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Disinfection of livestock production premises

V.J.C. FOTHERINGHAM *

Summary: *Livestock production premises (e.g. barns, and pens for lambing, calving, weaning and holding animals) encounter disease problems mainly associated with the housing of new-born and young animals, pregnant females and suckling mothers. The author describes a programme of cleaning and disinfection for use during the routine operation of livestock premises. A further programme is described for use in the event of an outbreak of an Office International des Epizooties List A disease, taking into account the particular problems associated with this type of disease.*

KEYWORDS: Cleaning – Decontamination – Disease – Disinfection – Fumigation – Hygiene programme – Infectious agents – Livestock – Microorganisms – Pathogens – Production premises.

INTRODUCTION

Livestock production premises are farms where breeding, birth and feeding for profitable growth are primary concerns. Such premises include barns, and pens for lambing, calving, weaning and holding.

New-born animals are very susceptible to disease, as their immune systems are not fully developed. Pregnant animals and suckling mothers are also susceptible due to the demands of a growing fetus or suckling baby.

The increasing demand for meat and animal products to feed the growing human population has resulted in changes in farming practice. The move to intensive farming and the increase in stocking densities have led to more disease problems and consequently greater financial losses to the farmer.

Prevention and control of disease relies on veterinary investigation, quarantine and isolation, vaccination, treatment, and the maintenance of a healthy environment through a hygiene programme which includes cleaning and disinfection.

The purpose of this paper is to consider the hygiene systems used with different species of livestock (cattle, pigs, sheep and goats) and to provide a programme of disinfection which can be adapted to suit particular situations, including an outbreak of an Office International des Epizooties (OIE) List A disease.

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FACTORS AFFECTING THE EFFICACY OF DISINFECTION IN CONTROLLING DISEASE

Causal agent

Microorganisms vary in their sensitivity to disinfectants: in general, bacteria (e.g. the causal agents of salmonellosis, brucellosis and scours [neonatal diarrhoea caused by *Escherichia coli*]) are more sensitive than fungi (e.g. those causing aspergillosis and ringworm) or viruses (e.g. those causing Aujeszky's disease and pneumonia), while bacterial spores (such as those of *Bacillus anthracis*) are the most resistant microorganisms (18). Some disinfectants may be effective against protozoan organisms, but activity against the resistant cysts should be confirmed if these organisms are present.

Method of transmission of the disease

If the disease is spread via insect bites (e.g. babesiosis) or bites from an infected animal (e.g. rabies), disinfection of housing is not a suitable control method. However, if the disease can be transmitted through contact with contaminated housing, feed or water (e.g. foot and mouth disease [FMD]), disinfection is an essential element of control. If the method of transmission is known, the usefulness of disinfection can be assessed.

Survival of the causal microorganism

The length of time for which a microorganism is able to survive outside the host (e.g. on bedding, in feed, in water or on building materials) also helps to determine whether disinfection is required. Some bacteria and viruses can survive for several months (e.g. *Salmonella* spp.) or even years (e.g. *Bacillus anthracis* spores) (10) in organic contamination, while many other microorganisms can survive for several days or weeks (e.g. rinderpest virus). In such cases, disinfection is essential to eliminate surviving microorganisms from surfaces or materials which may come into contact with susceptible animals.

Survival outside the host body also depends on the environmental conditions. The nature of the surface, the temperature and relative humidity all affect the survival time, e.g. the causal agent of swine dysentery can survive in manure for up to two months in cold moist conditions, but for only a few days in warm dry conditions (4, 11, 15).

DISINFECTION PROCEDURES

Cleaning

The survival time of a microorganism outside the host body is increased by the presence of organic soiling. Removal of this soiling is therefore an essential element in the disinfection process, particularly as the activity of disinfectants is adversely affected by soiling.

It is accepted that, under experimental conditions, cleaning alone removes approximately 99% of bacteria, while in a farm environment this figure is likely to be nearer 90% (14). Removal of a further 6-7% of bacteria is obtained in practice by disinfection, and a further 1-2% by fumigation.

Where the water supply for cleaning is drawn from a well or a river, it may be necessary to add a disinfectant to prevent contaminated water from spreading infection (9).

