around the U.S., and the rising numbers of immunodeficient people, public attention has increasingly focused on the integrity of drinking water supplies. This paper will focus on results from recent studies on *Cryptosporidium* and *Giardia.*

Protozoa

Human Transmission of Disease

C. parvum, long considered a veterinary disease, has emerged as an important infectious disease of human, as well as of animal origin. Our ability to distinguish between these organisms has only become possible recently with the advent of genetic testing (genotyping). "The genotype and experimental infection data suggest the possibility of two distinct populations of *C. parvum* in humans. One population appears to involve zoonotic transmission from calf-to-human with subsequent human-to-human and human-to calf transmission. The other population appears to involve an anthroponotic transmission cycle, exclusively in humans." In laboratory experimental infection studies, the exclusively human genotype could not successfully infect laboratory animals. Retrospective analysis of outbreaks at the Georgia water park (1995; 2900 cases), Florida day camp (1995; 70 cases), and in Wisconsin (1993; 403,000 cases) indicates these infections were caused by the genotype found exclusively in humans. 8

In the "*Cryptosporidium* White Paper" published by the San Francisco Public Utilities Commission in 1996, a number of interesting facts were cited:

- While not identified until relatively recently historically, *C. parvum* is ubiquitous to 6 continents, infecting a substantial number of people (up to 16% of people in the third world and between 1-4% of the total population in North America are

prevalent for *Cryptosporidium*;), potentially 10,000,000 people in the US and 1,000,000 in California.

- Detection of the presence of the organism in water does not indicate that it is viable (i.e., capable of inducing infection), and, there is no method for assessing the mechanisms by which it becomes virulent. Oocysts of *C. parvum* are present in many North American waters (0.0002-5,800 per liter) more so in lakes and rivers, less in groundwater.
- Analytical methods for understanding/ controlling the organism are so poor that the government cannot recommend control regulations.
- County environmental health officers of Alameda, San Francisco, San Mateo, and Santa Clara believe that Cryptosporidiodosis from drinking water is not a major concern. 9

Equine Transmission of Disease

Recently, several credible research papers have been published which demonstrate conclusively that adult horse guts do not significantly contain either *C. parvum* or *Giardia*, the two organisms of greatest human health concern when present in water supplies.

While some evidence exists that foals and their pregnant or lactating mothers can carry *C. parvum* or *Giardia*, neither foals nor their mares are likely to be found on trails. No studies had been done on adult horses until 1993, at which time watershed managers proposed to ban livestock from their property due to uncertainties about the role of livestock in shedding pathogens. In response to this, the Backcountry Horsemen of California (BHC) and High Sierra Packers Associations funded an independent study by UC Davis Tulare (Johnson et al). Fecal samples were obtained from 91 horses and 311 horses and mules used in backcountry riding to determine the potential risk of adult horses contaminating surface waters. Samples were collected at horse barns and round corrals throughout California during 1993 and 1994. Horses were between the ages of 4 and 24 years of age.

The typical backcountry horse trip in California lasts 4 to 7 days. The incubation period before these organisms start to shed is usually 1 to 2 weeks after infection. Thus, an adult horse acquiring an infection from contaminated surface water during a backcountry trip would likely not start shedding these organisms during the typical backcountry ride of 4-7 days.

The conclusions from Johnson et al "indicate that backcountry use of horses for recreational riding is unlikely to pose a significant risk of environmental contamination from *Cryptosporidium* of equine origin nor is it likely to create a significant threat to human health from either of these protozoans." 10 *Giardia* from cattle and horse has NOT been shown to be infectious for humans under normal circumstances. These data do not support the assumption that horses are infecting humans with *Giardia* in the back country. In fact, studies are underway to determine which mammals in the high Sierra are shedding the most *Giardia* and which mammals are the ones defecating closest to sources of water. The more a horse was used in the backcountry, the less likely it was to have *Giardia* infection.

