Disinfection and Disinfectants

BY F. W. TILLEY [1]

WHEN disease breaks out among farm animals, it is often necessary to do a thorough clean-up and disinfecting job to get rid of the infection. Here is practical information about the principal kinds of disinfectants, the advantages and drawbacks of each, and how to use them.

DISINFECTION is the destruction of the disease germs in or on infected material, and a disinfectant is a substance or agent that destroys disease germs. As they are usually employed, the words "disinfectant" and "germicide" are synonymous. An antiseptic is a substance that prevents the growth of germs without necessarily destroying them.

There are two opposing forces in infection—the disease germ and the defensive force of the animal body. The ability of germs to invade depends primarily on the number present and their vigor. The healthy animal body is able to resist invasion by considerable numbers of germs, especially if the germs have lost most of their original vigor. On the other hand, an animal in poor condition is generally more susceptible to infection.

The essential sources of disease germs are the bodies of diseased animals. After leaving such animals, the germs die or tend to lose their vigor. Their survival outside the animal body is favored by the presence of manure and other waste matter—the substances to which we give the general name "dirt."

The importance of cleanliness in the care of animals cannot be emphasized too much. Proper cleaning removes most of the germs along with the dirt that protects them, and the remaining germs are usually so weakened or so few in number that they are harmless under ordinary conditions.

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If in addition to having clean surroundings the animals themselves are kept clean, well-fed, and in good condition, there is ordinarily no need for the use of disinfectants. If disease breaks out, however, it will be necessary to make use of disinfectants as well as of the usual cleaning agents. Since the sick animal is the original source of infection it should be kept away from healthy animals, and since the number and vigor of disease germs are greatest near their source in the sick animal the best place to use disinfectants is in its immediate vicinity. The materials to be disinfected include manure, urine, and other body discharges and bedding or other material soiled by such discharges. If infected material is scattered, it becomes necessary to apply disinfectants very extensively and thoroughly in order to be sure of reaching all of it.

In some instances—for example, in scabies—disease is caused by insectlike parasites which are very small but not microscopic in size. In combating such diseases the destruction of the causative organism is usually accomplished through total immersion of the infected animal in a solution that is poisonous to the parasite but not dangerous to the animal. Such a process is called dipping, and the substance used for preparing the solution, or the solution itself, is called a dip. In cattle tick fever, formerly known as Texas fever, the causative organism is microscopic in size, but the disease is combated by destroying the tick that carries the micro-organism; hence in this case also dips are employed. A few chemicals or compounded mixtures may be useful for both dipping and disinfection, but there is no necessary relationship between dips and disinfectants because insects and ordinary disease germs are so different that a substance fatal to one may not be harmful to the other. Dips are therefore usually considered in a class by themselves, apart from disinfectants.

Disinfectants differ from one another in many of their properties, including their ability to kill micro-organisms, and germs also differ widely in their susceptibility to the various disinfectants. No single disinfectant is efficient against the germs of all diseases, nor is any disinfectant equally effective against the same germ under all conditions, for the activity of every disinfectant is influenced by such factors as the time of exposure to the disinfectant, temperature, chemical reaction and concentration, and the kind and amount of organic matter that may be present. Strictly speaking, there is no such thing as a "general disinfectant." So far as possible a disinfectant should be selected for its efficiency against the germs of a particular disease and its suitability for use in the place where it is to be applied.

GENERAL RULES FOR USING DISINFECTANTS

No matter what disinfectant may be chosen, however, there are certain general principles to be considered in using it. In the first place, since very few disinfectants act instantaneously even under the most favorable circumstances, it is always necessary to allow them ample time. In the second place, temperature has a great effect on the activity of disinfectants. Cold decreases and heat increases activity, so disinfecting solutions should, if possible, be used warm, or even

hot. Furthermore, under practical conditions there is always more or less dirt present, especially manure and other organic materials. Most disinfectants penetrate slowly and poorly, especially when organic matter is present. Solutions usually penetrate better than emulsions, while gaseous disinfectants cannot be depended on to penetrate to any depth. If manure or other similar material is to be disinfected, it must be broken up and thoroughly mixed with the disinfecting solution so that the latter is distributed through the mass.