Choice of disinfectant

The choice of disinfectant depends on the likely disease agent(s) present, the level of organic soiling, the type of surfaces to be cleaned and environmental factors. In some countries (e.g. the United Kingdom and Germany), lists of approved disinfectants are published by the relevant authorities (2), whereas in other countries specific chemicals (such as sodium hydroxide and citric acid) are recommended for particular diseases (e.g. in Chile, where sodium hydroxide is recommended for use against classical swine fever and other vesicular diseases).

Disinfection during the routine working of livestock premises

It is probable that several disease-causing pathogens will be present during routine animal production, although specific disease problems may not be evident.

Secondary infections with enzootic herd pathogens can be important, as with porcine reproductive and respiratory syndrome (PRRS), where secondary infections are important determinants of morbidity and mortality (13). Improving the existing disease situation and non-specific factors in disease spread and resistance (e.g. air quality, stress) is therefore advisable.

The procedures described below should be implemented as part of the routine hygiene programme.

Terminal disinfection

Terminal disinfection is the procedure used when the animal housing is not occupied and when soiling has been removed by thorough cleaning. This should be performed after the departure of each batch of livestock, or at least once a year if the premises are in continual use.

CALVES

Beef and calf units without a 'down time' (vacant period) can suffer from disease problems due to build-up of infectious agents and lack of disinfection. In order to reduce these problems, some down time must be planned into the year to allow for thorough cleaning and disinfection.

Calf pens

Pens should be cleaned out and disinfected using the following procedures (14).

– If dust presents a problem, the air should be moistened with water ('damping down') using a knapsack sprayer or other suitable equipment. Bedding, litter and unused feed should be removed; small quantities may be burnt, or soaked with disinfectant and then ploughed into the earth or removed to at least 0.4 km from the site and allowed to compost.

– Cleaning may be performed using detergent and water to loosen and remove dirt, and employing low-pressure/high-volume methods (e.g. a hose linked to the mains supply or header tank). High-pressure/low-volume washers can be used, set at pressures up to 90 bar (1 bar = 10^5 Pa) with a nozzle at a dispersing angle of 25-45° and dispensing at a rate of up to 12 l/min. High-pressure washers are very efficient in removing compacted soilage but can be destructive to some materials. Steam cleaners may also be

used and are particularly effective where compacted soilage is to be removed. Surfaces should be allowed to dry before disinfection.

– Disinfection may be performed by spraying, using a high-pressure washer set at low pressure (35 bar), a knapsack sprayer or a pump attached to a sprayer. Care should be taken to ensure that all areas are covered.

– Young calves may be fed on milk or milk substitute using individual buckets, but labour-saving methods such as communal vessels or automatic feeding machines are increasingly being used.

An area should be set aside for the cleaning of feeding utensils, if possible. Brushes must be kept specifically for use with feeding utensils. If a separate area is not available, utensils should be cleaned using buckets containing solutions of detergent disinfectant and separate buckets for draining.

Buckets should be cleaned and disinfected manually using detergent disinfectants suitable for use with dairy equipment.

Automatic feeding machines

Automatic machines may be cleaned and disinfected using the same disinfectants, but care should be taken as some parts of the machines may be made of aluminium and these will be liable to corrosion. In these cases, rinsing with potable water after disinfection will be necessary.

The following daily programme should be used for the cleaning and disinfection of automatic feeding machines:

– Discard remaining milk and brush exterior free of dirt.

– Dismantle and rinse milk residues away with a hand-hot (46°C) solution of detergent disinfectant, brush and soak for at least 2 min.

– Rinse in a weak solution of dairy hypochlorite or other suitable disinfectant.

– Flush pipelines and reservoirs with the above solutions.

– Reassemble, avoiding contamination.

– Leave to dry and rest for as long as possible before re-stocking.

Buildings

After disinfection, foot baths or containers of disinfectant should be placed at the entrances and exits of buildings. These must be large enough to walk through or be at least 10 cm in depth. If a trough is not available, an empty 25 l container turned on the side with one side removed is suitable. These should be filled with a heavy-duty disinfectant. It has been suggested that salt or antifreeze be added to baths in areas where freezing is likely to occur. However, as the effect of these additions on the activity of disinfectants may not be known, it is simpler to use an increased concentration of disinfectant to reduce the freezing point. The addition of salt to some disinfectants will precipitate surfactants in the disinfectant and cause a reduction in activity. Commercially-available antifreeze contains ingredients, apart from ethylene glycol, which may cause precipitation of toxic chemicals when mixed with some disinfectants. Foot baths must be kept clean by changing the disinfectant regularly, otherwise these form a potential source of infectious microorganisms which may survive and even grow in heavily-contaminated disinfectant (5).

