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Reducing Mud Problems in Cattle Heavy Use Areas With Coal Combustion By-Products (Fly Ash)

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Introduction

One of the many challenges on beef and dairy farms is the design and management of cattle heavy use areas. These areas are those locations where frequent cattle traffic and loafing prevents adequate grass growth. During wet weather, heavy use areas can also decrease cow comfort and health due to exposure to mud and pathogenic organisms in the mixture of soil, urine and manure. On dairies, the excessive mud increases labor during milking due to the extra cleaning that is required. Since these areas allow the mixing of rainwater, soil, urine and manure, any runoff water from these areas is a potential source of water pollution.

While is it not possible to completely eliminate these heavy use areas, it is possible to minimize both the size and impact of these areas. As mentioned in *Runoff Water Management for Animal Production and Environmental Protection* (FSA1036), the first step in managing heavy use areas is to reduce the amount of "clean" water that enters these areas. The next step is to slope these areas so that the water that does enter these areas is quickly drained. The final step is to use vegetation to filter the runoff water. However, even after these steps are taken, some soils and situations will still need additional efforts to address mud problems.

Traditionally, heavy use areas have been improved using concrete or gravel. While concrete is very durable, it is also expensive. On the other hand, gravel, while cheaper, has a tendency to have a limited life. Recently there has been interest in using the ash generated by the burning of coal to generate electricity to improve these heavy use areas.

Nationwide, an estimated 60 million tons of this ash is generated each year. Much of it is currently being land filled. Some is used as an amendment for concrete and as a soil stabilizer in road construction. To avoid disposal cost and to recycle a potentially valuable resource, additional uses are constantly being sought.

A unique feature of this ash is its "pozzolanic reaction." This pozzolanic reaction is due to the silica and alumina in the ash that will chemically react with calcium. As a result, the addition of water to some coal ashes causes them to set up in a manner similar to concrete. The chemical and physical characteristics, as well as the strength of the final product, depend on the initial chemical composition of the coal, whether lime is added during the combustion process to control emissions, how the ash is processed at the plant and how it used in the field.

Fly ash is typically extracted from the stack gases and tends to be a very fine powder with the consistency of talcum powder. It is very fluid and flows much like water, making transportation and handling a challenge. Due to its small particle size, it is very prone to blow in the wind. It is usually relatively high in pozzolanic activity and therefore has more market value than bottom ash.

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In contrast, bottom ash, which is typically removed from the bottom of the broiler, is like very fine gravel or coarse sand. As such, it is significantly easier to transport and apply than fly ash. However, much of its pozzolanic activity has often already been used when ash is exposed to water used to move it to storage ponds where it is stored until utilized.

Out-of-State Projects

In a study done by USDA-ARS in Pennsylvania on a dairy loafing lot, 33 tons of fly ash were applied on top of the soil in a 900 square foot area. This created a pad about 12 to 14 inches thick. In this study, water seeping from the pad was analyzed for various elements and heavy metals. While minute traces of elements like calcium and nickel were identified, the concentrations were below EPA drinking water standards.

In a study done by Iowa State University at a beef cattle feed lot, ash was mixed into the soil rather than making a pad on top of the soil. In this study the ash had relatively high calcium oxide levels because limestone was used during combustion to control sulfur emissions. The concept in this study was to mix the ash into the soil to allow it to pozzolanicly react with the calcium oxide and silica in the soil.

This reaction increased the soil's ability to support the cattle and keep them out of the mud. The soil strength of the untreated areas ranged between 0 and 74 pounds per square inch. The treated areas were able to support loads between 76 and 368 pounds per square inch. It is estimated that a 1,400-pound cow creates a load of about 40 pounds per square inch while walking.

Arkansas Projects

In the late 1990s, several Arkansas dairies in Yell and Washington counties were the sites of coal ash implementation demonstrations. These demonstrations were designed to answer questions about use of coal ash. Preliminary information demonstrated that using coal ash as a pad on the soil and mixing the ash with the soil are both effective in supporting cattle and equipment traffic.

On two sites, fly ash was mixed with soil. The first site was next to a feed bunk where wet soil conditions routinely prevented the soil from supporting a tractor and feed mix wagon. At this site, ash was mixed with clean clay soil brought onto the site. This mixture was then placed in a wide trench that was excavated to an average depth of 18 inches. The second site (where ash and soil were mixed) was a cattle travel lane that was treated to a depth of about 8 inches. In this situation, the fly ash was mixed with the existing soil. At both of these sites, the mixing was accomplished using the blade of a bulldozer. A water truck with spreader bar was used to increase the moisture content prior to compaction. In both cases, it was difficult and time consuming to thoroughly mix, water and compact the fly ash/soil mixture. It is expected that for shallower mix depths a plow and/or disc would mix the material adequately. In terms of thorough mixing, a PTO-powered tiller would be ideal. Since treatment, the soil/ash mixtures at these sites have supported vehicle and cattle traffic, even under wet conditions. However, the increase in the load-bearing capacity in the cattle travel lane was less than the feed bunk area. This was due, in part, to less ideal soil for mixing and the difficulty in mixing.

