DECISION SUPPORT TOOL FOR THE INTEGRATION OF PUBLIC HEALTH IN MANURE MANAGEMENT

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1 INTRODUCTION

Sustainable development must take into account economic, social and environmental aspects (Figure 1); however, one important, but often neglected, aspect is health and hygiene. Best management practices (BMPs) are those that best attain all of the abovementioned aspects. Manure may contain zoonotic agents that can be transmitted to humans via the food chain, contaminated water and environment. To minimise the risk of disease transmission, manure can be extensively treated in order to reduce the amount of pathogens. This may however not be practical or associated with an unbearable cost for the farmer. One helpful tool in order to integrate hygiene in BMPs is quantitative microbial risk assessment (QMRA) for the calculation of health-based targets to provide stakeholders (risk managers, farmers, politicians, environmental and health inspectors, Board of Agriculture, city planners) with decision support from a public health point of view. This paper outlines QMRA for manure management and suggests how it can be used to integrate public health in best manure management practices.

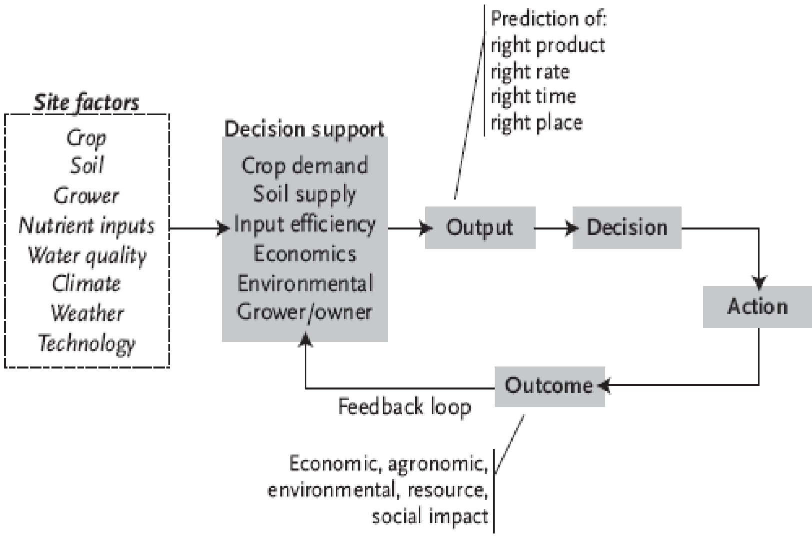

FIGURE 1 **Schedule of decision support leading to fertilizer BMPs as a dynamic process taking into account the local context (adapted from Fixen, 2005).**

2 MATERIALS AND METHODS

Risk assessment is a four-step analysis including: *hazard identification*, *exposure assessment*, *hazard characterisation* and *risk characterisation* (Table 1). The end-point of QMRA is the numerical values of the probability of exposure, infection, illness or death. From a decision support point of view, a more relevant target is that *the disease incidence from recycled manure should not exceed a minimal background level*; in food safety normally termed appropriate level of protection or acceptable risk (Figure 2).

Manure can contain high levels of zoonotic agents such as *E. coli* O157, *Salmonella* spp., *Campylobacter jejuni* and *Cryptosporidium parvum* (Hutchison et al. 2004) that can contaminate surface water, crops and pasture exposing humans and grazing animals. Some inactivation will take place during storage but significant numbers are still transmitted to the environment (Hutchison et al. 2005). Other barriers to exposure are holding times between manure application and exposure and dilution in soil and water. However, extensive treatment may still be necessary depending on organism, exposure and the risk of regrowth of bacteria. The level of treatment can be determined based on the amount of pathogens in manure, environmental inactivation/growth and the dose response relationship (Figure 2). The latter has been determined for many gastro-intestinal pathogens by Teunis et al. (1999).