Since organic matter serves to protect disease germs and otherwise interferes with the activity of disinfectants, disinfection should always be preceded by thorough cleaning. All manure, bedding, and rubbish in stables or barnyards should be removed to a place inaccessible to livestock and burned, if possible, or thoroughly mixed with disinfectant. Then after the area has been cleaned with hot water and soap or washing soda, the disinfecting solution should be applied liberally and thoroughly. If only a small surface is to be disinfected, the solution may be applied with a whitewash brush. In all cases, however, the best method of application is by means of a spray pump.

PRINCIPAL DISINFECTING AGENTS AND SUBSTANCES

Although no attempt will be made here to enumerate all the agents or substances that may be used to kill disease germs, some of the most useful physical agents and chemical substances will be discussed briefly. Among the physical agencies are sunlight and heat. Direct sunlight is an active germicide, but its intensity is so variable and its disinfecting power so superficial that it cannot be considered a reliable disinfecting agent. Heat may be applied in various ways. The chemical substances include acids, alkalies, compounds of various metals, chlorine and iodine and their compounds, and the general group that includes alcohol, carbolic acid, and substances chemically related to them. Some of these, such as sulfur dioxide and formaldehyde, are used as gases. The rest are used in solutions, usually in water.

Various substances or compounds are recommended or used as disinfectants on account of their odor. There is no connection between odor and disinfecting value, and disinfectants should be chosen only on account of their known disinfecting value.

Although none of the disinfecting agents or substances described in this article is universally useful, some of the simplest and least expensive can usually be employed in place of expensive proprietary preparations. When they can be used, such simple processes as burning, baking, boiling, or steaming will usually be more effective than any chemical disinfectant. Except for disinfection against the germs of tuberculosis, lime and lye, which are cheap and readily available, will be found quite generally satisfactory.

Heat in Various Forms

Burning is a most useful way of applying heat wherever circumstances permit. For example, if the place to be disinfected contains

a great deal of rubbish and articles of little value, burning will often be cheaper and easier than disinfection. Burning is also the most satisfactory method of disinfecting and disposing of small amounts of infected body discharges.

Dry heat is not so satisfactory as moist heat, since it lacks penetrating power and scorches fabrics, but it may occasionally be preferred. The ordinary household oven may be used for the purpose, and it should be heated sufficiently to brown cotton slightly (to about 320° F.). Objects to be disinfected should remain in the oven at this temperature for at least 1 hour. Moist heat is most often employed as boiling water or steam. Exposure to boiling water will destroy all ordinary disease germs, although it sometimes fails to kill the spores of such diseases as anthrax (splenic fever) or tetanus (lockjaw). Many disease germs are killed by moist heat at temperatures much below the boiling point of water as, for example, in the pasteurization of milk, and most of the ordinary disease germs are killed by boiling water in a very few moments. Boiling water may be used for the disinfection of fabrics of many kinds and of articles or implements made of materials that are not injured by boiling. In disinfecting objects made of iron or steel the addition of 1 percent of carbonate of soda to the water will prevent rusting. Although, as stated above, most of the ordinary disease germs are killed by boiling water very quickly, it is advisable in practice to allow at least 10 minutes' exposure so that every particle of the material to be disinfected may be heated to the required temperature.

Steam under pressure is perhaps the most effective of all disinfecting agents, but under farm conditions steam would usually be employed at atmospheric pressure as "streaming" steam. This has the same basic disinfecting power as boiling water, since streaming steam and boiling water have the same temperature—100° C. (212° F.). In practice, however, such steam requires a longer time to bring all of the material to be disinfected to the required temperature, and it is advisable, therefore, to allow an exposure of half an hour to an hour. Steam is useful for the disinfection of many kinds of material, but it shrinks woolen fabrics and ruins leather, fur, skins of all kinds, rubber shoes, oilcloth, and articles containing glue or varnish. Disinfection with streaming steam does not require any apparatus except a boiler to supply the necessary steam and a hose or tube to carry it. Feed bags or other articles of similar material may be disinfected by being hung in any sort of small compartment and treated with steam. Such a structure need not be tight, for the steam escaping through the cracks serves to produce a circulation that aids penetration of the heat.

