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Bachelor of Science

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Abstract:

This study was conducted in order to determine the most cost effective and environmentally friendly method for cleaning the free-stalls at the Cal Poly dairy. Four separate products, Terra-Firma, bleach, Wash Safe Stable & Kennel and a power washer, were tested on lanes at the Cal Poly dairy and observed for effectiveness. Each lane was visually inspected daily to better observe cow preference and product effectiveness. Furthermore, each lane was tested for water turbidity post flushing for one week to better examine each products longevity. With each product and method totals for labor and product costs were compared and reviewed. These tests helped to better evaluate which product may be a better suited process for the Cal Poly dairy. Results showed that through visual inspection the Terra-Firma product performed the best keeping the amount of visible filth minimal long after application. While bleach was effective initially it quickly faded. Power washing was cheapest although it took considerably longer in application than any of the other methods. The Stable and Kennel wash was overall ineffective. The turbidity testing of lanes showed similar results, Terra-Firma maintained a much less turbid water overall. The success of Terra-Firma proved it to be the best product. Although the product itself was considerably more expensive than the others. With all considerations taken into account the Terra-Firma product will be environmentally and economically a sound option for the Cal Poly dairy. This study may better be completed if the proper spray applicator had been used for the Stable and Kennel wash. Also a more in depth analysis of the long term effects of the microbial products on lagoon water quality, this may lead to a secondary benefit to the use of microbial washes.

Intro:

Cow comfort and foot health are vitally important to maintaining high milk production on any dairy (Warnick et al.). Maintaining cleanliness of free-stall lanes has long been a struggle for many dairymen, ineffective or overpriced methods have been used on the Cal Poly dairy before with no significant results (personal contact Rich Silacci). It has recently become apparent that the Cal Poly dairy must find an environmentally safe, effective, and efficient product which will help remove a majority of the excrement and waste found on these concrete lanes. Not only should the product be successful at removal but also to help keep the filth from returning over an extended period of time. A product which could successfully do these things would greatly benefit the dairy both through cost effectiveness and milk production.

As we examined different products it was important to consider the ease of application and each products effects on the animals and environment. A microbial based product was suggested for use and purchased made by ACT Bioremediation Inc. this powder like product uses living organisms to break down animal waste. Also used were two techniques which had been used at the dairy before; power washing and bleach. Finally, a product similar to hydrogen peroxide from Wash Safe Industries, the Stable & Kennel wash was used, however the product required a more commercial sized spray applicator than was used. Previous cleaning methods used by the Cal Poly dairy include hiring a professional concrete cleaning company, which proved not to have lasting effects and was extremely expensive. After reviewing a number of possible cleaning methods and products four separate experiments were decided upon. Each of these products and methods were selected for different

reasons from environmental friendliness to cost. The objective of this experiment was to determine the best method of cleaning the concrete free-stall lanes at the Cal Poly dairy.

Literature Review:

In the California Dairy industry dairyman are becoming more aware of the need for environmentally friendly products that can improve cow comfort and milk production. One of the greatest impacts on milk production is lameness and foot disorders in milking cows (Warnick et al.). Many factors can affect the amount of lameness in a herd including management decisions, free stall design and stall flooring. The ability for a dairyman to keep the flooring and bedding clean and comfortable for the cows can greatly impact the amount of lameness seen in the herd. Rich Silacci, the herd manager at the Cal Poly dairy, has expressed a need for a better method for cleaning the free-stall lanes which will be more cost effective and improve cow comfort. Current cleaning products include harmful acids which require professional application and can be very expensive with often poor results (Personal Contact Rich Silacci). A product with a simple application, able for dairy employees to apply, and inexpensive would be extremely beneficial to the Cal Poly dairy. However, with modern restrictions on environmental standards in the dairy industry a need for a more eco-friendly treatment for the cleaning of the concrete is needed. Along with expenses this new treatment may help improve cattle environment, ease of locomotion, and even milk production.