PIGS

On many pig farms, poor hygiene standards have been accepted as normal. For example, pig pens may have been disinfected only when there has been outbreak of a disease. Under such conditions, the build-up of infectious agents in the environment produces a level of disease challenge which vaccination and medication alone cannot control. The results of this level of disease challenge can range from reduced productivity, through subclinical disease, to high mortality from disease outbreaks. Fu *et al.* (7) have demonstrated that the environment of commercial piggeries is an important source of rotaviral infection for young piglets.

Replacement animals arriving on a farm should be placed in isolation premises. The new animals need to acclimatise or adapt to the microorganisms present on the farm and therefore – in contrast to other buildings – the isolation premises, although clean, should allow animals some contact with these microorganisms. Farrowing house waste material or manure can be placed in the isolation house, thus providing the necessary contact. The isolation period also allows for the occurrence of disease (e.g. transmissible gastroenteritis [TGE]) which may have been in the incubatory stage when the pigs arrived on the farm, and for testing to detect diseases such as pseudorabies in the replacement animals and in the source farm (1).

With 'all in/all out' systems, the housing should be cleaned and disinfected between each batch of pigs. Where the house is in constant use, at least 10% of the pens should be emptied, cleaned and disinfected in turn; once a year, provision should be made to move animals into alternative accommodation while the whole building is treated.

One of the main disease problems in piggeries is pneumonia, and the susceptibility of pigs to this condition is affected by air temperature and dust levels. Dust is a health hazard for personnel handling the animals, and needs to be controlled for this reason alone (20). Water and oil mixtures are often applied through 'fogging' systems to damp down dust. However, this results in hard, compacted soiling when the dust settles on ledges. This type of soilage is very difficult to remove, requiring water at 50°C or steam cleaning.

'All in/all out' systems are now recommended by the larger breeders, with a ten-day resting period between batches to maintain low infection rates.

Farrowing pens or sow crates

The type of pens used can affect the numbers of microorganisms present. Individual conventional farrowing crates, bedded with straw and wood shavings, have been shown to contain up to 300 times as many coliform bacteria as farrowing pens which allowed access to an outside area for defaecation and urination (19).

Sows should be washed with soap and water or with a detergent disinfectant suitable for use on skin. The animals should then be dried before they are placed in the farrowing house, to prevent wetting of fresh bedding and subsequent colonisation with bacteria.

Farrowing pens or sow crates should be washed, disinfected and left vacant for one day between batches, if possible. This will help to reduce the environmental microbial burden, and more specifically the pathogens which might be exclusive to new-born piglets (6).

Operators should wash their hands after handling pigs, piglets and afterbirths, and before handling the next set of animals. If washing facilities with hot water and soap are not readily available, then buckets of disinfectant, suitable for use on skin, should be kept on site for this purpose.

Weaning house

Manure should be removed from weaning houses while these premises are occupied, twice a day if possible.

When the premises are empty, all manure, bedding and unused feed should be removed by scraping or brushing, and transported from the site for disposal.

All surfaces should be soaked with water and detergent to soften 'caked-on' soiling.

All surfaces should be washed with a detergent using a power washer or knapsack sprayer. Washing should begin at the top of the building and work downwards, ensuring that dirty water does not run across previously cleaned areas. Surfaces should then be allowed to dry.

Loose equipment should be soaked in detergent, rinsed and allowed to dry before re-use.

All surfaces should be covered with disinfectant and allowed to dry.

Finishing houses, pens, breeding areas and dry sow accommodation

In practice, less attention is paid to these premises, as pigs housed in such areas are less susceptible to disease. It may be beneficial for the animals in the breeding area to come into contact with pathogens, to enable breeding stock to develop an immunity to agents associated with reproductive failure and neonatal diarrhoea (16). However, a build-up of pathogens in these areas could lead to contamination of more sensitive areas by aerial transfer or through movement of personnel between areas, and disinfection should therefore be performed on a regular basis.

Cleaning and disinfection should be performed as for weaning houses, paying particular attention to urine ditches.

Disinfection in the presence of pigs

Fogging or aerial disinfection in the presence of pigs reduces the numbers of bacteria and viruses in the air, settles dust, reduces odour by the absorption of ammonia, and has a cooling affect in warm weather. This method has been used successfully in Japan as part of a system to control enzootic pneumonia and arthritic rhinitis (21).

