Historic England

Building and Landscape Conservation

The Health Risks from Contaminated Flood Water in the UK

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Discovery, Innovation and Science in the Historic Environment

Research Report Series no. 39-2017

The Health Risks from Contaminated Flood Water in the UK

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ISSN 2059-4453 (Online)

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Front cover: Cleaning up after flooding in Shrewsbury. ©Paul Glendell

FOREWORD

Historic England is frequently called upon to give advice about remedial works and repair after incidents of flooding. Conventional approaches to remediation usually require extensive removal and replacement of building fabric, such as timber floors, joinery and plasterwork. This is costly and can result in substantial harm to the heritage significance of a building. In addition, buildings may remain unusable for extended periods, disrupting the lives and businesses of occupants. The research described in this report forms part of a programme of investigation to understand better the resilience of older buildings to flooding. In addition, the effectiveness of measures to increase their resilience and differing approaches to remediation are being assessed. The aim is to provide information that will enable informed, evidence-based decisions to be made on ways that minimise the impact of flooding on the historic built environment.

SUMMARY

This report presents a preliminary review of risks to human health from contaminated flood water in the UK.

ACKNOWLEDGEMENTS

The author would like to thank Tracy Manning for her assistance in producing this report.

DATE OF THIS REPORT

July 2017

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1.0 INTRODUCTION

Historic England's preliminary study of responses to flooding has indicated that there is no unified approach to microbial health risks. Major hazards, such as drowning or electrocution, are well understood and there is clear guidance. But assessing the risks from less dramatic hazards, such as contamination from overflowing sewage disposal systems, relies on the judgement of the individual flood assessor. This may not be a problem in a domestic situation, where saturated carpets and furniture can be disposed of and replaced under insurance policies. However, it can become a problem when the judgement is applied to the fabric of historic buildings. Stripping out porous materials, such as plaster and timberwork, because they might be difficult to clean and could pose a health hazard (albeit unquantified) can result in substantial harm to the heritage significance of a building. There are stories of skips filled with church pews, for example.

This report provides a preliminary review of the problem. The intention is to see whether currently available technical publications and official guidance would enable us to formulate a more coherent approach to dealing with contamination.

2.0 MICROBIAL HAZARDS

2.1 Epidemics of infectious diseases

In 2006 the World Health Organisation (WHO) published a Flooding and communicable disease fact sheet. They state under water-borne diseases:

> Flooding is associated with an increased risk of infection, however this risk is low unless there is significant population displacement and/or water sources are compromised.

This was a global review and they comment that of 14 major floods, between 1970 and 1994, only 2 (in Sudan and Mozambique) resulted in a significant increase in reported diarrhoeal diseases.

Ahern *et al* (2005) consider that while flood water increased the potential for faecal–oral disease transmission, this was especially in areas where the population had no access to clean water and sanitation. The risk from diarrheal illness was low in high-income countries.

The risk of an outbreak of infectious disease in Western Europe following flooding was investigated by Brown and Murray (2013). They state that unless there is a significant population displacement the risk is minimal. Significant population displacement – carrying disease from location to location – is unlikely to be a problem under normal flood conditions in the UK.

2.2 Local health hazards

Nevertheless, there is a health hazard for the individual affected by flooding. Reacher *et al* (2004) undertook interviews following flooding in Lewes and found that there was a reported increase in gastrointestinal problems, which seemed to be associated with depth of flooding.

Vasconcelos (2006) identified nine hazards from flood water, of which two are relevant to this review (the others include death, vector-borne disease such as yellow fever and snake bite). These are:

- Enteric infections due to increased faeco-oral cycling from disruption of sewage disposal and safe drinking water infrastructure.

- Rodent-borne disease such as *Leptospirosis*.

The pathogens generally considered to represent the hazard are discussed by Sterk *et al* (2008). These are:

- *Escherichia coli*: A rod-shaped bacterium (gram negative) commonly found in the lower intestine of warm-blooded animals. Most strains are harmless but a few can cause problems.

- *Enterococci*: These are lactic acid bacteria (gram positive) found in human and other animal intestines.