Locomotion scoring and lameness can have extremely adverse effects on a dairy if not properly treated and prevented. In the study done on Housing System, Milk Production, and Zero-Grazing Effects on Lameness and Leg Injury in Dairy Cows “foot lesions associated with lameness were found to affect milk production for a total of 117 days, leading to a cumulative loss of milk of almost 77 kg and a cumulative reduction in feed intake of almost 28 kg (dry matter).” (Haskell et al.). This significant statistic shows just how costly lameness in a dairy herd can be. Use of a new product to better treat the cement alleys on dairies would certainly bring down the negative effects of lameness seen in many herds. The use of a more effective cleaning process on dairies would help to decrease cost of lameness treatments and increase milk production. Many studies have been done concluding that housing conditions has a significant effect on the amount of lame cows per herd. In the Phillips and Morris examination of The Locomotion of Dairy Cows on Concrete Floors That are Dry, Wet, or Covered with a Slurry of Excreta, the difficulty of walking and footing increased as amount of the feces and urine, or “slurry”, increased (Phillips and Morris). The study showed that “...cows in deep slurry attempted to overcome the significant reduction in walking rate by increasing step length. ...this suggests that cows modify their walking behavior to take account of the risk of slipping.” (Phillips and Morris). This study revealed that the increase in slurry found in free-stall lanes directly relates to lameness in dairy herds, locomotion scoring and cow comfort. Lameness and foot disorders are significant health problems on a dairy both from an economic view and from an animal welfare view (Bruijn et al.). A huge amount of money is spent each year as dairyman attempt to

keep lameness and foot disorders to a minimum in their herds. This money could be better spent on a product, such as concrete cleaner, used to prevent these ailments by better removing the slurry and microbial growths from the free-stall lanes. Free-stall design can also have a great effect on cow comfort and foot disorders on a dairy. In a study on cow comfort and behavior in different stall types cows showed a significant difference in time spent lying down resting when kept in large free stalls as opposed to tie stalls (Haley et al.). The increased lying time in free stalls showed a significant improvement in growth hormone produced as well as cow behavior (Haley et al.). However feed consumption was unaltered between the two studies. The large free stall barns which allow the cows more freedom to move, lie down, and walk are a necessity to keep cow comfort and milk production up. This larger stall design usually requires a larger cement alley floor space which will be used much more frequently than in a tie stall. To allow cow's easier locomotion and improved milk production, a more cost effective and time efficient method of cleaning this surface is necessary.

Along with free-stall design, the flooring of the milking cow housing can also impact the quality of cow comfort and locomotion scoring. According to Mason, F.J. and J.D. Leaver, dairy cows have to cope with several environmental conditions when housed. The type of housing system used and other factors, such as cement floors, are some of the conditions challenging cow welfare daily (Mason and Leaver). The effect of cement housing floors has a significant effect not only on number of lame cows but on the production of milk totals (Mason and Leaver). In further studies on the effect of standing and walking surfaces lameness in herds showed higher numbers

of lameness and longer recovery when housed in cement lane free-stalls (Cook and Nordlund). This study examined that “The impact of flooring on lameness may be mediated through the duration of contact, the distance walked on the surface, and through properties of the surface which may cause trauma and wear to the claw.” (Cook and Nordlund). With the limited space and available pasture land at the Cal Poly Dairy cement free-stall lanes the only viable housing option. Due to the cost effectiveness, limited space and general use of cement floors in the dairy industry, this study brings rise for a need to better method of cleaning cement housing floors on dairies that is both economically and environmentally friendly.

In the California dairy industry one of the most challenging environmental impacts dairyman face is heat. Although every region has environmental challenges the increase in microbial counts due to warmer climates is unavoidable (DePalo et al.). P. DePalo and his associates came to the conclusion that, “The results of the present work clearly indicate the necessity of evaluating both materials that are already in use and those that are innovative... while taking into account the different micro environmental conditions in which the materials are to be used.” (DePalo et al.). In reference to their study, Influence of Free-Stall Flooring on Comfort and Hygiene of Dairy Cows During Warm Climactic Conditions. This study expressed the adverse effects from increased microbial counts in dairy housing in warmer climates (DePalo et al.). The use of a high quality cleaner may help to ease these increases, leading to better cow foot health, cow comfort and milk production. The importance of free-stall cleanliness, proper bedding materials, and stall design are crucially important to dairy cow comfort and performance. Impact of colder