When the Johnson et al paper was submitted to a scientific journal for publication, it was subjected to a rigorous peer-review. The major criticism voiced about the study by peers

concerned the fact that the 91 horses, while representing a broad geographical spectrum, were not sampled at trail heads prior to entering backcountry. A second study was undertaken between July and November of 1996 by Ford et al of Colorado State University Fort Collins to test fecal matter of 300 horses entering at 23 different trail heads in Colorado. Horses sampled ranged from 3 to 30 years old. Of these 300 horses, only one was positive for *C. parvum* and 2 for *Giardia*. Prevalence results were completely consistent with previous finding by Johnson et al, in California. In following up to get information on the infected individuals, the sole horse with *C. parvum* was determined to be 24 years old, had bad teeth, poor digestion and was immuno-compromised. He was ridden daily as part of a commercial string, and suffered from weight loss. He probably drank contaminated water downstream from a known beaver habitat. He was immediately put to pasture to recover. The conclusion from Ford et al is: "Based on the low prevalence of *Cryptosporidium* in the trail horse population surveyed, it can be concluded that the adult recreational trail horse population is not likely to be a significant source of *Cryptosporidium* environmental contamination in water shed areas."11

Interestingly, Dr. Rob Atwill of UC Davis/Tulare (a principle in the Johnson et al study) has found that wild animals have substantial rates of *C. parvum* in their guts, significantly higher than those found in either humans or horses. For example 30% of mice tested were found to have *C. parvum* in their guts; similarly 63% of rats, and 11% of feral pigs carried this organism.

While horse manure found on trails may contain some of the pathogens discussed here, they are unlikely to exist in significant numbers to impact human health. Life expectancy of most of the protozoa discussed, when deposited in manure on a trail, is very short. Atwill cites Robertson et al. 1992 "Oocysts appear to die after several hours of being dry". Most bacteria will not grow at a water activity below 0.95 according to Atlas and Bartha. (See reference 7).

Bacteria

Coliform bacteria are ubiquitous and are necessary beneficial organisms that help most normal healthy species including man and animals digest their food. *E. coli* under certain conditions - such as stress or infections - cause disease in its host or may be found as a secondary invader to other diseases. Strains that exist in one species generally do not affect others - consequently man's primary concern is for *E. coli* of human origin and then only if it is found in his food or water - not because of the *E. coli* itself but because of other germs that may accompany it. While *E. coli* from a number of species, including humans, can cause intestinal disease under certain conditions, those of equine origin have not been shown to do so. "On concentrated reflection, I can come up with no explanation why the horse should be singled out as a likely source of human disease. On the contrary, among domestic animals the horse is perhaps the least likely to play such a role". 12

In the winter 2000-2001, Dr. Atwill of UC Davis Tulare, conducted a further research study on 250 horses in the San Francisco Bay Area. Due to concerns expressed by organic gardeners about the safety of using composted horse manure as a soil amendment, Atwill determined again that insignificant levels of E. coli 0157:H7 and *Salmonella* were in adult horse guts. Composted manure showed no E. coli 0157:H7 after 24 hours in pile residence. Research results should be available in the near future.

A 1998 NAHMS study on "*Salmonella* and the US Horse Population" confirms *Salmonella* is not an issue in horses (www.aphis.usda.gov/vs/ceah/cahm/Equine/eq98salm.htm).

Is the Risk of Human Exposure to Untreated Horse Manure Acceptable?

There are three types of risks: true risk, calculated risk, and perceived risk.

There are 250 million people in the US and 6.9 million horses. There are 28 million people of the State of California and 642,000 horses. Over 70% of California horses are involved in showing and recreation (about 449,400).13 Probably only half of these potentially use trails (about 250,000). The rest are confined to show arenas, or are at pasture as retired family pets. The remaining 30% will virtually never be found on trails since they are involved in the expensive pursuits of racing and breeding, and are too valuable to expose to the dangers on trails. Thus, horses likely to be on trails are relatively few in number compared to the number of citizens who are likely to use trails. And, obviously, not all of these horses that could potentially be on trails are likely to be on trails simultaneously.