Fly ash being delivered to the farm where it will be mixed with clay soil prior to watering and placement. The mixing area is an existing road surface with the clean clay material for mixing windrowed on each side of the road.

On three other sites, fly ash was used to make pads on the soil surface. On two of these sites, a travel lane and the area around a watering trough have held up well. One pad placed at the entrance to a commodity barn failed when the tractor broke through. This failure occurred when the 4-inch pad failed to support a tractor when the soil under the

Mixing of fly ash and clean clay soil.

pad became saturated. This failure emphasizes the importance of proper design and using the minimum pad thickness required to support the expected load. It also helps to emphasize the importance of water drainage.

Watering of mixture of fly ash and soil during placement and compaction.

Another demonstration in Van Buren County installed a blend of fly ash and bottom ash to build a pad for a cattle travel lane and a feeding area. This bottom ash blend (BAB), due to its soil-like characteristics, proved to be very easy to work. It also resulted in a very durable surface that has held up well to cattle traffic. Another major advantage of this blend of bottom and fly ash was that it was mixed prior to delivery to the farm. This simplified the installation to a process of excavating the existing soil/manure mixture to firm soil, placing the BAB and finally compacting the BAB.

A Design Approach to Heavy Use Areas

At all of the Arkansas sites, the focus had been primarily on the use and benefits of coal ash products to strengthen the soil so that it will support cattle traffic during the wet winter months. What these limited projects did not do was to address clean water diversions and treatment or conditioning of runoff water. Information on managing the runoff water from cattle traffic areas can be found in *Runoff Water Management for Animal Production and Environmental Protection (*FSA1036), which is available at your county Extension office or the publication section of the Extension Service's web site (www.uaex.uada.edu).

To address these shortcomings, an EPA 319(h) funded project was conducted to take an existing dairy and redesign the cattle traffic areas to increase the ability of the heavy use areas to support cattle traffic. The design objective was to obtain both production benefits and environmental benefits of a properly designed and implemented heavy use area. The cattle production benefits stem from a reduction in mud. The environmental benefits are derived from the reduction of clean runoff water exposed to bare soil and manure and the treatment of the remaining runoff water with vegetated filter strips to trap sediments and nutrients.

In this project, the existing travel lane (that was narrowed) and an open lot (that had previously served as a loafing area) were covered with a 10-inch pad of a blend of bottom and fly ash. In addition, the loafing area was shaped to form a ridge so that 100 feet of feed bunks and two waterers could be installed along the ridge. The addition of feed and water to the loafing area will allow the cattle to be kept out of the mud and prevent the cattle from creating muddy conditions elsewhere on the farm during wet weather.

Before the pads were built, roof gutters were installed on a side of a hay barn that dumped clean rainwater onto the cattle travel area. The captured rainwater was piped under the travel lane to an adjacent pasture. Then the travel lane was scraped to remove accumulated manure and to get down to firm

Blend of bottom ash and fly ash being delivered to the heavy use area. The existing top layer of manure and mud has already been removed and land applied.

Blend of bottom ash and fly ash being spread and packed.

soil. The blend of bottom and fly ash was land applied to pasture. Then dump trucks and a bulldozer were used to deliver, spread and partially pack the ash blend. During the spreading of the ash, a water hose was used as needed to help control dust. Because the soil was moist and rain was expected in the next couple of days, no effort was made to supply enough water to initiate the chemical reaction that causes the ash to set. However, prior to the rain and after the rain, a homemade, water-filled roller was used to smooth and pack the pad.

Cattle were able to walk on the packed pad surface immediately even though it had not chemically reacted. After the pad absorbed water from the soil and rainfall, it reacted chemically and became a hard surface.

Bottom and fly ash pad feeding and watering area after a month of wet weather use. Note that while there is a thin layer of wet manure, the area is supporting the cattle traffic.

The installation of the pad confirmed that readily available equipment like bulldozers, dump trucks and tractors work well to apply the blend of bottom and fly ash. In addition, it was determined that while water should ideally be added to the blended ash as it is being applied and packed, it will absorb the necessary water from the soil and rainfall to cure and form the desired hard surface. However, packing of the surface is critical to ensure that the ash blend bonds into a hard surface. Without packing, the ash reacts but does not bond to itself, and the resulting surface is more like a packed gravel surface than a solid concrete pad.