Sulfur Dioxide

Sulfur dioxide is the gas liberated by burning sulfur. Although commonly used in the past, it is little used at present because it is too destructive to fabrics, colors, and metals. It is not a very good germicide and is more useful for the destruction of insects and vermin than for disinfection.

Formaldehyde Gas and Solution

Formaldehyde is practically the only gas suitable for general application because it does not injure fabrics, colors, or metals. The gas is used rather than the solution (formalin) where the value of materials, such as hay or fodder, would be lessened by wetting. Under farm conditions, however, its use is often impracticable. Since the gas escapes readily through any openings, compartments to be disinfected must be tightly closed and all openings sealed during the period of disinfection. Formaldehyde gas is not effective at temperatures much below 65° F., and it is desirable that the air be moist.

In disinfecting small compartments, formaldehyde solution (formalin) may be sprayed into the compartment and allowed to evaporate. At least 10 ounces of the solution should be used for every 1,000 cubic feet of space. For rooms and large compartments the usual method of liberating the gas is by the action of potassium permanganate on formalin. Since some of the formalin is used up in the chemical reaction with the permanganate, it is necessary to use 20 ounces of formalin and 16⅔ ounces of potassium permanganate for the disinfection of 1,000 cubic feet of space. The permanganate is placed in a wide-bottomed bucket or basin and the formalin poured over it. Since the reaction between the two substances liberates considerable heat, it is advisable to place the container on bricks or some other suitable material in order to prevent injury to the floor. As the action of formaldehyde gas is quite superficial, objects or materials to be disinfected should be spread out so as to offer the greatest possible surface to the action of the formaldehyde. After the formaldehyde gas has been liberated, the room or compartment should be kept tightly closed for at least 8 hours before it is opened and aired.

Formaldehyde solution is often used for disinfecting objects that are not injured by wetting. Its disinfecting power is great and not much affected by organic matter, but since it acts rather slowly ample time must be allowed. Formalin does not injure metals except after prolonged action, and it does not injure ordinary fabrics. It is not suitable for disinfecting furs because it tends to harden skins and make them brittle. It is usually employed in a 10-percent solution in water.

Boric and Acetic Acids

Boric acid is a very feeble germicide, although it is often used in solution as an application for the eyes and other sensitive parts of the body. Acetic acid is a more effective germicide, and the amount usually found in full-strength vinegar (usually about 5 percent) is sufficient to kill some of the less resistant disease germs. It is a stronger acid than boric and too irritating for application to the eyes or other sensitive parts of the body. Vinegar is sometimes used in the treatment of local infections or of skin diseases.

Lime and Lye

Lime is a very cheap and useful disinfectant. It is usually employed in the form of "milk of lime." Only quicklime should be used, since

air-slaked lime is practically useless. The quicklime is first slaked by adding 1 pint of water to 2 pounds of quicklime. Milk of lime is obtained by adding 4 parts of water to 1 of the slaked lime and mixing thoroughly. Whitewash may be prepared by adding water to milk of lime until a mixture of suitable density is obtained.

The following formulas for special whitewashes (from Farmers' Bulletin 1452, Painting on the Farm) may be found useful:

Whitewash No. 1 (for sheds, etc.).—Carefully slake half a bushel (38 pounds) of good quicklime; strain the paste, while still thick, through wire fly screen and add it to a solution made by dissolving 15 pounds of common salt in 7½ gallons of water, mixing thoroughly. Thin with more water.

Whitewash No. 2 (for sheds, etc.).—Carefully slake half a bushel (38 pounds) of good quicklime; strain the paste, while still thick, through wire fly screen and add about 4 gallons of hot water. While stirring vigorously pour into the lime mixture a solution made by first dissolving 12 pounds of salt and 6 ounces of alum in about 4 gallons of hot water and then adding 1 quart of molasses. Thin with water.

Whitewashing will help to make fences, pens, and outbuildings sanitary, besides improving their appearance. Milk of lime is well suited for use around dairy barns because it lacks odor. It is not effective, however, against the spores of germs that cause anthrax and lockjaw or against the germs of tuberculosis.

