A LABORATORY STUDY OF CLEANABILITY OF SURFACES FOR USE IN PIGGERIES

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SUMMARY

The aim of this laboratory study was to examine the effects of plastic coatings on cleanability of concrete flooring for use in piggeries. According to both colorimetric and radiochemical measurements, coating of concrete improved the cleanability of floorings intended for use in piggeries. The quantitative radiochemical method appeared to be an excellent way to detect soil absorbed in materials. This is important especially from the point of view of surface hygiene in animal houses. A colorimeter detects soil visible on surfaces, gives results instantly and can be used both in practical conditions in animal houses and in laboratory studies.

Keywords: animal house, piggery, flooring, cleanability, radiochemistry, colorimetry

INTRODUCTION

Material choices in animal houses are an important factor affecting the well-being of animals by allowing their species-characteristic behaviour and preventing injuries and diseases. For example the flooring should not be slippery or act as a reservoir of harmful microbes. Material choices also affect the comfort and safety of the personnel working in animal production buildings. When the aim is to produce safe food products, requirements for hygienic properties of the production plants are also of importance. Furthermore, the hygienic environment of the animals affects the quality of meat. Both chemical substances and mechanical impact on floorings cause corrosion and wearing that may promote injuries to the animals. In addition they may make cleaning difficult, thus promoting spreading of diseases (DeBelie, 1997). Therefore the use of coatings to protect the surface of concrete against wear is of interest. For example polyurethane has sometimes been used in cow houses and horse stalls, but its use in animal floorings is not widespread. The aim of the study was to examine the effects of plastic coatings on cleanability of concrete flooring for use in piggeries.

MATERIALS AND METHODS

Concrete, the most common material for solid and slatted floors of piggeries, and five plastic coatings were examined (Table 1). All materials and methods were presented in detail in Kymäläinen et al. (2007). The surfaces were examined both as new and as worn. Wearing was carried out by grinding the surface of the tiles for with a floor grinding machine (t = 30 s, m = 37.6 kg, sandpaper disc n:o 60 ø = 400 mm, p = 0.3 N/cm^2 = 3.0 kPa. The surface materials examined were characterized with SEM (scanning electron microscopy) and a laser profilometer.

Table 1. Codes and types of examined surface materials. All coatings were based on concrete tiles

Code	Type
EP mass	Epoxy mass including sand, finished with rubbing
EP concrete mass	Epoxy + cement mass, sand scattered on the top
MDI PUR	MDI-based polyurethane, sand scattered on the top
PUR concrete mass	Polyurethane + cement mass, sand scattered on the top
Rubber PUR	Rubber-polyurethane, rubber crush scattered on the top
Concrete	Concrete

The natural manure soil and other model soils were used for the cleanability experiments (Table 2). Radiochemical and colorimetric methods were used for assessing the cleanability result. The cleaning system for the colorimetric study consisted of a pressure cleaner (120 Bar = 12 MPa, angle of the nozzle 45° to perpendicular, T of water = 10°C, 40°C, 75°C), a conveyer belt to move the samples (v = 0.9 m/s, distance between the washing nozzle and sample surface = 18 cm). The samples were subjected to three soiling and cleaning cycles at each temperature. In addition, two different radiochemical methods, a gammaspectrometric method and liquid scintillation counting, were used for evaluation of the cleanliness of the surfaces. The use of different radio isotopes enables the determination of different components of soil. ^{51}Cr labels particle components and ^{14}C oil components of the model soils.

Table 2. Model soils used in the cleanability study and details of soiling

Method	Model soil	Amount of soil per sample,	Drying time after soiling, d
Colorimetrical	Paste model soil soil (Puumala and Lehtiniemi 1993) containing paste, rye flour, sawdust, water and red caramel color	38 ml	7
Colorimetrical	Manure soil: pig sludge manure containing sawdust	45 ml	14
Radiochemical	Inorganic particle and oil soil: Cr_2O_3, $C_{57}H_{104}O_6$, ^{51}Cr	50 µl	1
Radiochemical	Inorganic particle and oil soil: Cr_2O_3, $C_{57}H_{104}O_6$, ^{14}C	50 µl	1

RESULTS AND DISCUSSION

As can be seen in Figure 1, in general the effect of wearing on the surface roughness was minimal. Although the surface of concrete was visibly porous, the roughness values selected did not indicate any difference between the pores and peaks of the surfaces. The porosity of concrete was more clearly illustrated by SEM figures (Figure 2).

