The Use of Formaldehyde as a Biocide for Disease Prevention in Animal Housings and Thus to Protect Humans Against Animal Diseases

Chemiebüro Widulle, March 2015

The owner of Chemiebüro Widulle, Dr. Herbert Widulle, is co-author of Kramer, Assadian, Wallhäußers Praxis der Sterilisation, Desinfektion, Antiseptik und Konservierung, Thieme Verlag Stuttgart, 2008. So, usage of data publish in that book, especially in the articles about formaldehyde, glutaraldehyde, peracetic acid and chlorine may be done without proper citation, due to the fact, that the data where generated by Dr. Herbert Widulle himself.

1. Introduction

Formaldehyde is one of the oldest disinfectants in use and its benefits and dangers very well documented. Basically formaldehyde replaced chlorine and phenols in the disinfection of hospitals and animal housing because of is better ratio between toxicity and effectiveness. The toxicity profile of formaldehyde is shaped by the fact, that all living cells contain formaldehyde as necessary part of their metabolism. Formaldehyde is interim compounds necessary to produce carbon dioxide for energy production (1).

Because of this, low concentrations of formaldehyde are not toxic to organisms, but enhance cell growth. Only if formaldehyde activity is so great, that proteins and amino sugars of the cell´s pores in its bio membranes are altered by formaldehyde and loose their ability to work as valves for nutrients and gases, formaldehyde becomes poisonous (2).

Because of high hygienic standards in animal keeping, achieved by using formaldehyde as a disinfection compound, the number of cases of illnesses of deaths caused by diseases transmitted from animals to humans has decreased. As an example may be mentioned tuberculosis, which bovine form is pathogen for humans too. Bovine tuberculosis is still a major threat in the eastern parts of the EU (3).

Formaldehyde has a very broad spectrum of antimicrobial activity and no other compound with the same spectrum of activity is know, which is safer. This statement includes peroxides, especially peracetic acid, chlorine and glutaraldehyde.

Peracetic acid is a highly reactive, corrosive compound, which is detoxified by blood catalytically. Peracetic acid is only virucidal at pH- values below 8.3 under clean condition. In an animal housing peracetic acid should be used at pH- values below ≈ 4 to insure activity against non enveloped

viruses. Peracetic acid fumes at a pH- value of 4 damage eyes and lung.
Chlorine is not effective in contact with organic load, or dirt. This is knows since the early 1980 years, when the water of public swimming pools were examined in Germany. In spite of chlorine levels of 1 ppm active chlorine or more and chlorinated organic compounds in the air above the water, disinfection performance war not sufficient. For further information use the publications of the former "Institut für Wasser-, Boden-, Lufthygiene" of the former Bundesgesundheitsamt in Berlin.
Glutardialdehyde is not efficient against non enveloped viruses in contrast formaldehyde. The French AFNOR used the vaccine strain of polio for testing inactivation and proved the effectiveness against that particular strain (4). But addition testings with a wild strain proved that the results would not cover all strains of polio, only the vaccination strain. The toxicity is similar, especially the sensitizing properties (5,6)

2. Toxicity of Formaldehyde
The toxicity of formaldehyde and its effects on humans is well known. For many years the "Senatskommission zur Prüfung gesundheitsschädlicher Arbeitsstoffe" has collected data about illnesses of workers exposed to formaldehyde. From these data they have derived maximum workplace concentrations, which will ensure that a worker exposed to formaldehyde will not suffer from any damage caused be that chemical, even if he is exposed for 8 h/d his whole life (7). The Senatskommission sets the limits for a life long exposure to formaldehyde with 0.3 ml/m³ equiv to 0.37 mg/m³, Spitzenbegrenzung I(2), as skin sensitizer, cancer category 4, exposure during gravity C and mutagenic against sperms with 5 (8).
Category 4 of cancer generating poential means: "Stoffe, die bei Tier oder Mensch Krebs erzeugen oder als krebserzeugend für den Menschen anzusehen sind und für die ein MAK- Wert abgeleitet werden kann. Im Vordergrund steht ein nicht genotoxischer Wirkungsmechanismus, und genotoxische Effekte spielen bei der Ableitung des MAK- und BAT- Wertes keine oder nur eine untergeordnete Rolle. Unter diesen Bedingungen ist kein Beitrag zum Krebsrisiko für den Menschen zu erwarten. ....."(9)
Because fuming is only effective in exact controlled environments, e.g. tightly closed small rooms, as patient rooms in hospitals, disinfection with formaldehyde is commonly done in animal housing and stables by wiping and spraying with low pressure. Low pressure spraying is used to avoid small particles, which may pass trachea and bronchus and damage the lung. Only using the

common techniques of wiping and low pressure spraying makes it possible to disinfect a stable according to the DVG- guidelines (Deutsche veterinärmedizinische Gesellschaft). DVG- guidelines are the only ones, which take into account the influence of roughness of surfaces. That is the reason why DVG recommends 400 ml of disinfecting solution for disinfection.

