Animal & Grassland Research and Innovation Centre
Moorepark

Moorepark Dairy Levy Research Update

Non-chlorine Cleaning Protocols for Milking Equipment and Bulk Milk Tanks

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Non-chlorine cleaning protocols for milking equipment and bulk milk tanks

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Introduction

Due to increased food safety concerns regarding chlorine residues such as Trichloromethane (*TCM*) and Chlorate, it is becoming increasingly difficult to achieve dairy product specifications, when chlorine-based products are used as part of the milking equipment cleaning routines on-farm and/or in the CIP systems within processing plants.

Removal of chlorine from cleaning routines would significantly reduce the risk of these residues in milk and consequently, residues levels in the final products, such as lactic butter and milk powder. The adoption of non-chlorine cleaning of milking equipment internationally is normally associated with automatic milking systems (*AMS*). Therefore, the introduction of non-chlorine cleaning for traditional milking systems in Ireland is currently an on-going process in an early phase and this document is an attempt to guide industry on best options based on the knowledge available.

Cleaning and disinfection products that can impact on residues:

Products that contain chlorine are generally referred to as detergent sterilisers. These products can;

- Contain varying levels of sodium hypochlorite (*chlorine, 3-9%*) and sodium hydroxide (*caustic, 2-20%*), or;
- Just contain chlorine (*10 to 15%*).

Depending on the detergents used, the washing protocol will change and these products may be used on a daily basis. Alternatively, a further milking equipment washing protocol involves using a product that contains chlorine on one occasion per week. While the latter protocol can minimize the risk of residues, chemical manufacturers have responded to industry requests and have developed and are currently expanding a new chlorine-free product range to meet the demand for complete non-chlorine cleaning. In order to address industry queries, Teagasc is continually evaluating these new products and routines (*Table 1*). While these new cleaning products and protocols are described as chlorine free, they may not be chlorate free, as the sodium hydroxide component may still contain low levels of chlorate, formed during manufacture. Pharmaceutical grade sodium hydroxide contains quite low levels of chlorate, as it is a higher grade product; however it is more expensive (*than traditional grade sodium hydroxide used on farms*) and has been adopted by some milk processors for CIP cleaning.

Non-chlorine cleaning protocols can be more expensive than existing detergent steriliser based protocols. The three main components of alternate non-chlorine cleaning protocols involve the use of various combinations of caustic detergent (*sodium hydroxide*), acid (*phosphoric/ peracetic acid/ hydrogen peroxide*) and hot water.

Sodium hydroxide powder based cleaning products:

Powder based sodium hydroxide 'Cold wash' cleaning protocols (*one wash in 14 containing chlorine*) have been used by dairy farms for over 40 years and have been proven to be satisfactory from the point of view of microbiological control. The use of powder products are most suitable where manual washing is normally used and for small to medium plants (*5 to 15 units*), without axillary equipment like milk meters. These are less suitable where automatic systems are in place for cleaning both machine and bulk milk tank. The vast majority (*but not all*) of these powder products do not contain chlorine. Therefore making sure the product chosen does not contain sodium hypochlorite (*identified on the drum*) is critical, if non-chlorine cleaning is required. Powder products contain much higher levels of caustic (*76%*) as compared to most liquid caustic products (*21/29%*). This is why these powder products can be used in a cold or hot solution and recycled for a further wash occasion if required as compared to liquid products which contain the lower caustic levels and therefore should be used with hot water and only on one occasion.

Non-chlorine cleaning protocols

Option 1: Non-chlorine cleaning protocols using powder products

To adapt the traditional weekly powder cleaning routine (*one wash in 14 containing chlorine*) to non-chlorine cleaning (*no chlorine included*) there are a number of potential options that could be considered:

- Include a number of daily hot acid washes (*phosphoric acid*) per week (*up to 3*).
- Include peracetic acid in an additional rinse twice daily.
- Add hydrogen peroxide to the diluted powder solution on one occasion per week.