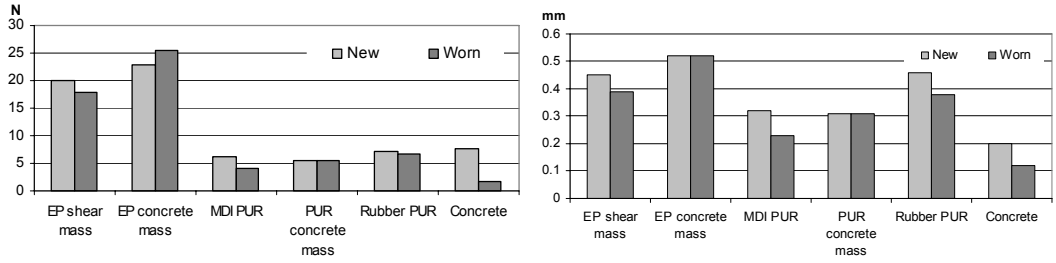

Figure 1. Mean roughness of new and worn surface materials as high spot count per 100 mm (left) and as peak average height (mm, from the mean centre line, right), determined with a laser profilometer. Results are means of 5 replicates with three independent measurements per replicate

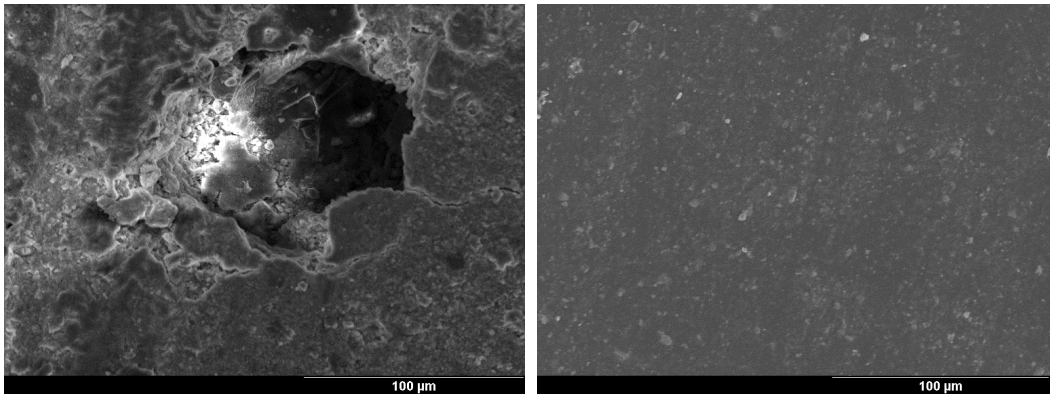

Figure 2. Examples of the SEM micrographs of new concrete (left) and rubber polyurethane coating (right), magnification x500

According to the colorimetric measurement the three different washing temperatures did not affect the cleanability of the surfaces from the paste soil. Therefore only the results of the warm wash (40 ºC) are presented in Figure 3. The coatings increased the cleanability of concrete. Uncoated concrete had the poorest cleanability. In the case of all surface materials both soils were mainly only wetted during the first wash cycle and removed during the second cycle. The third cycle did not improve the cleanability result. The effect of coating on cleanability was statistically significant but there was no significant difference between different coatings. There were only small, partly contradictory differences in cleanability of the coated surfaces from the two soils. Higher deviation in the E values of the manure soil compared to that of paste soil was mainly due to uneven removal of the manure soil.

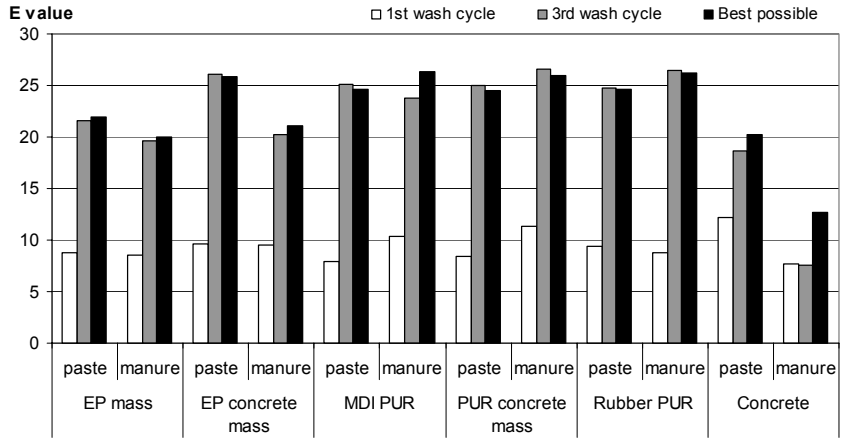

Figure 3. Colorimetrically determined cleanability of worn floorings from paste and manure soils using warm water (40ºC) in the three washing cycles, compared with the best theoretically possible cleaning results. In order to define the best possible E value, theoretical E values were calculated using colorimetric values of the unsoiled surfaces. Results are means of six replicates. The higher the E value, the better is the cleanability result.