The particle size of the droplets is important. Particles of 100 μm are effective in body cooling as these wet the animals, while particles of 30 μm are more effective against airborne microorganisms.

A disinfectant can be applied up to once a week. Low toxicity disinfectants are required, while phenolic disinfectants, in particular, should be avoided.

Outdoor units

Outdoor pig units generally encounter less disease problems than indoor units. However, disease problems can still occur.

Farrowing arcs should be moved to a fresh site after use. If possible, the new site should be on flat land not previously used for farrowing.

Once sited, the arc should be sprayed with disinfectant. During use, dead piglets and afterbirths should be removed to a collection point, and farrowing rails should be brushed down and sprayed with disinfectant.

Personnel should wash their hands after handling the pigs, piglets and afterbirths, and before handling the next set of animals. Buckets of disinfectant, suitable for use on skin, should be kept on site for this purpose.

Dry sow arcs should be moved every three months, and used bedding should be burned or removed from the site. The arcs may be sprayed with disinfectant twice a week.

Outdoor weaning pens should be treated as above. The water tank should be drained, cleaned and disinfected.

Wallowing troughs become heavily contaminated and must be carefully managed to avoid becoming a source of disease. The water should be changed regularly and disinfectant added to restrict numbers of microorganisms to a low level.

SHEEP

With an 'all in/all out' lambing system, terminal disinfection between lambing seasons is often considered to be unnecessary, as several months will pass before the pens are used again, and many microorganisms are killed by environmental influences, such as drying and sunlight. However, some pathogenic microorganisms can survive for long periods when protected against the elements. For example, orf virus has been shown to survive for several years in buildings (17), *Corynebacterium pseudotuberculosis* – the causal agent of caseous lymphadenitis – survives for up to eight months in pus-contaminated earth, and for up to five months in buildings which have housed cases of the disease (8). Disinfection is therefore advisable as an extra precaution, even when pens are left empty for some time.

Pens

Between batches of ewes, manure should be removed from pens and individual lambing pens re-bedded between lambing sessions, if possible. Dung should be brushed from the hurdles on a daily basis.

Ewes and lambs showing signs of disease should be isolated from the rest of the flock and their pens should be cleaned by removing manure, feed and loose equipment, and washing down with detergent (to loosen compacted soilage). Disinfectant should be applied, ensuring that every surface of the pen is covered. The surfaces should be allowed to dry, if possible, between cleaning and disinfection, and before new 'patients' are introduced.

Particular care should be taken to clean and disinfect buckets used for feed and water or milk, and any other equipment employed with sick animals.

Automatic feeding machines should be cleaned and disinfected as described for calves above.

GOATS

Goats are usually kept in smaller numbers than other livestock. Housing may be rudimentary and difficult to clean and disinfect. Numerous disease problems occur in larger herds, perhaps as a result of the lack of importance placed on hygiene measures. The programme described above for sheep pens is suitable for use with goat housing (14).

DISINFECTION DURING AN OUTBREAK OF AN OFFICE INTERNATIONAL DES EPIZOOTIES LIST A DISEASE

Table I indicates the OIE List A diseases for which the disinfection of livestock production premises may be an appropriate control measure, and the species affected.

Legislation and/or the national veterinary authorities will regulate the control of List A diseases, and contingency plans may be in place to deal with outbreaks (e.g. in Australia: AUSVET PLAN).

The authorities responsible for contaminated premises will supervise matters related to access, slaughter, compensation payments and the decontamination process, which will include disinfection where necessary.

TABLE I

Office International des Epizooties List A diseases for which disinfection of livestock production premises is an appropriate control measure

Disease	Species affected
African swine fever	Swine
Bluetongue	Sheep, goats, deer
Contagious bovine pleuropneumonia	Cattle
Foot and mouth disease	Cattle, swine and related species
Hog cholera	Swine
Lumpy skin disease	Cattle
Peste des petits ruminants	Sheep, goats
Rift Valley fever	Sheep, goats, cattle, humans, dogs
Rinderpest	Cattle
Sheep and goat pox	Sheep, goats
Swine vesicular disease	Swine
Vesicular stomatitis	Cattle, horses, swine, possibly sheep, goats, rodents and humans

In the case of an outbreak of a List A disease, information is available on the infectious agent, the method of transmission and the likely survival of the agent outside the host body. Some diseases (e.g. lumpy skin disease) are aggravated by secondary infections, and disinfection may therefore be used to eliminate microorganisms other than the primary infectious agent. An informed decision regarding the suitability of disinfection as a control method can be made on the basis of the information available.

