

Mitigating Silt and Microbe Risks in Flooded Forages

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The recent flooding has left behind many silt-covered fields. This has raised concerns that harvested feed may be contaminated with microbes and other contaminants. Proper management of these risks will be necessary to reduce negative impacts on livestock.

SILT REDUCES FEED QUALITY

Many flooded fields are covered with a layer of silt. The amount of silt on plants differs from field to field. Depending on the forage type, <10% soil ash is a conventional feeding limit, above 10% poses a higher risk to animals. Consider hand sampling silt laden forage and submitting for ash analyses. Keep in mind most grasses typically have <8% ash as inherent mineral content; legumes <15%. Total ash values greater than these values can be attributed to soil contamination.

Soil contamination will be much worse for corn silage than for corn harvested for grain since most of the soil is trapped on the leaves and stalk. If possible, heavily silted corn should be harvested for dry or high moisture grain. However, if harvested for silage, the feed should be analyzed for total ash and minerals (including heavy metals). Normal corn silage has about 3.0% to 5.5% ash (dry matter basis) but flood-damaged silage could have greater than 6.0%. Some forage reports from this season have shown over 20% ash content. This means that for every 5 pounds of silage, the cow is consuming 1 pound of dirt. Soil contamination will reduce the energy value of silage and can also reduce availability of some essential minerals, especially copper.

There is little data that documents how high levels of ash will impact livestock productivity. Standard forage quality tests in collaboration with the farm's nutritionist/feed consultant will help you determine modifications required to feed programs.

Heavy Metals - Fields that were flooded with high-risk contaminants (i.e. fields downstream from waste water treatment plant, dumps, gas stations, etc.) may potentially have silt deposited on plants that is high in heavy metals. It is recommended that at least one sample be taken as 'green' forage from the suspect field as it is delivered to feed storage areas. Taking 15-20 grab samples should be sufficient to analyze for heavy metal content. Having a clean plastic bucket sitting near the area can serve as a sampling container. Taking grab samples as the loads come in will help to make sure the field is well represented in the sample. The contents of the bucket should be mixed, and an approximate one-pound sample placed in a gallon size plastic bag. Remove as much oxygen from the bag as possible.

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Samples can be stored in the freezer prior to transport to the laboratory. One heavy metal test per field or set of high-risk fields will be sufficient to document any potential heavy metal contamination. When analyzing forages for heavy metals and/or mineral concentrations, wet chemistry is required. The NIR equipment does not accurately analyze for minerals. Furthermore, high ash contents will produce inaccurate NIR results of other components such as dry matter, crude protein (CP) and fiber.

Heavy metals of concern include lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As). In recent forage analyses from flooded corn fields, there have been reports of extremely high iron (Fe) concentrations in the feed. Iron toxicity can cause diarrhea, metabolic acidosis, hypothermia, and reduced gain and feed intake (National Research Council, 1980). The maximum tolerable concentration of iron for cattle has been estimated at 1,000 ppm (National Research Council, 1980). Dietary iron concentrations as low as 250 to 500 ppm can also cause copper depletion in cattle (Bremner et al., 1987; Phillippo et al., 1987a). "Mineral Tolerance of Animals" was published in 2005 by the National Academy of Sciences/National Research Council and this book provides estimates of the maximum tolerated level for several elements in complete feed. The maximum tolerable levels of dietary nutrient for domestic animals are shown in Table 1. These levels are expressed in terms of parts per million (ppm) or percent (%) in the total diet. If levels in flooded forage are greater than the FDA recommendations, you should work with a nutritionist and/or vet to

Table 1. Maximum Tolerable Levels of Dietary Minerals for Domestic Animals

Element	Species					
	Cattle	Sheep	Swine	Poultry	Horse	Rabbit
Aluminum, ppm	1000	1000	200	200	200	200
Arsenic, ppm	-	-	-	-	-	70-150
Inorganic	50	50	50	50	50	50
Organic	100	100	100	100	100	100
Iodine, ppm	50**	50	400	300	5	-
Iron, ppm	1000	500	3000	1000	500	500
Cadmium*, ppm	0.5	0.5	0.5	0.5	0.5	0.5
Chromium, ppm						
Chloride	1000	1000	1000	1000	1000	1000
Oxide	3000	3000	3000	3000	3000	3000
Lead*, ppm	30	30	30	30	30	30
Mercury*, ppm	2	2	2	2	2	2
*levels based on human food residue concentrations						
** may result in undesirably high iodine levels in milk						

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develop a TMR or ration that will reduce heavy metals to an acceptable level. The TMR will need to be tested prior to feeding to assure that heavy metals concentrations meet acceptable ranges. Regulatory action for elements in feed and feed ingredients will be decided on a case-by-case basis.