The inclusion of the additional acid rinses (*either from phosphoric, peracetic or hydrogen peroxide*) sterilises the plant surfaces and the later product is promoted to minimise protein deposits which would previously have been addressed when using chlorine solutions.

Sodium hydroxide liquid based cleaning

It is recommended to avoid recycling of liquid based sodium hydroxide detergents. As stated earlier, the concentration of caustic within these products is much lower than in powder products and therefore, is less suited for reuse at a subsequent wash occasion. All of the new non-chlorine protocols using powder and liquid based sodium hydroxide require more regular use of acid based products which act as a steriliser (*as a replacement for chlorine*) as well as having cleaning benefits. Acid products are often referred to as '*acid descale or milk-stone removal*' which generally contain phosphoric acid and to a lesser extent, nitric acid. Additional care needs to be taken when using these acid products, e.g. eye protection, gloves. Liquid sodium hydroxide and acid based products are ideally suited to situations where automatic cleaning systems are in place.

Option 2 & 3: Non-chlorine cleaning protocols using sodium hydroxide liquid and acid

A range of commercially available products representing various combinations of sodium hydroxide liquid and acid can be selected for cleaning protocol Options 2 and 3, which are not mentioned in this booklet. A list of these products can be found on the Teagasc milk quality web site (*web-link given under additional information*). A number of caustic/acid cleaning products/protocols which were supplied by chemical distributors have been evaluated over a four/five month test period at Moorepark (*Biocel, Deosan, Grassland Agro and Kilco*). These protocols have been demonstrated to maintain effective plant cleaning without detection of residues.

Depending on the products and chemical distributors, different cleaning steps may be recommended in a weekly milking machine wash protocol:

- A caustic liquid product (*21/29%*) used with hot water (*70/75°C*) four times weekly after AM milking and used with cold water seven times weekly after PM milking. Acid is then used with hot water on the remaining three times weekly after AM milking (*Option 2*).
- Alternatively, a caustic liquid product (*21/29%*) used with hot water seven times weekly after AM milking and used with cold water seven times weekly after PM milking may be put in place. Additionally hydrogen peroxide may be added to the main wash solution on two AM occasions. An additional rinse with peracetic acid included should be carried out after the completed detergent rinse cycles at both AM and PM milking (*Option 3*).
- Peracetic acid may also be used with cold water in place of a caustic liquid product after each PM milking, with caustic liquid product used with hot water for each AM wash (*See page 10*).

Option 4: Non-chlorine cleaning protocol with acid as the main cleaning agent

Where acid is used as the main cleaning and sterilising agent, current evaluated choices are limited to products promoted by Diversey and Grassland Agro. Acid based products that combine both cleaning and sterilisation of the milking plant and are both chlorine and chlorate free are generally more expensive. However, this simplifies the cleaning protocol as one product is multi-functional; it removes organic materials, such as carbohydrates/fats, and mineral deposits, such as manganese/iron, and also sterilizes the stainless steel surfaces (*Option 4*). The inclusion of a caustic based product to the wash routine on one or two occasions per week helps to reduce the overall cleaning cost and maintain plant cleanliness.