Personal protection equipment was introduced by farmers and workers of service companies only recently. So, if wiping and low pressure spraying of formaldehyde would cause cancer, this should be measurable and would have been published. The International Agency for Research on Cancer IARC has published maps of the different cancer risks in the EU, differentiated by type of cancer and administrative unit (10). If formaldehyde generates cancer in humans under working conditions without personal protection equipment, this should be visible in the map on page 226, which displays the cancer deaths of male of trachea, bronchus and lung. Astonishingly the Kreis Vechta in southern Niedersachsen does not show an increased rate of cancer of that type in males, as expected. The Kreis Vechta, the area with the highest density of pigs and chicken in Germany, most of them housed in big stables, which have to be disinfected often and with formaldehyde or formaldehyde products does not show an increased risk of cancer for the people. The data of IARC in Lyon show, that the comment in MAK- Werte Liste of 2014 on page 81 is true: Short term exposure to formaldehyde does not create a risk of cancer, even if the concentration is so great, that irritation of the eyes occurs. The data published by IARC prove, that wiping and low pressure spray do not put a risk on the worker.

On the other hand, since disinfection of animal housings and stables is taking place, the number of farmers, who were infected with a diseases transmitted from animals kept in a housing, has become smaller. So the decision is not, to prevent farmers and workers of service companies from the dangers of formaldehyde, but to compare the number of dead with and without the usage of formaldehyde in animal housings. Even if no data should be available for farmers being killed by diseases transmitted from animals, the ethical problem remains the same. BfR does not publish data for farmers and workers of service companies, but for the entire human population in Germany. The data show good correlation between contaminated meat samples and infection of humans by Camphylobacter species (11). In addition the data of BfR show a massive contamination of herds in Germany with Camphylobacter species (12). So, reducing hygienic standards in animal housing by restricting the use of formaldehyde will increase the number of humans infected with a zoonosis and the number of deaths.

3. Formaldehyde and its Use as a Disinfectant in Animal Housing for Disease Prevention

DVG (Deutsche veterinärmedizinische Gesellschaft) has developed guidelines for the disinfection of animal housings and stables to ensure low microbial contamination in those buildings. This was not only done to increase the well being of the animals but to reduce the risk of being infected with transmittable diseases for farmers and workers. Diseases which may be transmitted from an animal to a human are Leuschmanniose, MERS, influenza, Tuberculosis and others.

To gain an approval from DVG, a biocidal product and the total disinfection process has to be tested by DVG. DVG approves a biocidal product, if the product is active in a suspension test and in a carrier test, the carrier being from wood to resemble the wooden surfaces in animal housings. Recommendations of biocidal products by DVG are only valid, if the recommended product concentration is used and the surfaces are treated with the recommended amount of solution, which is 0.4 l/m² treated surface. If a ready to use solution of 0.7 percent formaldehyde is approved by DVG, it means that 0.0028 kg formaldehyde have to be used per square meter surface. In addition these 0.0028 kg formaldehyde have to be applied to the treated surface and have not to be settling in the air as fog.

It is essential, that the biocidal product is applied directly to a surface and not blown into the air. Every mixing increases the mixing entropy and thus reduces the biocidal activity of the biocidal compound.

Stables for animals are complicated constructed buildings, which do have opening to the outside and necessary equipment inside. For the construction of animal housings, timber, concrete and metal are used. Parts of these buildings are dry, others are exposed to faeces, urine and humidity from the lung of the animals. To guarantee a successful disinfection by fumigation, the surfaces of the stables, which are to be disinfected have to have all the same water activity on the surface, if the formaldehyde fog has the same concentration and duration time at all places of the building. Due to openings, this can not be guaranteed. Even if doors and known openings of a modern lightly constructed stable are shut, unknown openings may generate airflow and air circulation which prohibit proper disinfection. Because of the variety of types of stables, the effectiveness of fogging procedure has to be validated for each single building, because otherwise the effectiveness of the procedure cannot be guaranteed. Because of this, it should a standard procedure when fogging, to document size of the building, air flow, air circulation, duration of fogging, location of fogging apparatus, type of fogging apparatus, heat of fogging, consumption of formaldehyde, concentration of formaldehyde and humidity of the air to ensure reliable results.