Details of the disinfection programme will change depending on the infectious microorganism involved in the outbreak. However, the basic principles will remain unchanged.

Step 1: Setting up

Extractor fans should be switched off in all buildings, particularly when diseases such as FMD or PRRS (12) are present, to prevent further airborne dissemination of the infectious agent.

In the building which is to be decontaminated, the electricity supply should be switched off to allow removal of sensitive equipment and prevent electrical accidents during wet cleaning. Alternative arrangements should be made to supply power for the necessary cleaning equipment.

As a copious supply of water is required, it may be necessary to make arrangements for alternative sources to mains water (e.g. tankers or pumping from natural sources), particularly in the case of drought, or if the mains supply is of limited capacity.

Drains and run-offs should be blocked and disinfected, and allowed to run free only when all effluent has been treated. Channels and gullies must be emptied and the contents disposed of by burying in a prepared pit.

Disinfectant solutions should be prepared in dilutions applicable to the particular infectious agent present. Disinfectants with some detergent properties should be used, if available, as these will also help surface cleaning.

Foot baths or containers with disinfectant should be set up at all entrances and exits to the building, and at other points where it is necessary for personnel to move from a contaminated area to a decontaminated area.

Disinfectant mats or wheel baths containing disinfectant should be set up at all vehicle entrances and exits.

Personal decontamination will be required to prevent operators from disseminating the disease agent. An area must be set aside at the perimeter of the contaminated premises for decontamination of personnel; this site may be moved as the decontamination procedure progresses. Operators should be provided with overalls (plastic or fabric), protective footwear, head covering, gloves and goggles. Each of these items must be decontaminated by disinfection (and dry cleaning after disinfection in the case of fabric garments) each time the operator moves from a contaminated to a non-contaminated area. A changing area with hot shower or washing facilities should be available. Buckets of disinfectant should be used to soak clothing, and plastic bags should be used to transfer disinfected articles for further cleaning if required.

The safety of all personnel on the site must be safeguarded. Before commencing work, each person must be made aware of the hazards of the use of heavy machinery, chemicals, flame guns, etc., and provided with the necessary personal protective equipment. Clear instructions must be given for each procedure.

Lagoons and slurry pits may need to be decontaminated. This is achieved by raising or lowering the pH (to more than 11 or less than 2) and leaving for at least seven days. After this period, the pH of the contents can be neutralised and the contents transferred to a pit dug for the purpose (lined with plastic if seepage into watercourses is likely). Semi-solid slurry may be treated with caustic soda and allowed to stand.

Some diseases are spread by vermin. If necessary, vermin control should be instigated before disinfection begins.

Step 2: Preliminary disinfection

The disinfectant should be applied using a low-pressure sprayer such as a knapsack sprayer or a pump with spray attachment, covering all areas to damp down dust, which could spread microorganisms (particularly airborne disease agents) to other areas. This procedure should be implemented as soon as possible after the disease is confirmed. The aim is to cover all surfaces without creating pools of liquid which could run into drains.

Step 3: Equipment

Washable, portable equipment should be placed in a soaking bath filled with diluted disinfectant and left to soak. Fans and shafts should be opened to allow cleaning.

Sensitive equipment should be removed to a separate area for cleaning and disinfection, while sensitive equipment which cannot be moved (e.g. electrical switchboards) should be protected.

Equipment used to apply disinfectants – e.g. manual equipment such as brushes and scrapers – as well as mechanical equipment such as diggers and tractors, and personal equipment such as cameras will all require decontamination after use. Pumps, pressure washers and mechanical equipment may be sprayed and washed, while smaller items may be soaked and washed.

Sensitive equipment should be used inside plastic bags (to prevent gross contamination) where possible, and wiped down with disinfectant after use.

Step 4: Removal of gross soiling

Manure, soiled bedding and unused feed should be removed by using a manual or mechanical scraper. Under-floor areas and lofts above false ceilings must also be cleared. Debris should be disposed of away from the building by burning or burial.