Option 5 & 6: Minimum chlorine based cleaning protocols

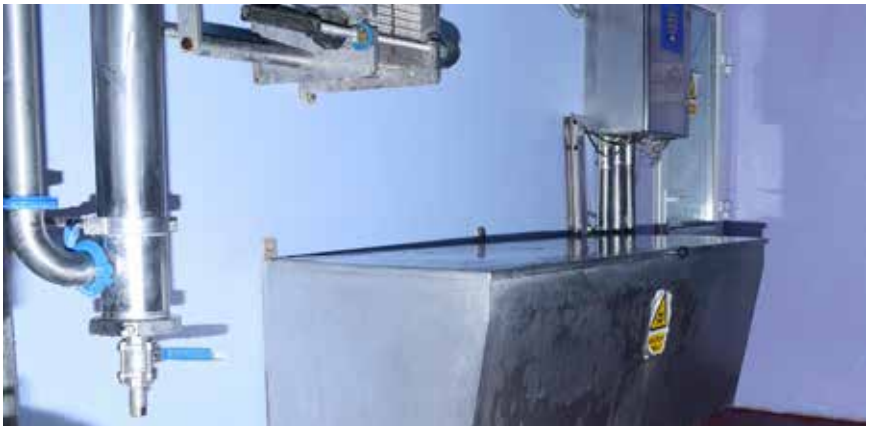
The 'cold wash' powder based cleaning protocol with chlorine added on just one wash occasion per week has been used by dairy farms for over 40 years and has shown to be satisfactory from microbiological and residues viewpoints, when used correctly. The cold wash powder protocol is best suited where manual washing is used and is less satisfactory where automatic cleaning systems are in place for cleaning both machine and bulk milk tank (*Option 5*). A similar protocol adapted from this powder system, but using existing available liquid caustic products (*20/29% caustic*) 13 times per week with a detergent/steriliser product used just once weekly has also proved satisfactory from both residue and microbiological viewpoints (*Option 6*). For this protocol hot water would be required at a minimum of seven occasions per week. Immediate rinsing should be carried out after the wash cycle containing chlorine. Peracetic acid should be included in an additional rinse cycle twice daily to both the 'cold wash' powder and adapted liquid caustic cleaning protocols above.

Peracetic acid: a replacement for chlorine

Peracetic acid (CH_3CO_3H) which has similar antimicrobial properties to sodium hypochlorite is effective against a broad spectrum of bacteria including spores, yeasts, moulds and viruses. Peracetic acid is considered a stable equilibrium mixture of peracetic acid, water, hydrogen peroxide and acetic acid. Wash routines can include the use of peracetic acid in an additional rinse that may be undertaken after each milking. But the caustic detergent solution must be rinsed thoroughly from the plant before the peracetic acid is included in an additional rinse. This is important because of (*i*) safety concerns, and (*ii*) the caustic alkaline solution will neutralize the acid solution making it less effective. If using two post-rinses, 9 litres (*2 gals*) per unit can be used to remove detergent residue and 4.5 litres (*1 gal*) per unit can be used for the peracetic acid rinse. No additional rinsing of the plant is required after rinsing with peracetic acid, under two conditions: (*i*) if the manufacturer recommended usage rate is adhered to (*generally 60 mls per 45 litres*); and (*ii*) the routine is completed at least one hour before the start of the next milking occasion. In situations where peracetic acid is used twice daily, then there is not a requirement to use an acid descale product (*phosphoric/nitric*) weekly; once a month would be considered sufficient.

Hot water for daily cleaning

With non-chlorine liquid based cleaning protocols (*as opposed to powder products*) the use of regular hot washes is necessary and the recommend temperature for circulation is 70/80°C and not reducing to < 40°C on completion of the wash cycle. The inclusion of a warm water post milking rinse, as opposed to the normal cold rinse, has benefit in removing fat deposits from stainless steel surfaces, making detergent cleaning easier. This has particular importance during the latter half of lactation when fat levels in milk are higher. From an electrical cost point of view, it is recommended to use night rate electricity and apply hot washes daily after the AM milking; with cold wash circulation being an option after the PM milking. There are a number of other water heating options available. See attached link to Teagasc infrastructure handbook under additional information.