No major human disease has ever been accurately attributed to the intimate contact human beings have had with horses for thousands of years. 14 Veterinarians and vet students probably have the greatest exposure to true risk from horse manure. The horse has a very inefficient gut: it's a one-way throughput system. Horses are physiologically incapable of vomiting or regurgitating. If something gets stuck on the way through, the only way to get it out is by surgery or physical intervention. As a result, you will often find vets armpit deep under a horse's tail. Nevertheless, there has never been a documented case of veterinarians contracting illness as a result of this rather extreme true exposure to horse manure. People employed by or who provide services at horse keeping facilities, could possibly have the next most frequent opportunity for exposure to horse manure, but they don't have reported problems either. Because horses are big, imposing animals, infrequently encountered by people, the perceived risk of human exposure to horse manure is probably greater than the true risk.

We have found that many younger people in parks and open spaces near urban areas have rarely seen or even petted a horse. The average trail horse in California, ridden by an employed owner from an urban area, would likely not be present on public trails more than 12 to 16 hours per week- a maximum of about 10% of a week. Winters are difficult to ride on trails, so most riding occurs between April and November. Many more people use trails than horses. For example, in San Mateo County, a supposed "horsey" jurisdiction, the human population is nearly 700,000 compared to 4,000 horses. While all citizens and all horses may not be trail users, the horse subset that uses trails is probably very small. We believe that such small numbers of horses on urban trails and the brief time spent on them constitutes very little true risk in terms of volume or contents for people encountering horse manure.

In the California backcountry average pack trip of 4-7 days 15, trail time might be 7 hours per day - maximum of about 30% of a week. Access for much of the high country is limited to horses from June through October. Most individual horse riders would be lucky to spend two weeks a year in the mountains with their animals. Thus, out of 20 weeks of available trail time, privately owned backcountry horses probably use only a maximum of 10% of time available. We believe that such limited numbers of horses on

backcountry trails and brief time spent on them constitutes very little true risk in terms of volume or contents for people encountering horse manure.

Horses spend most of their time in pastures or paddocks where the majority of their excrement is deposited, collected and managed. Horse manure is about 70-80% liquid and 20-30% solids16. The liquid portion is quickly retained by soil or vaporizes rapidly into the atmosphere. In composted scenarios, total mineralization (breakdown into CO2 and H2O) occurs within 21 days with more than 50% of the total CO2 produced during the first 6 days.17 There are no documented studies of decomposition rates under ambient conditions because the large number of variables (temperature, wind, moisture, direct sun, disturbances, etc.) would be difficult to control in scientific experiments. According to Jeffrey Schaffer, wilderness writer, "700 backpackers in Desolation Wilderness (West of Lake Tahoe) contribute about a ton of human waste per week. Whereas horse and cattle excrement lying on the ground decomposes rapidly, buried human excrement takes longer, for in mountain soils, subsurface decomposers such as bacteria and fungi are not abundant".18

Dr. Aaron Wildavsky, Professor at UC Berkeley has written, "The richest, longest-lived, best protected, most resourceful civilization is on its way to becoming the most frightened. Government has contributed to this process by taking responsibility for risk management away from individuals." People are exposed to a variety of risks every day of their lives and must make decisions about which risks to ignore and which ones to manage actively. We believe that exposure to horse manure is one fear people can cross off of their list of things to worry about.

People vastly outnumber horses likely to be found on trails in both the United States and California. Because horses are encountered infrequently by most people, it is likely that their perceived risk of exposure to horse manure is actually much higher than their true risk. As we have seen, manure is physically handled by only a few people with no notable health effects reported. It desiccates and decomposes rapidly in the environment. There are no known toxic effects on humans due to the exposure to horse manure. It is unlikely that the average hiker practicing conventional hygiene will experience adverse effects from exposure to horse manure on a trail. We believe that based on the information currently available, the exposure of people to untreated horse manure on trails is an acceptable health risk.