Old insulating material (polystyrene, fibreglass), if this is not in a sound condition, should be removed for burial or burning. Rotten wooden fittings, posts and flooring should also be removed for burial or burning.

Where earth floors are present, the top layer of manure and debris should be removed. The firm earth underneath should then be dug out to a depth of approximately 3 cm, and the earth broken up and soaked with disinfectant or caustic soda.

Step 5: Cleaning

Hot water with added detergent, degreaser or detergent-disinfectant should be applied through a knapsack or backpack sprayer, or pressure washer, starting at the apex of the building or the top of the pen and working downwards to the floor and then across to the drain. If necessary, caked-on soilage should be removed manually, paying particular attention to inaccessible areas such as fan shafts and waste feed ducts. Outside areas should also be cleaned, paying particular attention to ventilation and fan inlets (15).

Step 6: Water system

The water system should be drained (if possible) by isolating the header tank and draining off from points furthest from the tank. The tank should be cleaned, removing any sludge, and refilled with clean water. Disinfectant should be added and allowed to stand for a minimum of 10 min. This should then be flushed through to the drain-off points and left for 30 min. The tank should be refilled with fresh water and the system flushed through once more. If it is not possible to drain off the system, the tank should be isolated, allowed to run dry and then cleaned. Dirty water should be washed away by hosing down.

Step 7: Disinfection

The building should be inspected visually and, if visibly clean, allowed to dry. Step 5 should then be repeated using disinfectant at the appropriate dilution applied through a sprayer. If necessary, cleaning should be repeated to remove any stubborn soilage before continuing with disinfection. Outdoor concrete areas and the outside of air inlets should be disinfected using a knapsack, backpack or pump sprayer.

Step 8: Drying

The building should be allowed to dry. Covers should be removed from electrical switches or other fittings into which water may have entered, and these should be allowed to dry. Equipment should be replaced and the building sealed if fumigation is to be undertaken.

Step 9: Flaming

In outbreaks of some diseases (e.g. swine vesicular disease), a flame gun may be used on outdoor concrete, brick or metal surfaces after disinfection. The surfaces should be wet before starting, so that flamed and unflamed areas can be easily distinguished by the operator. A flame gun may be used only where no combustible materials are present. Disinfection and flaming should be repeated after fourteen days or other specified period.

Step 10: Fumigation

Fumigation (3) may be required as an extra precaution when dealing with very persistent infectious agents (e.g. FMD virus). Fumigation can only be performed where it is possible to seal the building completely, and requires considerable care if it is to be performed safely and correctly.

Fumigation is also suitable for use with sensitive equipment. The equipment should be fumigated inside a plastic tent or in a small sealable area.

Empty silos can also be fumigated if required, depending on the construction.

Use of formaldehyde

The activity of formaldehyde is greatest when vaporised in an atmosphere of high humidity. Generation of formaldehyde using the reaction between potassium permanganate and formalin releases water vapour, thus increasing the humidity. However, if formaldehyde is generated by heating paraformaldehyde, a separate means of increasing the humidity is required (e.g. by using an aerosol generator), but no free standing water should be present (formaldehyde dissolves in water and loses its activity). In cold conditions, the building should be warmed to 15°C before fumigation, particularly if the roof is poorly insulated. Fluctuating temperatures can cause polymerisation of formaldehyde on cooler surfaces, leading to reduced efficacy.

Generating formaldehyde from paraformaldehyde

Formaldehyde may be generated from paraformaldehyde using electrically-heated pans designed for the purpose. At least 5 g of paraformaldehyde is required per m^3 of air space. Up to 0.5 kg paraformaldehyde can usually be placed in each pan, and pans should be spaced not more than 30 m apart. Pans should be connected to the nearest power supply points and switched on by an operator, who should then immediately leave the building. Gas will not be liberated until the pan has had time to heat up.

Generating formaldehyde by adding potassium permanganate crystals to formalin

A sufficient number of metal or earthenware (**not** plastic) containers should be used to avoid the necessity of using more than 1 l of formalin in each container. To prevent the reactants from boiling over, the containers should have deep sides at least six times higher than the depth of formalin used. As an additional safeguard against spillage or overflow, each container should be placed on a lipped metal tray or vessel with sufficient capacity to contain the whole of the reactants.

Because of the potential fire hazard, containers should never be placed on surfaces which are combustible or sensitive to heat. For example, if the building has wooden floors, the containers should be placed on bricks or other inert supports. At least 2 m clearance must be allowed between the tops of containers and any combustible material.