Ordinary lye usually contains about 94 percent of a chemical known as sodium hydroxide, which is a very effective disinfectant. It is effective against the viruses of foot-and-mouth disease and hog cholera and the germs of fowl cholera and bacillary white diarrhea of young chicks. In strong solutions it is effective against the spores of anthrax but not against the germs of tuberculosis. It is usually employed as a 2-percent solution in water, but for disinfection against anthrax it is necessary to use a 5-percent solution. A 2-percent solution may be prepared by adding 1 pound of lye to 5½ gallons of water. In cases where lime is not objectionable, the addition of 2½ pounds of water-slaked (not air-slaked) lime to the 5½ gallons of lye solution to form a whitewash will increase the effectiveness of the solution by preventing the transformation of the sodium hydroxide into a carbonate.

A whitewash made in this way should not be applied to materials that are injured by lye. **Concentrated lye is a caustic poison. Care should be taken to avoid getting any of it into the eyes or breathing in any of the fine dust that may arise while handling the dry material. Solutions should be so disposed of as to prevent injury to livestock.** Solutions of lye are injurious to painted or varnished surfaces and to woolen or silk fabrics if allowed to remain in contact with them for a considerable period of time. Since they do not injure bare wood, earthenware, enamelware, or any of the common metals except aluminum, they may be kept in containers made of these materials. Since exposure to the air soon converts sodium hydroxide to the relatively inactive sodium carbonate, containers should be kept tightly covered.

Various Chemical Compounds

Sodium carbonate and trisodium phosphate are used chiefly as cleansing agents, but they also have appreciable disinfecting value.

If they are to be used in solution for disinfecting purposes at ordinary temperatures it is advisable to add 0.5 percent of sodium hydroxide, but if the solutions are to be used hot this will not be necessary. Sodium carbonate is obtainable in the form of washing soda, soda crystals, and also as soda ash. Washing soda should be used in 6-percent and soda ash in 2-percent solution. Trisodium phosphate can be obtained as tribasic phosphate of soda, which should be used in a 2.5-percent solution.

The various inorganic compounds of mercury, especially the bichloride (corrosive sublimate), are known to be powerful disinfectants. They are not suitable for farm use, however, on account of the danger to the farm family and to livestock as well as their relatively high cost. From time to time various compounds of copper, arsenic, or zinc have been recommended as germicides, but they all have relatively little germicidal value. Sulfate of copper (blue vitriol), however, is extremely effective against algae, and since algae often cause unpleasant odors or tastes in drinking water, copper sulfate is sometimes added to water to check or destroy their growth.

Chlorine gas as a disinfectant is almost exclusively used for the treatment of water supplies or sewage. Some of its compounds, however, are widely used for disinfection on the farm. Chlorinated lime is commonly known also as chloride of lime, or bleaching powder. Although it is a powerful disinfectant its potency is greatly reduced by contact with organic matter, so that when it is employed for disinfecting manure or body discharges it must be used in considerable quantities. Since it is often of uncertain strength, is injurious to metals, and has an odor that is readily taken up by milk, it is not a very practical disinfectant, especially for use around dairy barns. It is usually employed in a water solution containing about 6 ounces to the gallon, or 1 pound to 3 gallons.

Besides chlorinated lime certain other chlorine compounds are in more or less general use. The hypochlorites, usually sold in solution and under various proprietary names, have been used quite extensively to disinfect dairy equipment such as milk cans and bottles. In the concentrations usually employed they are effective when applied to clean surfaces, but their efficiency, like that of chlorinated lime, is largely reduced by organic matter. They will not sterilize dirty equipment, and their application to surfaces that are not thoroughly clean is entirely useless. Chlorinated lime and the hypochlorites are not effective against the germs of tuberculosis.

Iodine

Iodine in solution is extensively used for skin disinfection, and it remains the standard for this purpose although there are many proprietary preparations containing organic compounds of mercury or silver that are widely advertised. Tincture of iodine is the solution most generally employed. Although complete sterilization of the skin by any disinfectant is almost impossible, the application of tincture of iodine for treatment of superficial wounds or for pre-

paring the site for an operation does serve to reduce the number of disease germs to a minimum. Since dirt interferes with the germicidal efficiency of iodine, the skin should be cleaned as well as possible before the solution is applied.