environmental conditions can also increase chance of lameness in a dairy herd. In a Wisconsin based study 30 herds of dairy cattle were evaluated on lameness scores and milk production, with varying stall types and surfaces. “In free-stall herds, mean lameness prevalence during the winter ($27.8 \pm 10.2\%$) was significantly ($P = 0.004$) greater than mean prevalence during the summer ($22.8 \pm 8.1\%$)” (Cook, Nigel B.). This increase in lameness in winter may be due to the damp or icy conditions during winter causing a slicker surface on free stall floor. A new method of cleaning cement lanes may also help to reduce the slickness of lanes even in winter.

Although not common in the dairy industry rubber mat flooring has been examined many times on its effects on lameness and milk production in dairy herds. In the study done by Vockey, Guard, Erb, and Galton, cows with concrete free stall alleys showed a much greater chance of lameness than those with rubber alleys (Vockey et al.). The number of days in the hospital pen from cows kept in free stalls with cement alleys was double that for cows kept in free stalls with rubber lanes. Although this study implies that rubber lanes may be more beneficial, the variance in free-stall bedding also had a significant impact on lameness. Furthermore, when a rubber mat was placed at the Cal Poly dairy in the milk lane it was observed that cows tended to avoid the mat; it appeared that the mats were slicker than the concrete (personal contact Rich Silacci). In 2004 Jose Fregonesi, and his colleagues, performed an experiment to see if rubber mating in front of the feed bunks increased feed intake or time spent eating versus concrete flooring (Fregonesi et al.). The study showed that although feeding time did not increase, time spent standing on the rubber mat was greater than time standing on concrete. Due to the Cal Poly dairies

experience with rubber mats and the cost effectiveness of concrete lanes in the free-stalls Cal Poly has chosen not to implement rubber matting in free stall lanes. Leading to a need for a more effective method of cleaning the cement, to decrease slickness and microbial count. Another alternative flooring option requires the cutting of slats, perpendicular to the feed bunk, in the cement versus the more common cut grooves, parallel to the feed bunk. In a study done on cow preference to grooved and slotted concrete cows showed a preference to the slotted lanes tending to eat more in these lanes (Stefanowska et al.). One reason that many dairies choose to use the grooved floors, despite this study, is the ease of cleaning, a mechanical scraper can be used to push manure and filth into the lagoons. A new cleaning product which acts to break down the waste material may make the ease of cleaning a non-factor in this situation possibly leading to a new trend in the dairy industry, using slotted floors. It is clear through the years of research that the cleanliness and floor quality in free-stalls is of significant importance on any dairy. A high quality, inexpensive product would significantly influence the milk production, lameness, cow comfort and the budget of the Cal Poly dairy.

Products tested in this experiment were from a variety of different chemicals and even microbes. Made by ACT Bioremediation Products the Terra-Firma Concrete cleaner uses living microbes to break down any protein based substance, no water is needed in this process due to the unique ability of the microbes to draw moisture from the atmosphere (ACT Bioremediation Products). Application of this product is as simple as hand tossing it on affected area. By easing the stress of water demands on a dairy a simple cleaning product like this may benefit not only in the

dairy financially but also holistically by improving resources to the dairy. By not using any hazardous chemicals this product is able to remove all organic matter without causing damage to the concrete or to the cows. One other product used was made by Wash Safe Industries, a powder that is mixed with water and sprayed on. Once in liquid form this product is a hydrogen peroxide concentrate which when applied will bubble and breakdown any residual matter. This all natural product also avoids corrosive effects on the concrete and animals (Wash Safe Industries). By chemically breaking down any residual filth this product should act effectively in keeping the concrete clean for many days post application. Although not new to the Cal Poly Dairy, bleach was also tested on one lane to examine its strengths and weaknesses as a cleaning product. One problem seen with bleach is its corrosive nature, it can irritate skin or eyes or the animals and also be toxic if ingested. This makes it a product which must only be used when cows are not within contact and it must be washed away before allowing the animals back in the pen. The benefits of bleach are very apparent upon use, instant results along with a cheaper product price than the other products.