It is recommended that a soil test also be taken from these fields in the fall or early spring. This will help confirm if heavy metal levels will potentially pose problems for the crops to be grown in the following season.

Heavy metal testing in forage and soil can be conducted through several certified testing laboratories around the region including the University of Vermont Agricultural and Environmental Testing Laboratory (<https://www.uvm.edu/extension/agricultural-and-environmental-testing-lab>), Dairy One (<https://dairyone.com/>), and Cumberland Valley (<https://www.foragelab.com/>).

Clostridia - Other feed quality issues can arise from silt-covered silage. Clostridia are naturally present in the soil and therefore silt-covered crops may contain high levels of clostridia bacteria. You will easily recognize silage that goes through clostridial fermentation because it has a putrid and rancid odor. Clostridial fermentations stink because of the high levels of butyric acid, amines (e.g. putrescine and cadaverine), and ammonia that are produced through these fermentations. Clostridia are anaerobic (no oxygen required) bacteria that convert forage sugars and organic acids in butyric acid, carbon dioxide, and hydrogen gas. Clostridia bacteria prefer conditions of high pH and moisture. If corn silage has a final pH of 4.2 or less, then there will probably be no clostridial problems. A simple pH test of the silage would provide this information. Therefore, management techniques that help in a rapid reduction in silage pH will help minimize risks of clostridial fermentation. These techniques include rapid fill of storage area, aggressive packing, addition of a lactobacillus inoculant, and harvesting feed above 34% dry matter. Silage that has undergone clostridial fermentation can reduce intake and increase blood ketone levels of livestock. The main management approach to minimize the risk of clostridial fermentation is to harvest corn silage and haylage at dry matter above 34%. Regular inspection of ensiled feed will help identify clostridial fermentation. Additional testing to evaluate volatile fatty acid profiles (VFA), ammonia, and pH will help further management of the forage. Clostridial feed should not be fed to transition and high DMI cows. Clostridial feed should be diluted to contain less than 50 grams of butyric acid per day. It is best to dispose of silage that has very high butyric content (>2%). Ultimately a strategy should be developed between the farm, veterinarian, and nutritionist. Testing can be conducted through several certified forage labs listed above.

MOLDS AND MYCOTOXINS

Yeast and molds will alter fiber integrity and will decrease fiber digestibility of forages. They will also reduce the capacity of the fiber to float and to build an effective rumen mat. As these fungi grow, feed quality is depleted. Available carbohydrates and other nutrients are converted to carbon dioxide and other fungal metabolites not readily available as animal nutrients (DiCostanzo). Yeast and mold alone can negatively affect animals' productivity and health. Absence of toxins does not guarantee "safe" feed. Animal health issues as a result of yeast and mold include reduced intake, reduced palatability, reduced energy consumption due to high inert mineral intake, reduced rumen function from "wild" yeasts and molds

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competing with normal rumen microflora; lastly actual toxins affecting the animal.

While most fungi only reduce the yield or nutritive value of the feed they infest, some fungi can produce toxic chemicals called mycotoxins. Mycotoxins are complex organic compounds that are produced by some fungi to increase its impact on the plant. In addition, saprophytic fungi (fungi that help to decompose plant material) will release toxins to outcompete other fungi or bacteria. Once produced, these toxins cannot be destroyed by heat, time, or fermentation. These toxin-producing fungi did not have animals in mind as part of their environmental competition. The affect on animals and humans is purely coincidental due to the similarity of affected metabolic systems.

TOXINS OF CONCERN AND THEIR CONDITIONS FOR GROWTH

In the United States, some of the primary toxin producing fungi found in silage includes *Fusarium* and *Aspergillus* (Shurtleff). Several toxins of great concern are produced by *Fusarium* and include vomitoxin (DON), fumonisin, zearalenone, and T-2. *Aspergillus* is known to produce aflatoxin. All of these fungus toxins have been associated with acute, chronic, and sub chronic diseases of livestock.