- *Campylobacter*: These are curved bacteria (gram negative) that are usually, but not exclusively, found in poultry. It is said to be the most common form of food poisoning in the UK.

- *Cryptosporidium*: Parasitic protozoans that live in the guts of warm-blooded animals.

- *Giardia*: Parasitic flagellate protozoans with a similar habitat to *Cryptosporidium*.

Sterk (loc cit) analysed the health risk from flooding in Utrecht by looking at contaminated water from overflowing sewers. They concluded that the most important health risk was from playing in the water or being splashed by it so that some was swallowed. They conclude:

> To give a framework for the magnitude of the risk, flood water is compared to bathing water, since for bathing water 'acceptable risk' is defined by WHO, based on *E. coli* and *Enterococci*. The doses of *E. coli* and *Enteroccoci* in urban flooding are 20–30 times higher for pedestrians and 60–90 times higher for children than is considered acceptable for swimmers according to WHO guidelines.

They also point out that the risk is going to be case specific. We might suppose, for example, that the risk in a town where there is a sewer system is going to be different from the risk where the land is open fields. Open fields, however, might still pose a significant risk if they are full of cow dung.

Fewtrell *et al* (2011) working with the same organisms but adding *Salmonella*, concluded that the main contamination was in sediment so that the most significant health risk was during the clean-up process. Their risk assessment was based on the assumptions that either people did not wear gloves or this did not stop them ingesting 1ml/hour of water. Similarly ten Veldhuis et al (2010) found that the values for *E. coli* were 100 times greater in the sediment than in the water.

3.0 MICROBIAL VIABILITY FOLLOWING DRYING

It would seem that most of the risk from contaminating micro-organisms is removed when water recedes and surfaces are cleaned. Historic England's preliminary investigations following flooding in Hebden Bridge, Yorkshire and Appleby in Westmorland, Cumbria, in 2015 showed that in many cases this is undertaken by the householder/occupier using buckets, mops, disinfectants etc, and that official guidance was available.

Organisms vary in their ability to survive drying. Robertson *et al* (1992) showed that *Cryptosporidium* resting spores (oocysts) would only live for a few hours at normal room temperatures. Alum *et al* (2014) showed that the viability of both *Cryptosporidium* and *Giardia* resting spores was inversely proportional to substrate porosity. The greater osmotic stress within a pore of fabric, ceramic or presumably wood (not tested) caused the spore to desiccate at a faster rate than on an exposed surface.

The problem of residual contamination would therefore seem to relate to bacteria and gastrointestinal viruses. Kramer *et al* (2006) reviewed the literature (research on hospital acquired infections) and found the following survival rates on inanimate surfaces for the relevant bacteria and viruses:

Pathogen	Survival on dry surfaces
Campylobacter	Up to 6 days
E. Coli	1.5 hours to 16 months
Enterococcus	5 days to 4 months
Gastrointestinal viruses	2 Months

It must be remembered that these are for surfaces that had not been cleaned and disinfected.

4.0 ABSORPTION OF BACTERIA INTO WOOD

Abrishami *et al* (1994) looked at bacteria adherence and viability on plastic and wooden chopping boards. They showed that bacteria were absorbed into the wood, but that this was inhibited if the wood was already wet. In practice this suggests that contamination during a flood would not be accumulative.

They also demonstrated that oiling the surface changed it from an absorbent to a non-absorbent surface. This will mean that paint, varnish and other surface finishes would restrict absorption.

5.0 CONTAMINATION WITHOUT FLOODING

The bacteria we are discussing are found in the digestive tracts of many warm-blooded animals. Human waste goes into sewers but animal waste is deposited on the land and becomes potentially distributed on many surfaces including fence posts and styles. Much of the work on bacterial survival in wood and other materials (outside of hospitals) has been concerned with farm surfaces. Bale *et al* (1993) looked at bacterial survival rates in farm buildings and found that gram-positive bacteria survived for longer than gram-negative bacteria under dry conditions. But it is important to note that this study was not concerned with flooding. It was about contamination that is generally present in those environments. The destruction of wooden structures because they might have been contaminated by flood water (as has frequently been suggested) would be a meaningless exercise because they were probably already contaminated.