Conclusion

Horse manure is a solid waste excluded from federal EPA solid waste regulation because it neither contains significant amounts of hazardous chemicals, nor exhibits hazardous characteristics. The chemical constituents of horse manure are not toxic to humans. Horse guts do not contain significant levels of the two waterborne pathogens of greatest concern to human health risk, *Cryptosporidium* or *Giardia*, neither do they contain significant amounts of the bacteria E. coli 0157:H7 or *Salmonella*. Fungus, viruses, bacteria and worms found in horses have never been shown to infect humans and are unlikely to be zoonotic. Finally, the reality is that there are very few horses, and even fewer numbers of them that frequent trails. People seldom encounter or handle horse manure. People who do have occasion to handle horse manure have never been infected by this intimate contact. Humans and other sources within the environment (e.g. wild animals and birds) with their overwhelming population numbers are far more likely than horses to contribute to human health risks.

While horse manure may not be aesthetically pleasing, it should not be harmful to human health nor pose a significant health risk to people when they encounter it on public trails.

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Acknowledgments, References & Tables

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See EnviroHorse April 2001 paper on HORSE WASTES AND COMPOSTING: PATHOGENS AND WEED SEEDS. This study contains information on pathogens and weed seeds, plus references to Best Management Practices for managing manure. www.californiastatehorsemen.com/envirohorse.htm

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Table 1. - MAXIMUM CONCENTRATION OF CONTAMINANTS FOR THE TOXICITY CHARACTERISTIC

EPA HW No. [1]	Contaminant	CAS No. [2]	Regulatory Level (mg/L)
D004	Arsenic	7440-38-2	5.0
D005	Barium	7440-39-3	100.0
D018	Benzene	71-43-2	0.5
D006	Cadmium	7440-43-9	1.0
D019	Carbon tetrachloride	56-23-5	0.5
D020	Chlordane	57-74-9	0.03
D021	Chlorobenzene	108-90-7	100.0
D022	Chloroform	67-66-3	6.0
D007	Chromium	7440-47-3	5.0
D023	o-Cresol	95-48-7	[4]200.0
D024	m-Cresol	108-39-4	[4]200.0
D025	p-Cresol	106-44-5	[4]200.0
D026	Cresol		[4]200.0
D016	2,4-D	94-75-7	10.0
D027	1,4-Dichlorobenzene	106-46-7	7.5
D028	1,2-Dichloroethane	107-06-2	0.5
D029	1,1-Dichloroethylene	75-35-4	0.7
D030	2,4-Dinitrotoluene	121-14-2	[3]0.13
D012	Endrin	72-20-8	0.02
D031	Heptachlor (and its expoxide)	76-44-8	0.008
D032	Hexachlorobenzene	118-74-1	[3]0.13
D033	Hexachlorobutadiene	87-68-3	0.5
D034	Hexachloroethane	67-72-1	3.0
D008	Lead	7439-92-1	5.0
D013	Lindane	58-89-9	0.4
D009	Mercury	7439-97-6	0.2
D014	Methoxychlor	72-43-5	10.0
D035	Methyl ethyl ketone	78-93-3	200.0
D036	Nitrobenzene	98-95-3	2.0
D037	Pentachlorophenol	87-86-5	100.0
D038	Pyridine	110-86-1	[3]5.0
D010	Selenium	7782-49-2	1.0
D011	Silver	7440-22-4	5.0
D039	Tetrachloroethylene	127-18-4	0.7
D015	Toxaphene	8001-35-2	0.5
D040	Trichloroethylene	79-01-6	0.5
D041	2,4,5-Trichlorophenol	95-95-6	400.0
D042	2,4,6-Trichlorophenol	88-06-2	2.0
D017	2,4,5-TP (Silvex)	93-72-1	1.0
D043	Vinyl chloride	75-01-4	0.2

[1] Hazardous waste number.
[2] Chemical abstracts service number.
[3] Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.
[4] If o-, m-, and p-Cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of total cresol is 200 mg/l.