In the United States, the aflatoxins are the only mycotoxins that are formally and specifically regulated. Aflatoxin, the most serious carcinogen, can be found in high levels in peanuts, corn, cotton seed, and grain and can contaminate milk. This toxin is a serious problem for human and animal health and can contaminate corn in warmer growing regions. Aflatoxin can be transferred into meat, milk, cheese, and eggs if fed to livestock. The FDA has established specific guidelines on acceptable levels of aflatoxins in human food and animal feed by establishing action levels that allow for the removal of violative lots from commerce (Table 2). The action level for human food is 20 ppb total aflatoxins, except for milk, which has an action level of 0.5 ppb for

Table 2. The FDA has issued regulatory levels for AFLATOXIN as follows:

For	Level	Commodities
Humans	20 ppb	All food except milk
All animal species	20 ppb	All Feed (exceptions below)
EXCEPTIONS:		
Breeding cattle and swine, mature poultry	100 ppb	Corn
Finishing swine (>100lbs)	200 ppb	Corn
Finishing beef cattle	300ppb	Corn

aflatoxin M1. The action level for most feeds is also 20 ppb.

Aflatoxin requires warm (optimum 81 to 86° F) and moist conditions. Where fall conditions are cool, aflatoxin is rarely found. For example, in Vermont fall conditions are often wet, but temperatures normally average between 50 and 60 degrees. On corn in the field *Aspergillus flavus* is evident as a greenish-yellow to yellowish-

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brown, felt-like or powdery mold growth on or between the corn kernels. It is highly unlikely that flooded corn will contain aflatoxins. Preharvest aflatoxin contamination of corn is favored by high temperatures, prolonged drought conditions, while warm temperatures and high humidity favor postharvest production of aflatoxins. Neither of these conditions were present in the 2011-growing season.

Fungi in the '*Fusarium*' family produce many of the mycotoxins common in the Northeast. *Fusarium* produces toxins between 45- and 75-degrees Fahrenheit. The fungi itself is ubiquitous and found in the soil, plant residue and even blown around through air currents. Corn ears can be infected through the silks at flowering or through any type of damage such as insect feeding in ears, stalks, or roots (Farar). As the fungus grows in the plant tissue, it may or may not form toxins in high enough levels to cause contamination problems in feeds. However, a common scenario for high levels of *Fusarium* toxin infection in corn starts with wet conditions during silking accompanied by insect damage to silks. The fungus infects the silks directly or through insect damage and grows down the silks and infects the kernels and cob. The longer corn is allowed to stand in the field after maturity, the greater the likelihood of significant toxin development. Levels of *Fusarium* toxins can be the result of a continuous accumulation of toxin over time during the growth period and continuing after maturity and into storage until oxygen becomes limiting or, in the case of grain, moisture is reduced to less than 20%.

The following are descriptions of *Fusarium sp.* produced mycotoxins common to this area.

Fumonisin B1 is produced by *Fusarium verticillioides* and is mainly found in corn. High levels are often found when there are hot and dry weather conditions followed by period of high humidity. This mycotoxin is known to cause leukoencephalomalacia in horses, and pulmonary edema in swine. Fumonisin B1 is much less potent in ruminants than in hogs and has recently been shown to be toxic to sheep, goats, beef cattle, and

Table 3. FDA guidance levels for total fumonisins in animal feeds.

Class of animal	Levels in corn & corn by-products	Levels in finished feeds
	ppm	ppm
Equids and Rabbits	5	1
Swine	50	10
Breeding ruminants, breeding poultry*	30	15
Ruminants \geq 3 months old being raised for slaughter	60	30
Poultry being raised for slaughter	100	50
All other species or classes of livestock	10	5

*includes lactating dairy cattle and hens laying eggs for human consumption

dairy cattle. U.S. Food and Drug Administration guidance levels can be found in Table 3.

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Deoxynivalenol (DON) is a *Fusarium* produced mycotoxin, commonly detected in feed. It is sometimes called vomitoxin. Swine are more sensitive to DON than dairy cattle. This mycotoxin can impact the immune and gastrointestinal tract systems. The U.S. Food and Drug Administration advisory levels for deoxynivalenol can

Table 4. FDA advisory levels for total vomitoxin (DON) in animal feeds.