Williams *et al* (2005) looked at the persistence of *E coli* on various samples, including wood, removed from farms. They found that contamination declined over a few months if the samples were dried, but for us the important point is that contamination was present. They showed that even brief hand contact was enough to pick up contamination. They suggested that farm workers acquired a higher resistance to infection.

6.0 PRELIMINARY CONCLUSIONS

The risk from contamination following flooding is mostly concerned with flood water and cleaning up. Residual contamination could potentially be by bacteria that might persist for a few months on dry surfaces. These could cause gastrointestinal problems if ingested following skin contamination. However, they should be easily removed from non-porous surfaces, and recommendations for cleaning are available.

Bacteria will penetrate into the surface of porous material such as wood and remain viable for some months, but not if there is a surface finish that makes the material impermeable. The risk from human contact with the backs of panels, or joists under floors etc, must be minimal. The same hazard would be common to plaster, brickwork or any other porous material – there is nothing special about wood. If a stone surface can be cleaned then so can a wooden one.

The hazard from these bacteria is already present in the environment for anyone visiting or working in a farm environment or walking in the countryside; a flood just brings that environment into a building. (Presumably, the hazard would also be associated with keeping pets, although this has not yet been investigated.) Measures used to clean on farms or in animal houses etc. should be equally effective in buildings following floods.

7.0 REFERENCES

Abrishami, S, Tall, B., Bruursema, T., Epstein, P. and Shah, D. (1994). 'Bacterial adherence and viability on cutting board surfaces'. *Journal of Food Safety,* 14, 152–172.

Ahern, M., Sari Kovats, R., Wilkinson, P., Few, R., Matthies, F. (2005). 'Global health impacts of floods: epidemiological evidence', *Epidemiological Reviews*, 27, 36-46.

Bale, M., Bennett, P., Beringer, J., Hinton, M. (1993). 'The survival of bacteria exposed to desiccation on surfaces associated with farm buildings', *Journal of Applied Bacteriology*, 75, 519–528.

Brown, L., Murray, V. (2013). 'Examining the relationship between infectious diseases and flooding in Europe', *Disaster Health*, 1:2, 1–11.

Fewtrell, L., Kay, D., Watkins, J., Davies, C., Francis, C. (2011). 'The microbiology of urban UK floodwaters and a quantitative microbial risk aswsesment of flooding and gastrointestinal illness'. *Journal of Flood Risk Management*, 4: 77–87.

Kramer, K., Schwebke, I., Kempf, G. (2008). *BMC Infectious Diseases,* 6: 130.

Reacher, M., McKenzie, K., Lane, C., Nichols, T., Kedge, I., Iverson, A. (2004). 'Health impacts of flooding in Lewes: A comparison of reported gastrointestinal and other illness and mental health in flooded and non flooded households'. C*ommunicable Disease and Public Health*, 7: 56–63.

Robertson, L., Campbell, A., Smith, H. (1992). 'Survival of *Cryptosporidium parvum* Oocysts under various Environmental Pressures', *Applied and Environmental Microbiology*, 58 (11): 3494–3500.

Sterk, G., ten Veldhuis, J., Clemens, F., Brends, B. (2008). 'Microbial risk assessment for urban pluvial flooding', *11th International Conference on Urban Drainage*, Edinburgh.

Vasconcelos, P. (2006). 'Flooding in Europe: a brief review of the health risks', *Eurosurveillance* 11 (16) April.

ten Veldhuis, J., Clemens, F., Sterk, G., Berends, B. (2010). *Water Research,* 44: 2910–2918.

Williams, A., Avery, L., Kilman, K., Jones, D. (2005). 'Persistence of *Escherichia coli* on farm surfaces under different environmental conditions'. J*ournal of Applied Microbiology,* 98: 1075–1083.

World Health Organisation (2006). Humanitarian Health Action–Flooding and communicable diseases fact sheet. (3 pages)






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ISSN 2059-4453 (Online)