Materials and Methods:

Three products were tested on separate lanes in the free-stalls at the dairy and a fourth lane was pressure washed to remove visible filth as a control to better visually understand the abilities of each product to keep the concrete clean. The first product, a microbial based product, made by ACT Bioremediation Products, was unique in its application in that it was put on dry and left dry for 12 hours. The product required no biohazard equipment and was rather simple in its application no

tools required, simply a bucket and one employee to hand toss the product on. The product works by accumulating moisture from the surrounding atmosphere encouraging the microbes to break down any protein substance such as animal waste. The product was sold to the dairy for the testing at a discount bulk rate of \$5.00 per pound totaling \$250.00 for fifty pounds. The second product was a hydrogen peroxide like chemical made by Wash Safe Industries, which was a dry powder then mixed with water and the sprayed on. Unfortunately a large commercial sprayer would have better suited the application of this product and a small hand sprayer was the available resource and so that was used. Rubber gloves, safety glasses and a NIOSH/OSHA face mask were necessary, as the product in a dry state may irritate the lungs and or eyes if contacted. The chemical sat for 20 minutes to allow the “bubbling” effect that many hydrogen peroxide based solvents show allowing the product to break down the protein based animal residue, and was then washed away by flooding. No scrubbing was done with this product and in total this product was \$130.00 for two 10 pound tubs. The third product was a bleach concentrate which was applied by pouring bleach right onto the concrete and scrubbing it in with hard bristle brooms. This also required rubber gloves, a NIOSH/OSHA face mask and safety goggles. This product and application has been used before at the dairy and proved again to be extremely tedious with extensive labor. Cost of the bleach was only \$32.22 for ten 1 gallon jugs. Overall product costs alone bleach and power washing are far cheaper than the two new products. Each lane was examined pre and post application and continually for one week by flushing each lane then allowing a towel to soak up residual water which will then be squeezed out capturing 10 mL of

the water and examined for turbidity, on a scale of 1-10 (low to high turbidity), and any residual solids after 24 hours at rest. Two samples on each lane will be taken with each sampling; the average between the samples will give a better understanding of each products effect on the large space. These samples will be analyzed to help better illustrate each products benefits and longevity. Turbidity is the clouding of particles within water there for the lanes which show a more turbid water mean there are more particles found on the concrete post flushing leading to a greater buildup of fecal matter and filth. As each product works to keep the concrete clean over time we will see a gradual increase in turbidity. Also each lane was under visual inspection for one hour post application, and for one hour each day for one week, to better understand how the cows adjust to each product and whether or not the products would last for multiple days. Time spent walking on each product and ease of cow locomotion were all taken into consideration when examining results. With each applicant and lane we timed the process of application to better access the ease of application with each product. Finally, results were input into data sheets and analyzed to express a final suggested product for continued use at the Cal Poly Dairy which would prove environmentally friendly, cost effective and beneficial to cow comfort and free-stall quality.

Results and Discussion:

To complete this evaluation four different products or methods were tested on the four cement lanes found in the housing barn for milking cows. In table 1 each lane is shown along with which product was used to clean it as well as whether or not it was a feeding lane, feeding lanes having higher usage time overall by the cows.

Lane 1 - Holstein rear alley - Bleach
Lane 2 - Holstein Feed lane - ACT Terra-Firma
Feed Lane
Lane 3 - Jersey Feed lane - Wash Safe Ind. Stable & Kennel Wash
Lane 4 - Jersey rear alley - Power Washed

Figure 1. Cal Poly Dairy Barn Layout. Cow breed and use division of lanes along with products used on each lane for concrete cleaning experiment.

After application each product was rated on ease of application by 2 separate dairy employees, Table 1.

Table 1. Ease of Application. As rated by employees on scale of 1-10 (easy to difficult).