Class of animal	Levels in grain & grain by-product	Levels in finished feeds
	ppm	ppm
Ruminating beef and feedlot cattle older than 4 months	10	5
Chickens	10	5
Swine	5	1
All other animals	5	2

be found in Table 4.

T-2 toxin is a very potent *Fusarium* produced mycotoxin. The effect of T-2 on dairy cattle includes gastroenteritis, intestinal hemorrhages and death. Guidelines for T-2 toxin are not established, but avoiding levels above 100 ppb has been recommended.

Zearalenone is a *Fusarium* produced mycotoxin that is chemically like estrogen and can produce an estrogenic response in animals. Symptoms in heifers have included vaginitis, vaginal secretions, poor reproductive performance, and mammary gland enlargement. Its production is favored by high humidity and low temperatures. Currently there is no FDA action, advisory, or guidance levels established for zearalenone in US feed. However, reproductive problems in dairy cattle have been associated with Zearalenone concentrations of about 400 ppb.

There are other various genera of fungi that can produce toxins. Regardless, all these fungi have three critical environmental requirements:

- temperatures above freezing,
- moisture above 20%, and
- oxygen.

Limiting any one of these requirements will reduce or prevent the production of toxins. When considering silage, it is neither practical nor desirable to limit temperature or moisture. Limiting oxygen is the key to successfully limiting toxin production during the fermentation process. Oxygen is like a light switch. It can turn toxin production on and off during storage. Therefore, one of the best management strategies to mitigate further production of toxins is to create optimum fermentation conditions. This includes practices stated earlier as well as those outlined in the University of Vermont Extension Bulletin “Managing Flood Damaged Crops and Forage” (https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/Articles_and_Factsheets/Managing_Flood_Damaged_Crops_and_Forage_Updated_July_2023.pdf).

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MONITORING FLOODED FEED FOR TOXINS

There is a chance that flooded fields may become infected with fungi that also have the potential to produce toxins that can harm animal health. Monitoring for yeasts, molds, and mycotoxins in flooded feed will be critical.

First and foremost, it will be important to document that aflatoxins are not present in corn harvested for silage or grain. Given the Vermont climate it is unlikely that this mycotoxin is present. However, the FDA as well as milk haulers will want to know that there is no risk of aflatoxin contamination. Although there are many strategies for sampling aflatoxins, a simple and effective strategy is to select 20 corn ears from a flooded field that exhibit signs of moderate to severe mold growth. Put the corn ears in a paper bag and store in a cool and dry place if they cannot be sent to the lab immediately. Contact the closest UVM Extension Specialist to pick up the sample as soon as possible. The ears will be dried, ground, and analyzed using a reputable immunoassay test. Other certified labs are also capable of testing corn grain for aflatoxin levels. If aflatoxins are found above the FDA regulatory levels, feed may be condemned. The above testing protocol prior to harvest will determine if further testing for aflatoxins in milk, meat, and eggs need to be conducted. If corn has been harvested, aflatoxin testing can still be conducted on stored feed. Procedures are outlined below for post-harvest mycotoxin testing.

Other potential mycotoxins (DON, T-2, Fumonisin, Zearalenone) should be analyzed once the feed has been harvested and completely ensiled (3 to 4 weeks post-harvest). Feed analysis of mycotoxins is often hindered by the difficulty in gathering a representative feed sample. Obtaining representative feed samples can be difficult because mold growth is inconsistent, and mycotoxins are non-uniformly distributed within a feedstuff. Visible mold may not have any mycotoxins. Conversely, it is also possible to NOT see any visible mold and have relatively high levels of mycotoxins. This is what makes management and the potential identification of mycotoxin feeding problems so difficult.

If corn was flooded and silt covered, it would be wise to take regular yeast, mold, and mycotoxin tests from stored feed. A monthly sampling regime would be recommended for farms that harvested fields with high-risk contaminants (i.e. fields downstream from waste water treatment plant, dumps, gas stations, etc.). In most other cases, testing would be limited unless marked changes in herd health are documented/observed with little or no explanation available. The farm veterinarian and nutritionist should request a mycotoxin analysis to help explain herd health issues.

Sampling Recommendations

If yeasts, molds, and/or mycotoxins are suspected to be causing herd health issues, both the stored forage and the total mixed ration (TMR) (if available) should be sampled.