Where several containers are required, these should be distributed evenly along the length of the building. The potassium permanganate crystals should be weighed out in advance into small glass or metal containers (**not** paper, cloth or fabric). The formalin is then measured into each reaction vessel. Before adding the potassium permanganate, the access door to the building should be securely fixed **open**. All other entrances to the building should be locked and sealed, and warning notices displayed on all doors stating that toxic gas is present inside.

It is essential to add the potassium permanganate crystals as quickly as possible, as the formaldehyde vapour is produced almost immediately on contact. During this operation, the operator should wear a full-face respirator fitted with the appropriate canister for formaldehyde. A second person with similar protection should watch the operation and be ready to help in case of accident. Starting with the container furthest from the door, the operator should stand well back and, without bending over the container, carefully pour the previously weighed potassium permanganate crystals into each vessel in turn, working towards the exit. As soon as the operator has completed the task and left the building, the door should be locked and sealed.

The building should be left sealed for 24 h and then thoroughly ventilated before re-entering. Alternatively, formaldehyde can be neutralised by ammonia gas (7.5g/m^3) after decontamination. This can be produced by heating ammonium carbonate to 120°C in electrically-heated pans.

The remains of the reaction mixture in the vessels will still have oxidising properties and must not be allowed to come into contact with organic material such as paper, straw or wood shavings. The residue should be mixed with water and the resulting slurry buried or washed down a drain.

Detectable quantities of a potent lung carcinogen may be formed when high concentrations of formaldehyde gas are mixed with chlorine-based disinfectants. Particular care should therefore be taken when chemicals containing chlorine (e.g. hypochlorite) are present.

Step 11: Re-stocking

When the decontamination process is complete, the premises should be left empty for a period of time before re-stocking. This length of time depends on the disease concerned. Sentinel (susceptible) animals should be introduced first, to detect any remaining contamination before recommencing full production.

CONCLUSIONS

Livestock production is economically important to all countries, and in developing countries this may provide the main source of income. Animal diseases may result in losses of up to 20% of production and it is therefore vital that these be controlled. The procedures described above should be used as part of an overall disease control programme. Used correctly, disinfection can reduce the need for the more expensive aspects of disease control, such as vaccination and antibiotic therapy, and is the easiest way for the farmer to exercise disease control without the need for external resources.

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DÉSINFECTION DES LOCAUX DE PRODUCTION ANIMALE. – V.J.C. Fotheringham.

Résumé : *Dans les locaux de production animale (c'est-à-dire les étables, les loges d'agnelage, de vêlage et de sevrage, les enclos, etc.), les problèmes sanitaires se posent surtout dans les logements réservés aux nouveau-nés et jeunes animaux, aux femelles gravides et aux mères allaitantes. L'auteur décrit un programme de nettoyage et de désinfection destiné à l'entretien de routine de ces locaux. Il présente également un autre programme applicable en cas de maladie inscrite sur la Liste A de l'Office international des épizooties, qui tient compte des problèmes particuliers liés à ce type de maladie.*

MOTS-CLÉS : Agents infectieux – Agents pathogènes – Animaux d'élevage – Décontamination – Désinfection – Fumigation – Locaux d'élevage – Maladie – Micro-organismes – Nettoyage – Programme d'hygiène.

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DESINFECCIÓN DE LAS INSTALACIONES DE PRODUCCIÓN ANIMAL. – V.J.C. Fotheringham.

Resumen: *En las instalaciones de producción animal (tales como establos, locales de contención, locales de parto para ovejas y vacas y locales para jóvenes al destete), los problemas de sanidad se plantean sobre todo a nivel del alojamiento de las crías recién nacidas, los jóvenes, las hembras preñadas y las que amamantan. El autor describe primero un programa de limpieza y desinfección para el mantenimiento de rutina de estos locales, y a continuación un programa aplicable en caso de presentarse una de las enfermedades inscritas en la Lista A de la Oficina internacional de epizootias, teniendo en cuenta los problemas específicos de ese tipo de enfermedad.*

PALABRAS CLAVE: Agentes infecciosos – Agentes patógenos – Descontaminación – Desinfección – Enfermedad – Fumigación – Ganado – Limpieza – Locales de producción – Microorganismos – Programa de higiene.

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