	Employee 1	Employee 2
Lane 1	6	x
Lane 2	2	x
Lane 3	X	6
Lane 4	X	8

The ease of application as well as the turbidity test helped better evaluate the impact and effect of each product. Furthermore upon observation of the cattle each day lanes 1 and 4 were used considerably less than lanes 2 and 3 by the cows. This is most probably because lanes 2 and 3 face the feeding trough increasing need a desire for cows to spend time in these lanes. The difference in time spent in each lane was averaged to 70% of cows time spent in lanes 2 and 3 and 30% on lanes 1 and 2. This leads to consideration that products applied to lanes 2 and 3 must act stronger and be more durable than the methods used in the other lanes. Lane 1 was tested with bleach, although this product had been used previously at the dairy the addition of scrubbing with a hard bristle broom was added. When asked about the ease of application the employee's expressed that the process seemed tedious and was exhausting work rating it 6 out of 10 in difficulty of application. Seen in Figures 2 and 3 the bleach did work remarkably well with instantaneous results, although a strong scent was noticed by all workers.



Figure 2. Post application - Lane 1



Figure 3. Post application - Lane 1

In Figures 4 and 5 the dry application microbe based product can be seen post application although no visible effects right away the product does take 12 to 24 hours to react. The application of the product took only half an hour, the shortest of all products, this lowered labor cost brings the overall cost of the product down.

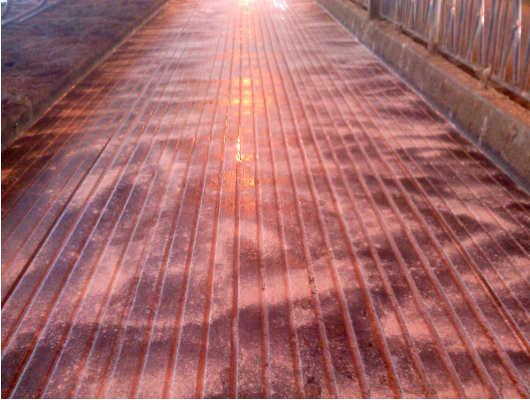


Figure 4. Post application - Lane 2



Figure 5. Post application - Lane 2

In lane 3 the hydrogen peroxide based applicant was hand sprayed on with a 1 gallon sprayer, the need for a larger sprayer created some problems, with the sprayer used a solid result was unattainable. However examples of the application and bubbling process of the product are shown in Figures 6 and 7. Unfortunately the product was unable to be used with proper application rates decreasing its performance making it immeasurable.



Figure 6. During application - Lane 3



Figure 7. During application - Lane 3

The labor intensive process of power washing is shown in Figure 8 while Figure 9 shows the instant cleaning effects, however this product proved to have little lasting effect over time.



Figure 8. During application - Lane 4



Figure 9. Post application - Lane 4

Although this process is cheapest according to product pricing labor costs for all lanes may become very pricey. We evaluated labor rates at approximately \$10 per hour, it is also important to consider that lanes 1 and 4 have significantly less square meters, about 215 square meters as opposed to lanes 2 and 3 at 371 square

meters. By calculating total costs per 100 square meters for this experiment, we can better understand overall costs of products. In Figure 10, we saw that although power washing products were cheapest, the tedious labor prevented employees from other work overall costing the dairy more. While the microbial product was the most expensive its unique ability to keep the concrete cleaner over a long period of time and ease of application may lead to the use of such a product. By adding total costs for each product including labor costs or other expenses, e, and divide it by the total square meters of the lane then multiply by 100 will give us the total expense for each product per 100 square meters.

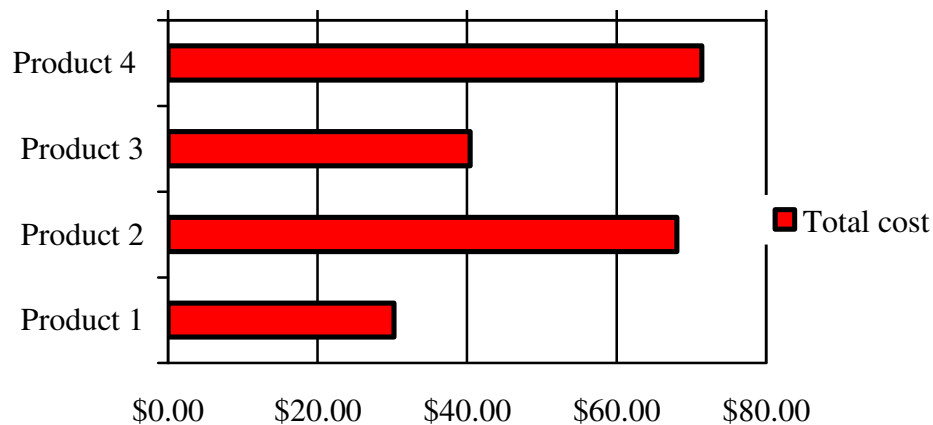


Figure 10. Total Cost - of each product per 100 square meters.