Table 2

Fresh Manure Production & Characteristics Per 1,000 kg/lb Live Animal Mass per Day

Manure Production & Characteristics

American Society of Agricultural Engineering

Adopted by the ASAE
Dec. 1976, 1992, &revised 6-14-73

ASAE Data: D384.1
(Data Exerpted for Horses Only)

Parameter*- mean	1000 lb in pounds (450kg)
Total Manure (79.5% water)	45 or 0.75ft^3/da
Urine	10
Density lb/ft^3	60
Total Solids	9.4
Volatile Solids	7.5
5 day biochem O_2 demand	1.7
Chemical O_2 demand	-
pH	7.2
Total Kjeldahl Nitrogen (No Ammonia Nitrogen)	0.27
Phosphate P_2O	0.105
Potassium K_20 Potash	0.205
Calcium	0.29
Magnesium	0.057
Sulfur	0.044
Sodium	0.036
Chloride and Lead	-
Iron	0.016
Manganese	0.0028
Boron	0.0012
Molybdenum	0.00083
Zinc	0.0022
Copper	0.00053
Cadmium	0.0000051
Nickel	0.00062

(Per Dr. Meyer UC Davis, may be overstated by 25%)

*Feces & urine as voided. All values wet basis from a typical live animal

USDA Agricultural Waste Management Field Handbook Ch 4-17 concurs:

Wt lb/da/1000# horse	50.0
Vol ft3/da/1000#	.8
TS lb/da/1000#	11.0
VS "	9.35
FS "	1.65
N "	0.28
P "	0.05
K "	0.19
C:N ratio	19.0

TABLE 3
Pathogens excreted by livestock and transmitted to humans through water

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List of pathogens of primary concern that can be shed in the feces of livestock and transmitted to humans through water.

Waterborne protozoa pathogens of primary concern (known livestock component)	**Special concerns and comments**
Cryptosporidium parvum	Low infectious dose; environmentally resistant oocysts; oocyst 5 x 5 microns
Giardia duodenalis	Low infectious dose; environmentally resistant cysts; zoonotic potential under debate; cysts approximately 12 x 15 microns
Waterborne bacterial pathogens of primary concern	size ranges from 0.2 x 1.5 to 1.5 x 6.0 microns
Campylobacter spp.	Common in livestock and wild birds
Salmonella spp.	Common in livestock feces
Pathogenic strains of *E. coli*	Can be highly virulent for humans
Yersinia spp.	Swine are considered a primary reservoir; apparent low annual incidence in humans

Pathogens of secondary concern whereby livestock have either no role or an unclear role in human waterborne infection have also been listed.

Waterborne protozoa pathogens of secondary concern	
Toxoplasma gondii	Felines are the definitive host, not livestock
Balantidium coli	Swine suspected, but no clear role
Entamoeba histolytica	Human reservoir
Cyclospora cayetanensis and microsporidia (*Enterocytocytozoon bieneusi, Septata intestinalis*)	Unknown reservoir and livestock not known to shed these protozoa at this time
Waterborne bacterial pathogens of secondary concern	
Clostridium perfringens types A & C	Waterborne transmission unclear
Listeria monocytogenes	Waterborne transmission unclear; human infection typically foodborne
Brucella spp.	Waterborne transmission unclear
Leptospirosis interrogans	Waterborne transmission unclear; human infection typically by direct contact
Waterborne viral pathogens from livestock	Little scientific evidence that viruses shed in the feces of livestock pose a health threat to humans in the U.S.A.