When disinfecting a small room in a hospital with formaldehyde fumes, all this has to documented, according to TRGS 522 all these things have to be taken into consideration.

Fuming of small stable of 3000 m² and 5 m height with formaldehyde would need 75 kg pure formaldehyde or about 200 kg of a 33 percent solution if the procedure of BGA is used (13). A building of that size would have an inner surface of approximately 4300 m², without the roof. According to DVG it would take 12,0 kg pure formaldehyde in 1720 kg solution to soak the whole building such, that decontamination is guaranteed, if low pressure spraying or wiping is used. This is less than a sixth of the amount BGA thinks necessary. But in hospitals with their smooth surfaces, 30 g/m² disinfection solution is considered sufficient, where as DVG considers 400 g/m² solution as sufficient due to the rough surfaces in animal housings *)(14). In contrast to hospitals stables have rough surfaces, with a much greater effective surface than visible. To decontaminate an animal housing, the total effective surface has to be disinfected, not only the visible one. Because of this, DVG still insists on a wooden carrier for the carrier test.

So, to achieve the same hygienic standard, DVG thinks to be necessary and using the recommendation of BGA for hospitals as basis for the calculation, 1000 kg pure formaldehyde would have to be fumigated in the stable, which is used as an example.

4. Microbial Properties of Formaldehyde

Formaldehyde is a compound, which is distributed all over the planet. Even above the high seas formaldehyde can be detected and measured. Most of the formaldehyde is not from human origin, but naturally produced.

Formaldehyde reacts with the protein coating of the pores in the cell pores. The cell pore proteins, which are modified by formaldehyde, cannot function as valves anymore. This causes the death of bacteria and fungi. Humans and other mammals are protected by the epithel layer of dead horn cells, which protect the living dermis beneath it. Enveloped viruses have an envelope which is part a modified sacculus of the infected mammalian and sensitive to formaldehyde. The genome of non enveloped viruses is protected by a capsule, made from proteins as the capsule in the envelop of an enveloped virus.

*)Today hospital floors are only wiped with less than 30 g/m² disinfection solution. Some times, they are only wiped with 2 g/m². Because bacteria and bacterial spores do not stick to the ground but are distributed in the air according to the barometric formula this may be one of the reasons for the high number of up to 60000 deaths per year related to nosocominal infections in German hospitals alone (The number was reported at the annual meeting of VAH, Berlin 2014).

The capsule is, being made from proteins, is sensitive to formaldehyde. Formaldehyde reacts with the capsule of spores. Because of this formaldehyde does not have a gap in its efficiency, but is nearly equally efficient against all types of germs, as long as microbicical concentration is reached. Formaldehyde kills all type of germs, even in the presence of dirt. Formaldehyde is the only biocidal compound, which does that. Neither chlorine, nor peracetic acid does that. In inefficiency of chlorine against enveloped viruses under dirty conditions is the reason for the spreading of the Ebola epidemic last year and this year in Africa.
Discharged formaldehyde can easily be degraded biologically, as soon as the minimal microbicidal concentration is not reached any more.
In an animal housing, the exact type of germ, generating losses in lifestock is mostly unknown and it would be too cost intensive to specify the type of germ. In addition, the need for a high hygienic standard is extremely high, because the number of animals per area and the cost of losses.

5. Summary

If wiping or low pressure spraying of aqueous formaldehyde solutions should be prohibited in future, the losses of lifestock will increase. To reduce the losses of lifestock, antibiotics will have to be used. Fumigating formaldehyde is no alternative, because the amount of formaldehyde to achieve a secure decontamination of an animal housing are greater than the amount needed by wiping and low pressure spraying.
Publication from IART has shown, that wiping stables and low pressure spraying with formaldehyde seem to be only a theoretical risk for the worker of the farmer. No epidemic proof could be found for an increased risk of cancer for people farmers or workers of service companies, who wipe surfaces with formaldehyde solutions or use low pressure spraying to decontaminate the surfaces. In addition it could be shown, that the risk of farmers and workers of service companies and normal consumers of meat or milk products to be infected and eventually die from diseases transmitted from infected animals, like Spanish influenza.

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6. Literature

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