Alcohol

Grain alcohol has been used more or less as a disinfectant, and laboratory tests have shown that it is effective against the less resistant disease germs, such as those that cause typhoid fever. Absolute alcohol or solutions containing less than 50 percent of alcohol have comparatively little germicidal value. The most effective solutions are those containing about 70 percent of alcohol—the amount usually contained in "rubbing" alcohol.

Carbolic Acid and Cresol

The term "carbolic acid" has been rather loosely employed to designate a variety of substances that are chemically related but differ in their disinfecting properties. Although so-called carbolic acid has been widely used as a farm disinfectant, there is little to be said in its favor. It is generally uncertain in composition, and it has no advantages over other disinfectants that are readily available. The true carbolic acid (phenol) is not well suited for disinfection on a large scale because it is expensive and not as powerful as other disinfectants that cost less. It may be found useful, however, for disinfection on a small scale. Carbolic acid is not effective against the virus of hog cholera or the spores of anthrax, but it is very effective against most of the ordinary disease germs. It is most often used in a 5-percent solution in water. Carbolic acid and other similar disinfectants are not suitable for use in refrigerators or compartments where food is stored or in dairy barns, because food products tend to take up these substances from the air and acquire a disagreeable taste and odor.

Commercial cresol is known under various names such as tricresol, cresylic acid, and liquid carbolic acid. It consists of a mixture of closely related chemical compounds, all of which are superior to pure carbolic acid in disinfecting value. Cresol is not readily soluble in water and is therefore most generally used in mixtures with soap. It may, however, be used in a water solution in the same way as pure carbolic acid. Since it is more powerful than the latter, a 2-percent solution of cresol may be considered the equivalent of a 5-percent solution of carbolic acid. Unlike carbolic acid, cresol is effective against the virus of hog cholera.

A soap solution of cresol, known as the compound solution of cresol, is described in the United States Pharmacopoeia (U. S. P. XI, Liquor Cresolis Saponatus) and may be obtained at drug stores. A substitute for the compound solution of cresol, known as saponified cresol (also called cresylic disinfectant), is sold by companies dealing in disinfectants. Saponified cresol is cheaper than the compound solution and is just as good a disinfectant. It is extensively used

for disinfection under the supervision of the Bureau of Animal Industry. Saponified cresol is usually employed in a water solution, 4 ounces to a gallon of water. Solutions of cresol should not be used in or near compartments where food is kept, on account of the odor. Soap solutions of cresol do not mix well with hard water.

Besides disinfectants containing cresol in soap solution there are many proprietary disinfectants that contain cresol along with coal-tar oils and soap in mixtures that form milky emulsions in water. The disinfecting power of these products varies. Since there is no trustworthy method of determining their relative values by chemical analysis, they are compared by laboratory tests on typhoid fever germs. They are tested along with carbolic acid (phenol), and their values in comparison with it are expressed in the form of a "phenol coefficient." Since these coal-tar-emulsion disinfectants vary so much in disinfecting value, it is advisable to use only those that have a guaranteed phenol coefficient. However, since phenol coefficients are determined under laboratory conditions that are likely to differ from conditions in practical disinfection, the coefficient often does not accurately indicate the relative values of disinfectants in actual use. Thus it is safer to use these disinfectants, especially in the presence of organic matter, in concentrations twice as great as would be indicated by the phenol coefficient.

In the disinfection of dairy barns and similar places in the campaign for eradication of tuberculosis the cresol disinfectants have been found objectionable on account of their odor. Under such conditions a disinfectant called sodium orthophenylphenate is extensively used because it is free from objectionable odor.

Soaps

Soaps have some germicidal power, especially when used with hot water, but this power is rather limited. Cleaning with soap and hot water kills some of the less resistant disease germs but the effect is largely mechanical through the removal of dirt and infective material. Of the soaps commercially available those prepared exclusively from coconut oil, such as so-called salt-water soap, usually have the greater disinfecting value. Medicated soaps, in general, have little disinfecting power and cannot be relied upon to destroy resistant organisms.