Terra-Firma is a considerably more expensive product although one application may last as long as two applications of products 1 and 4, the cost of application of power washing is what makes it overall most expensive. It is also important to consider availability of student employees at the dairy and the ability to increase student's hours for lane cleaning methods, this may not be practical. It has been stressed that something time efficient and something that will last are

needed for the Cal Poly Dairy. The use of a larger sprayer for the product on lane 3 may also significantly impact results on the ease of application and labor costs, this being said we cannot truly rate the other products or methods against it. The application and instant effects of each product were vastly different, the bleach and power washer both had instant results cleaning the lanes of visible filth through extensive labor burdened methods, which showed no pay off in lasting results.

The greater time spent in lanes 2 and 3 by cows led to a greater buildup of filth and sludge and although no immediate changes were originally seen in these lanes, after 12 hours the lanes were flushed and it was clear that the product used in Lane 2 had a very drastic effect, visible in Figure 11 we see a clear visible line on the concrete where we began application of the product and its reaction to the residue on the concrete.



Figure 11. Day 2 - Lane 2

As each day progressed it was clear through the turbidity sampling that of the three methods attempted to their fullest ability, the microbial based dry-application product performed the best, seen in Figure 12.

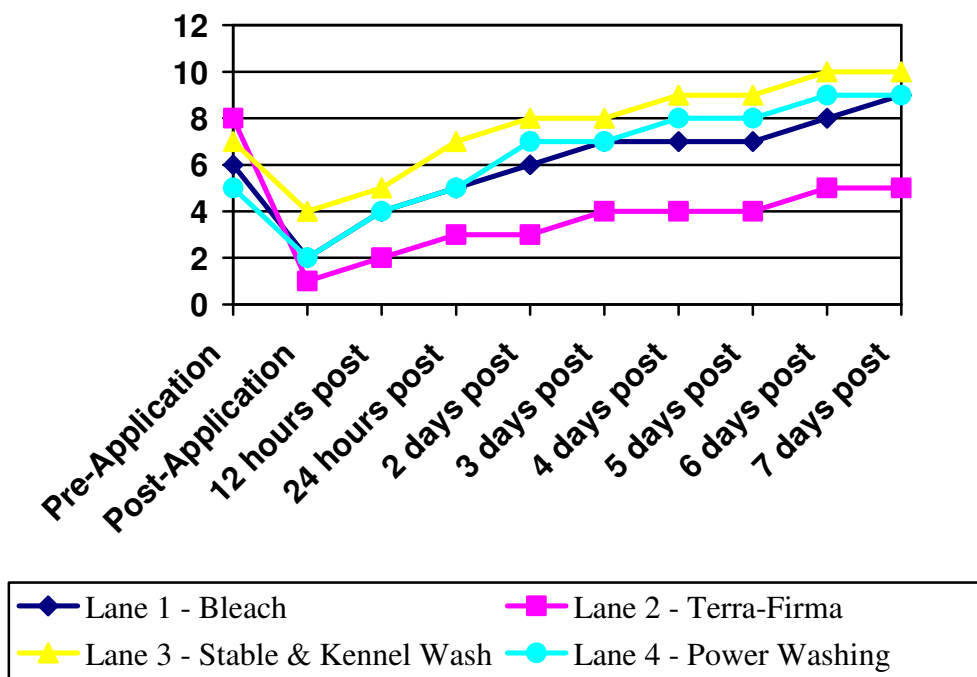


Figure 12. Turbidity of Water. Turbidity of water flooded over lanes post washing.

This lane was by far the most filth covered at the beginning of the test and saw the greatest recovery along with showing huge leads over the power washer and bleach methods in longevity. As can be seen in Figures 13-15, the first five days after application Lane 2 remained the cleanest, not allowing the buildup of residual filth and sludge. The slats in the concrete are clear and visible showing that the product has allowed the filth to be carried away by the water.