Steps to take if changing to non-chlorine cleaning products

If changing from chlorine based detergent steriliser products to non-chlorine products, it is critical that the automatic detergent dosing systems for both machine and bulk milk tank are re-calibrated. This is necessary to ensure the correct uptake of the different detergent products, as uptake rates may be lower for products that do not contain chlorine and that have slightly higher caustic content than products previously used. To check if the correct quantity of product is being used, the following steps should be taken:

- Determine the quantity of water being used in the wash trough for the main wash cycle (*this may require that water is measured into the trough manually until the normal level used in the trough is reached*). The recommended water usage rate is nine litres per milking unit.
- Calculate the quantity of detergent required based on drum label; recommendations normally indicate a rate (*e.g 400 mls*) per 45 litres of water depending on hot or cold water. Higher levels of detergent are necessary when cold water is used.
- Fill a clean container with a fixed quantity of detergent (*level above what your calculations suggest*) and place the automatic dosing tubes in the container prior to the next cleaning occasion.
- Subtract the remaining quantity of detergent from the original amount to establish the amount used for the wash.
- Should the levels be lower or higher than recommended by the manufacturer (*as determined on the label*), then the automatic system needs adjustment (*probably by the milking machine or bulk tank fitter*). The exercise must be repeated until the required level is achieved.

Sourcing advice from chemical product distributors is also an important consideration when changing to non-chlorine cleaning, as product technical personnel are best placed to advice on their own product range and routines.

Residues arising from the use of disinfectant products associated with other dairy related tasks: Potential risks of residues exist from chemicals used in dairy farm tasks, such as dipping clusters between individual cow milkings and disinfection of the on-farm water well source, using hypochlorite products. Peracetic acid based products should be used as a direct replacement for hypochlorite for these tasks. Chlorine dioxide based teat disinfectants are known to be effective against mastitis causing bacteria, however they may also contain a level of chlorate which may impact on milk residues especially if teat preparation is not carried out prior to milking.

It is also acknowledged that mains water supplies can contain added hypochlorite (*at measured levels*) and consequently, may contain a level of chlorates.

Key points of non-chlorine cleaning

- Hot water usage is critical.
- Increased use of acid based products is necessary.
- No recycling of liquid products for a further wash occasion.
- Automatic wash units must have dosing pumps recalibrated when different detergent products are used.

Non-chlorine cleaning protocols evaluated at Moorepark

Table 1. Non-chlorine cleaning protocols evaluated at Moorepark

Weekly Cleaning Protocol	Chemical cleaning products			Wash time	
	Name	Main ingredient	Usage-weekly	AM	PM
Biocel (3 products)	Multisan CF	Sodium hydroxide (25%)	Main wash AM	Hot x 7	-
	Serpent	Acid-Acetic/ peracetic, hydrogen peroxide	Main wash PM	-	Cold x 7
	Boost	Hydrogen peroxide	Added to AM wash twice weekly	Hot x 2	-
Biocel (3 products)	Multisan CF	Sodium hydroxide (25%)	Main wash AM	Hot x 7	Cold x 7
	Boost	Hydrogen peroxide	Added to AM wash twice weekly	Hot x 2	-
	Serpent	Acid-Acetic/ peracetic, hydrogen peroxide	Additional Rinse	-	Cold x 14
Diversey (1 product)	Divosan OSA-N	Acid –Nitric, glycolic, octanoic, octenylsuccinic	Main wash AM & PM	Hot x 4 Cold x 3	Cold x 7
Grassland Agro (2 products)	Hypracid One	Acid-Methanesulfonic	Main wash AM & PM	Hot x 6	Cold x 7
	Hypral One	Sodium hydroxide (28%)	Main wash AM Once weekly	Hot x 1	-
Kilco (2 products)	AUTOSAN BLUE	Sodium hydroxide (21%)	Main wash AM & PM	Hot x 4	Cold x 7
	AUTOSAN RED	Acid-phosphoric	Main wash AM	Hot x 3	-

These protocols maintained satisfactory microbial counts when used as shown above. A number of other non-chlorine cleaning protocols are presently being evaluated.

OPTION 1: Non-chlorine cleaning based on powder detergent (sodium hydroxide) and peracetic acid in an additional rinse

After each AM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Add an approved alkaline powder detergent at the recommended use rate in cold water or hot water at 70-80°C (*minimum two hot washes per week*), allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste. Can retain for the PM wash occasion.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit within one hour of start of the next milking.
- Add peracetic acid at recommended rates in an additional cold water rinse.