Summary

Experiences from across the nation and the Arkansas demonstrations show the promise of coal ash in reducing the impacts of excessively muddy conditions on cattle operations. With proper design, cattle heavy use areas can usually be reduced in size and do a better job of keeping cattle out of the mud. To properly design a heavy use area, the practices covered in *Runoff Water Management for Animal Production and Environmental Protection* (FSA1036) should also be followed. Where appropriate, coal ash products can be used to strengthen the soil of the heavy use area.

There are two basic approaches to using coal ash to minimize mud problems in high cattle traffic areas. The first is to mix fly ash with a clay soil, then water and compact it into place. The second approach is to use either pure fly ash or a blend of fly and bottom ash to build a pad on top of the soil. Soil mixing is probably the most difficult to implement correctly due to the need for the proper type of clay soil and the difficulty in on-farm mixing of soil and ash. Due to the fine powderlike nature of fly ash, specialized equipment is needed to handle fly ash. The simplest method to utilize coal ash products is to purchase a blend of bottom and fly ash that is mixed prior to delivery to the farm. This material can be delivered in dump trucks, spread with bulldozers or tractor blades and packed with either tracked or rubber-tired equipment.

Key Utilization Concepts

- Coal combustion products are very variable in reactivity and, therefore, ability to set into a firm load-supporting surface.
- Fly ashes have not had water added and are, therefore, still reactive. The level of reactivity varies with both the supplier and time.
- Bottom ashes typically have already had water added and, therefore, have very little reactivity left. They should be thought of as a filler or bulking material to be mixed with fly ash.
- The two basic approaches to using coal ashes are to build a pad from blended fly and bottom ashes on the ground surface or to mix fly ash with the soil as an amendment. Due to the difficulty with soil mixing, it is not generally recommended. Experience has shown that while the soil mixing approach can produce a good surface, it is much more difficult to implement than using the blended ashes.
- The problem with using pure fly ash is that it has the consistency of talcum powder. Because of this, it must be hauled in special pneumatic trailers and is extremely dusty to work with.
- Ideally, the end user is better off if the supplier mixes about 70% bottom ash to 30% fly ash on a volumetric basis. This makes a material with a soil-like consistency that is easy to transport and handle at the application site.

- If the supplier won't be supplying a premixed material, it can be mixed onsite. It is possible to use a CLEAN clay soil material instead of bottom ash; however, the mix ratio should probably be changed to 50:50 volumetric.
- To build the pad, remove surface manure and mud to get down to firm sub-material. Generally, since the pad will bond together, filter fabric should not be required.
- For areas that will only have cattle and light tractor traffic, a pad with a precompaction depth of 10 inches should be sufficient. However, for heavy loads such as mix wagons, the initial precompaction pad thickness should be increased to 18 to 24 inches.
- Concerns about surface drainage need to be addressed and corrected. Ideally, the only rainwater entering the area when finished will be direct rainfall. In addition, there should be positive drainage off of the pad.
- During installation of the ash, adding water and compaction are critical. IF ADEQUATE HYDRATION AND COMPACTION DO NOT TAKE PLACE, THE FINAL PAD STRENGTH AND LIFE WILL BE SIGNIFICANTLY REDUCED. This is especially true when using pure fly ash or soil mixing. When using a blend of bottom and fly ash, soil moisture and rainwater supplied within a few days will work.
- When adding water, it is possible but very difficult to add too much water. Ideally, the final moisture content should be about 25%. It should be moist to the touch, but you should not be able to squeeze out water. If too much water is added, either add more ash (preferred) or let the material dry a day or two, then compact. Remember, it is better to use slightly too much water than not enough.
- Compaction can be provided by tracked or rubber-tired equipment. Usually the rubber-tired equipment will pack better but may leave ruts unless care is taken. Water-filled rollers have proved to be effective at packing and smoothing the surface. To help ensure adequate compaction, the material should be packed in 6- to 8-inch layers or less.
- It would be best to add moisture and compaction as the pad is built.
- If fence posts will be placed in the treated area, it is strongly recommended that they be driven in before the material cures. After curing it will be difficult to impossible to do so.
- The material takes about a month to reach near ultimate strength. However, under dry weather conditions, cow and equipment traffic should be acceptable immediately after construction. For wet weather conditions, a 12- to 24-hour or more cure period should be attempted if possible.
- After curing, the treated area should develop a hard, stonelike surface. However, it will not be quite as durable as concrete. Therefore, while routine scraping to remove accumulated manure is required and recommended, care should be taken to prevent gouging the surface with scraper blades.
- It has also been observed that these surfaces are subject to erosion from roof line drips. Therefore, this, in addition to the need to divert clean water from heavy use areas, is reason to gutter appropriate roof lines.
- **Cautionary note:** This material has a pH of 10 or 11. This means that it does not need to be used in conditions where the unreacted ash is added to ponds and creeks. Once set, there are no documented concerns regarding runoff and leachate water from the ash.

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