As can be seen in Figure 4, the radiochemical model soil with ^{51}Cr was removed more efficiently from surfaces than the soil labelled with ^{14}C. This indicates that the particle components of soils were removed more efficiently from the surfaces than the oil components. As in the case of the colorimetric measurement, coating of concrete was found to affect the cleanability, that of the uncoated concrete being the poorest. In the cases of both model soils the coatings did not differ statistically from each other. However, when individual materials were compared, more detailed information about the differences between the coatings was obtained with the radiochemical than with the colorimetric method. In addition, the difference between the coatings and uncoated concrete was more evident in the radiochemical method than in the colorimetric measurement.

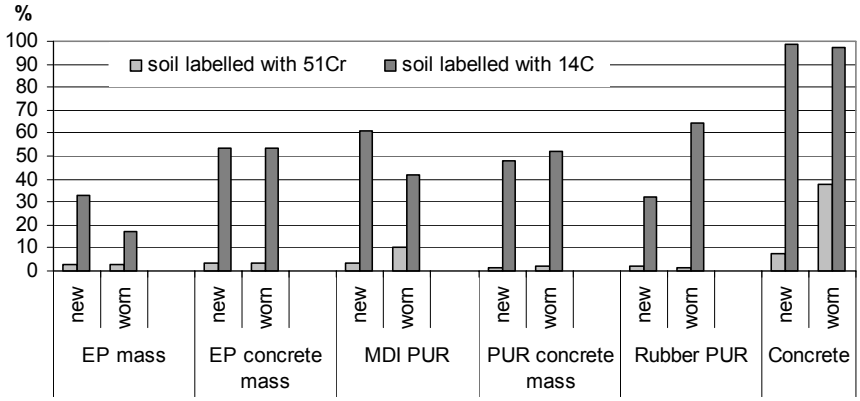

Figure 4. Cleanability of new and worn floorings from manure soil using radiochemical measurement. Results of soil residues (%) are means of five replicates. The lower the soil residue, the better is the cleanability result.

In the case of all soils in both the colorimetric and radiochemical studies, no general differences were observed between the new and worn surfaces. However, when examining the radiochemical results, soil residues on worn surfaces of rubber PUR and concrete were greater than on the new surfaces of these materials, whereas the colorimetric method showed no difference between the new and worn surfaces. There was a significant correlation between the cleanabilities of the surfaces from both radiochemical soils (soil residue %) and manure soil.

In earlier studies concerning the cleanability of materials in animal houses (Sundahl, 1974; Hörndahl, 1995; Puumala & Lehtiniemi, 1993; Larsson, 2000; Zhang et al., 2006), visual and qualitative evaluation methods were mainly used. Other methods used are microbiological contact methods (Larsson 2000, Pelletier et al. 2002), a protein test (Larsson 2000) and optical methods (Zhang et al. 2006). In the present study both the semi-quantitative colorimetric method with real manure and artificial paste soils, and the quantitative radiochemical method with simplified model soils gave similar results concerning cleanability of the examined surfaces. This is a very important methodological result for further studies. However, in the present study all other examined surfaces were non-porous except for the uncoated concrete. In the case of porous surfaces the radiochemical method is of even greater importance, since it also detects soil from inside the material.

Ideal flooring is a compromise (Baxter 1984) or a balance between different properties (Shaw 1988). Cleanability is one important factor determining the hygienic properties of the floorings, which in turn affects both the well-being and health of the pigs and the hygienic quality of products. However, coatings increase the cost of the flooring and therefore the coating might be used at selected sites of high hygienic importance in piggeries. Furthermore, preventing slipperiness should be taken into consideration.

CONCLUSIONS

According to both colorimetric and radiochemical measurements, coating of concrete improved the cleanability of floorings intended for use in piggeries. The use of coatings can thus be justified in sites in which a high level of cleanliness is required, probably meaning that coatings will be used only in some sites in animal production buildings. According to the colorimetric results, coating also decreases the time required for cleaning. Cleanability should be taken into consideration when selecting materials for sites with hygienic requirements. From the methodological point of view, in this study we demonstrated the applicability of two different evaluation methods for soiling and cleanability of agricultural surfaces, namely the radiochemical method for laboratory studies and colorimetry for both laboratory studies and field use.

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