After each PM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Re-use the detergent solution retained from AM milking; circulate the solution for 8-10 min.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit within one hour of start of the next milking.
- Add peracetic acid at recommended rates to an additional cold water rinse.

* Hydrogen peroxide may be added as recommended to the detergent solution on one occasion per week as an alternative to using peracetic acid twice daily.

OPTION 2: Non-chlorine cleaning based on liquid detergent (sodium hydroxide) and an acid (phosphoric/nitric)

(*Example: Kilco protocol in Table 1*)

After each AM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Add an approved alkaline detergent on four occasions per week and acid on three separate occasions per week at the recommended use rate in hot water at 70-80°C, allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit immediately after the 8-10 min wash cycle.

After each PM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Add an approved alkaline detergent at the recommended use rate in cold water, allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min having allowed the first five litres to run to waste.
- Leave the stain of the solution in the milking plant until just before the next milking (*if manual wash*) and if automatic wash rinse the plant immediately, with a minimum of 14 litres (3 *gals*) of water per unit.

OPTION 3: Non-chlorine cleaning based on liquid detergent (sodium hydroxide) and peracetic acid in an additional rinse

(*Example: Biocel protocol in Table 1*)

After each AM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Add an approved alkaline detergent at the recommended use rate in hot water at 70-80°C, allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit immediately after the 8/10 min wash cycle.
- Add peracetic acid at recommended rates to an additional cold water rinse.

After each PM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Add an approved alkaline detergent at the recommended use rate in cold water allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit immediately after the 8-10 min wash cycle.
- Add peracetic acid at recommended rates in an additional cold water rinse.

* Hydrogen peroxide should be added as recommended to the liquid detergent solution on two occasions per week.

OPTION 4: Non-chlorine cleaning based on acid only

(*Example: Diversey and Grassland Agro protocols in Table 1*)

After each AM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- *Add an approved acid detergent at the recommended use rate in hot water at 70-80°C, allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit immediately after the 8-10 min wash cycle.

After each PM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) with warm or cold water per unit.
- Add an approved acid detergent at the recommended use rate in cold water allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit immediately after the 8-10 min wash cycle.

* Hot water used on minimum of four wash occasions per week

* Option to replace the acid detergent with an alkaline detergent solution on one or two occasions per week to reduce overall cleaning costs and maintain plant cleanliness

OPTION 5: Minimum chlorine cleaning based on alkaline powder detergent (sodium hydroxide), liquid detergent/steriliser (used once weekly) and peracetic acid in an additional rinse

After each AM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Add an approved *powder detergent (*sodium hydroxide*) at the recommended use rate in cold or hot water (*70-80°C*), allowing about 9 litres (*2 gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste. Solution may be retained for the second daily wash. Leave the stain of the solution in the milking plant until just before the next milking.
- Rinse with a minimum of 14 litres (3 *gals*) of water per unit.

After each PM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit
- Re-use the retained wash solution from AM or create a new solution by adding an approved *powder detergent (*sodium hydroxide*) at the recommended use rate in cold or hot water (*70-80°C*), allowing about 9 litres (*2 gals*) of solution per unit
- Circulate the solution for 8-10 min. Leave the stain of the solution in the milking plant until just before the next milking
- Rinse with a minimum of 14 litres (3 *gals*) of water per unit

A detergent/steriliser (*<3.5% chlorine content*) should be used in place of the *alkaline powder detergent product on one occasion per week. On this occasion, it is critical to rinse the plant immediately after the main wash cycle to remove any chlorine residues.