There are several acceptable ways to collect a sample from the TMR. One strategy is to place small clean plastic buckets in the feed mangers and fill as TMR is fed out to the livestock. Take the plastic buckets and flip over, split the pile in quarters, and take a grab sample from each quarter. Make sure to mix all grab samples and collect an approximate 1.5-pound sample. The sample should be put in a gallon size freezer

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bag; air squeezed out of the bag and put in the freezer. This protocol should be replicated for at least 3 to 4 feedings. Once all samples are collected, one final composite should be prepared for submission to the lab. Prepare a final 2-pound composite to submit to a laboratory for testing, and keep an additional 2-pound composite frozen for forage quality analysis.

Sampling for yeast and mold concentrations should also be done regularly, but these samples should not be frozen. The samples should be kept cool (not frozen), shipped cool (with ice packs), and as quickly as possible to get the most accurate analysis of yeasts and molds.

Sampling the feed in the storage area is also an important component of the testing procedure. Knowing the mycotoxin level of the feed could potentially help identify problematic areas in the storage area. When sampling the storage area, use a loader (or other appropriate equipment) and scrape across the face the quantity of silage to be fed. Move the silage to an area away from the face. From this pile take 15 to 20 grab samples. Alternatively, the silage could be put in a mixer wagon, mixed, and unloaded and then sampled. The samples should be placed in a clean plastic bucket. Samples are mixed and subsample extracted and frozen. The process is repeated at 3 to 4 feedings. A final 2-pound sample should be submitted to the lab.

Remember that even if only the TMR is submitted for testing, sampling the storage area is very important. If the TMR is high in mycotoxins, it may help to pinpoint causative problem areas in the storage facility. It may enable you to avoid or remove the problematic feed.

Once the forages have been sampled, they should be sent to a reputable lab for mycotoxin testing. Most labs will perform mycotoxin analysis through one of two tests, a quick test or confirmatory test. The confirmatory test gives exact toxin levels present in the feed. Whereas the quick test primarily identifies mycotoxin presence in the forage. Costs for mycotoxin tests vary for both kinds of tests. Quick tests often range from \$10 to \$50 per sample. Confirmatory tests generally cost \$75 to \$150 per sample, depending upon methods used and the number of mycotoxins included in the scan. Testing from some laboratories may require 7 to 14 days or more from submission until a report is received.

MANAGING FEED WITH MYCOTOXINS

It is not recommended to feed forage that has been flooded. However, in some cases it may be the only feasible option for a farm. Knowing that flooded feeds may cause herd health issues can help you prepare to mitigate these risks. Mitigation of these risks starts at harvest time. Remember, best harvest and storage practices will help reduce some mycotoxin and other microbial issues.

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Once flooded feed is being fed, herd health should be monitored closely through routine vet clinics or other farm clinics. Before feeding flooded forage, consult a nutritionist. Flooded forage should be fed in limited amounts and should not be fed to the most at risk animals such as close up dry cows, fresh cows, and young calves.

Unexplainable herd health problems may indicate mold, yeast, or mycotoxin issues and testing should be implemented. Positive results that exceed guidance or advisory levels will likely require a change in the feeding regime. When mycotoxins are at potentially harmful levels, forages should be fed at restricted levels and even discontinued at least temporarily if performance problems cannot be rectified. A farm veterinarian and nutritionist can help make decisions on how best to utilize the problematic feedstuffs to minimize herd health risks.

ADDITIONAL FLOOD RELATED ARTICLES

Flood Damaged Forage Considerations: Documenting Damage, Cutting Losses, Avoid Compounding the Damage (https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/Articles_and_Factsheets/Flood_Damaged_Forage_July2023.pdf).

Managing Flood Damaged Corn (https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/Articles_and_Factsheets/Managing_Flood_Damaged_Corn_Updated_July_2023.pdf).

CERTIFIED LABORATORIES FOR SOIL AND FORAGE ANALYSIS

Lab	Phone	Email	Soil	Forage	Mycotoxins
UVM Agricultural & Environmental Testing Lab	(802) 656-3030	www.uvm.edu/extension/agricultural-and-environmental-testing-lab	X		
Dairy One Laboratory	(800) 344-2697	https://dairyone.com	X	X	X
Cumberland Valley Analytical Services	(301) 790-1980	www.foragelab.com			X

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