Figure 13. Day 4 - Lane 2



Figure 14. Day 4 - Lane 2



Figure 15. Day 6 - Lane 2

In Lane 3, shown in Figures 16-19, the filth never seemed to go away even after flushing, this being the lane on which a better application process may improve results. Although not beneficial to our study this lane better shows an untreated lane, slats in the concrete have been filled in with fecal matter and filth from the animals making the surface more slick. These pictures better show the adverse effects when the flushing of the lane has not removed the filth as well as Lane 2.



Figure 16. Day 2 - Lane 3



Figure 17. Day 4 - Lane 3



Figure 18. Day 5 - Lane 3



Figure 19. Day 6 - Lane 3

Although not used as frequently, lanes 1 and 4 showed an increase in the amount of filth in the days following the experiment which shows the poor longevity of the methods used. In Figures 20 - 26 we see the progression over about a week as the lanes begin to become covered in fecal matter, the extensive labor costs and need for repetitive cleaning make these methods not a feasible option for neither the Cal Poly dairy nor any commercial dairy.



Figure 20. Day 2 - Lane 4



Figure 21. Day 4 - Lane 4



Figure 22. Day 6 - Lane 4



Figure 23. Day 2 - Lane 1

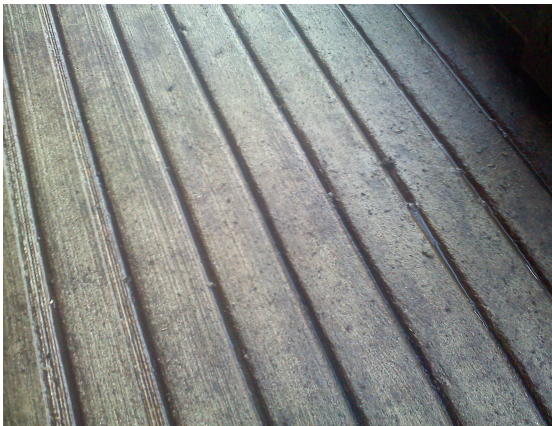


Figure 24. Day 2 - Lane 1



Figure 25. Day 4 - Lane 1



Figure 26. Day 6 - Lane 1

The complex pros and cons of each product cause selecting the proper product for further use imperative. Although overall cost points to Products 1 and 4, Product 2 proved it was the easiest to apply and most effective by far. Product 1

did perform slightly better than Product 4 showing lower turbidity ratings on days 2, 4, 5 and 6. Over all the longevity and ease of application for the Product 2, the microbial based cleaner proved to be the best method for cleaning the concrete lanes at the Cal Poly dairy. The higher price of the product may result in the use of cheaper methods intermittently. With labor costs taken into account overall costs for each method show that Product 4 is by far the cheapest to use and that Product 2 was the most expensive. Performance of product however clearly shows that Product 1 was the best suited for cleaning residual filth and slime from the cement in the free stalls. Nearly one week later the product was still able to keep the concrete clean and less slick for the cows.

Conclusion:

As crucial as economic management on a dairy is it is important for any operation to only use products if they are needed, if lameness is high or when trying to improve cow comfort a more expensive but effective way of cleaning the lanes may be implemented. I suggest that the Cal Poly dairy begin use of the Terra-Firma once every two months to better maintain non-slick and clean free-stalls. This would be the most time efficient, cost effective and environmentally friendly way to maintain clean free stall lanes at the dairy. It is this environmental friendliness and simple application which make this product truly stand above the others. While power washing and bleaching took extensive application processes

and showed little lasting results, Terra-Firma proved it could continue to keep the concrete clean long after these other methods stopped being effective. The safety of the product around the animals also sets it apart from many other methods of cleaning the concrete. Through my research and data collection it has become apparent that products like the microbial based Terra-Firma could prove extremely beneficial to many commercial dairy operations in their attempt to clean organic matter from the concrete free-stall lanes. Price has a significant factor for this product however bulk pricing of the product may also alter the total costs. Implementing occasional washings using bleach may be more financially responsible and still be beneficial to the lanes and cow comfort.

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