Once weekly: add an Acid descaler (*milkstone remover*) at the manufacturers recommended usage rate to hot water

- Circulate the solution for 8-10 min and then discard
- Rinse plant with 14 litres (3*gals*) of cold water per unit

OPTION 6: Minimum chlorine cleaning based on liquid detergent (sodium hydroxide), liquid detergent/steriliser (used once weekly) and peracetic acid in an additional rinse

After each AM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Add an approved *alkaline detergent (*sodium hydroxide*) at the recommended use rate in hot water at 70-80°C, allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit immediately after the 8/10 min wash cycle.
- Add peracetic acid at recommended rates to an additional cold water rinse.

After each PM milking

Remove or replace the milk filter sock

- Wash outside of clusters and jetters. Attach jetters to clusters.
- Rinse plant with 14 litres (3 *gals*) of warm or cold water per unit.
- Add an approved alkaline detergent at the recommended use rate in cold water allowing about 9 litres (2 *gals*) of solution per unit.
- Circulate the solution for 8-10 min, having allowed the first five litres to run to waste.
- Rinse the plant with a minimum of 14 litres (3 *gals*) of water per unit immediately after the 8-10 min wash cycle.
- Add peracetic acid at recommended rates in an additional cold water rinse.

* Detergent/steriliser (<3.5% *chlorine content*) should be used in place of the alkaline detergent product on one occasion per week.

Non-chlorine cleaning of bulk milk tanks

Combinations of caustic detergent (*sodium hydroxide*) and acid (*phosphoric/peracetic acid*) may be used to clean bulk milk tanks in a similar manner to that used for milking machine cleaning.

Bulk milk tanks may be cleaned using:

(i) Fully automatic detergent dosing equipment (*two pumps connected to two dosing plastic tubes*).

(ii) Semi-automatic when the detergent is manually filled into a bowl before washing commences.

(*iii*) Totally manual cleaning.

There are a number of cleaning protocols that can be used for fully automatic systems:

(i) Dosing unit can be programmed to use the caustic detergent (*21/29%*) or the acid detergent (*phosphoric/nitric*) on alternate milk collections days or the acid detergent may be used after every third collection, using hot water (*60/75°C*). The water temperature setting in some instances is determined by the bulk milk tank manufacture and may need to be adjusted.

(ii) The unit can be programmed to use the caustic detergent (*21/29%*) with hot water and the second pump could be used to add peracetic acid to an additional final rinse after each collection. When peracetic acid is used, it is not necessary to use acid descale (*phosphoric/nitric*);

(*iii*) If an acid based 'one for all product' is used, then just one automatic dosing pump is used.

Where semi-automatic bulk tank cleaning is in place, then protocols (*i*) and (*iii*) are most appropriate.

Procedure for disinfecting the farm well supply without the use of hypochlorite

Peracetic acid or hydrogen peroxide can be used as a replacement for chlorine for once off disinfecting of farm well supplies. Where wells need continued disinfection then UV ULTRA VIOLET LAMP procedure is recommended as a more permanent and safe way of disinfecting wells. For more detailed information on the disinfection of wells contain water technology companies that offer solutions for contaminated water.

Procedure for disinfection with peracetic acid or hydrogen peroxide:

- Add 1 litre of peracetic acid to 4 litres of cold water.
- Carefully pour the solution down the flue of the well.
- Leave to rest over night or up to eight hours if possible.
- Run the water from the taps in the dairy and dwelling house for five minutes.

Procedure for disinfecting well water using UV ULTRA VIOLET LAMP:

- A UV lamp which looks like an inline filter is connected to the electricity supply; it contains a tube which omits Ultra Violet Rays which kill any bacteria present in the water and renders it safe for human consumption. The unit size depends on the water volume used. Local county council grants are available in some instances towards the purchase of the unit.

Additional information:

Gleeson, D., O'Brien, B. and Jordan, K.N. (2013). The effect of using non-chlorine products for cleaning and sanitising milking equipment on bacterial numbers and residues in milk. International Journal of Dairy Technology, 66 (*Issue 2*), 182-188.

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https://www.teagasc.ie/publications/2017/dairy-farm-infrastructure-handbook.php

Notes

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