TABLE 1 **Microbial risk assessment paradigm for public health (adapted from Ashbolt et al., 2005)**

Step	Aim
Hazard identification	To describe acute and chronic human health effects from the transmission of infectious agents associated with a particular hazard
Exposure assessment	To determine the size and nature of the population exposed and the route, amount and duration of the exposure
Hazard characterisation	To characterise the relationship between various doses administered and the incidence of the health effect (probability of infection, illness or death)
Risk characterisation	To integrate the information from the exposure and hazard characterisation steps in order to estimate the magnitude of the public health problem and to evaluate variability and uncertainty

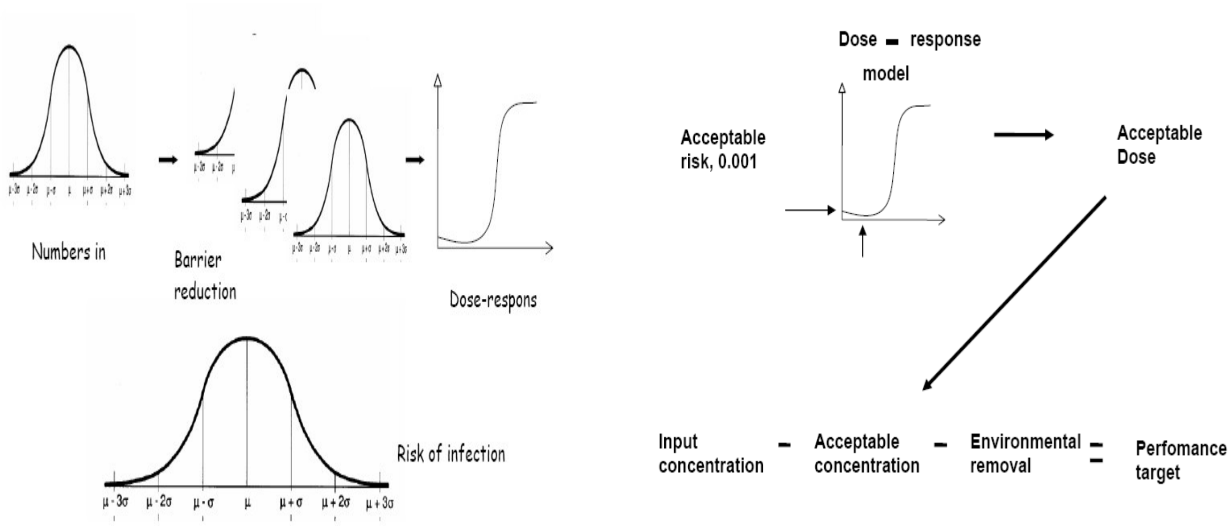

FIGURE 2 **Monte Carlo simulations are commonly used in risk assessment analyses when the data are based on a number of distributions.** The normal procedure is to calculate the risk of infection (left). However in the suggested approach, QMRA is used to calculate treatment performance targets (right). Based on an acceptable risk, for example 0.1% of gastroenteritis for a certain pathogen, an acceptable dose can be calculated from established dose-response relationships. Depending on exposure, this dose equals an acceptable concentration for the targeted hazard/pathogen. The $\log_{10}$ treatment performance target can be calculated from the $\log_{10}$ concentration of pathogen in manure – $\log_{10}$ acceptable concentration – $\log_{10}$ reduction in concentration over barriers other than treatment, *i.e.* dilution and inactivation in the environment (adapted from Ottoson, 2005).

3 RESULTS AND DISCUSSION

Recycling of manure should not increase the prevalence of a certain disease. The prevalence differs between regions and hence must be taken into account as a site factor (Figure 3). Based on the exposure scenario and pathogen in question (hazard characterisation or dose response relationship) the treatment performance target is calculated. This can be done in an early phase of the planning process to give an indication of the performance need in order to recycle manure safely. Based on the calculated performance targets different manure treatment technologies can be suggested for the future process of planning, weighing in other parameters such as economics, environmental, soil supply etc. in order to predict the optional treatment (Figure 3). A significant increase or decrease of the prevalence might be detected in the national reporting system or determined from epidemiological studies and further fed back to the decision makers. Briefly, Table 2 outlines the suggested information to include in the model by Fixen (2005) (Figure 1) in order to integrate hygiene in manure BMPs.

TABLE 2 **Suggestions for information to include public health in BMPs in Figure 1**

Under:	Include
Site factor	Endemic level of disease
Decision support	Treatment performance target
Output	Prediction of: right treatment
Outcome	Public health impact (disease incidence < endemic level of disease)

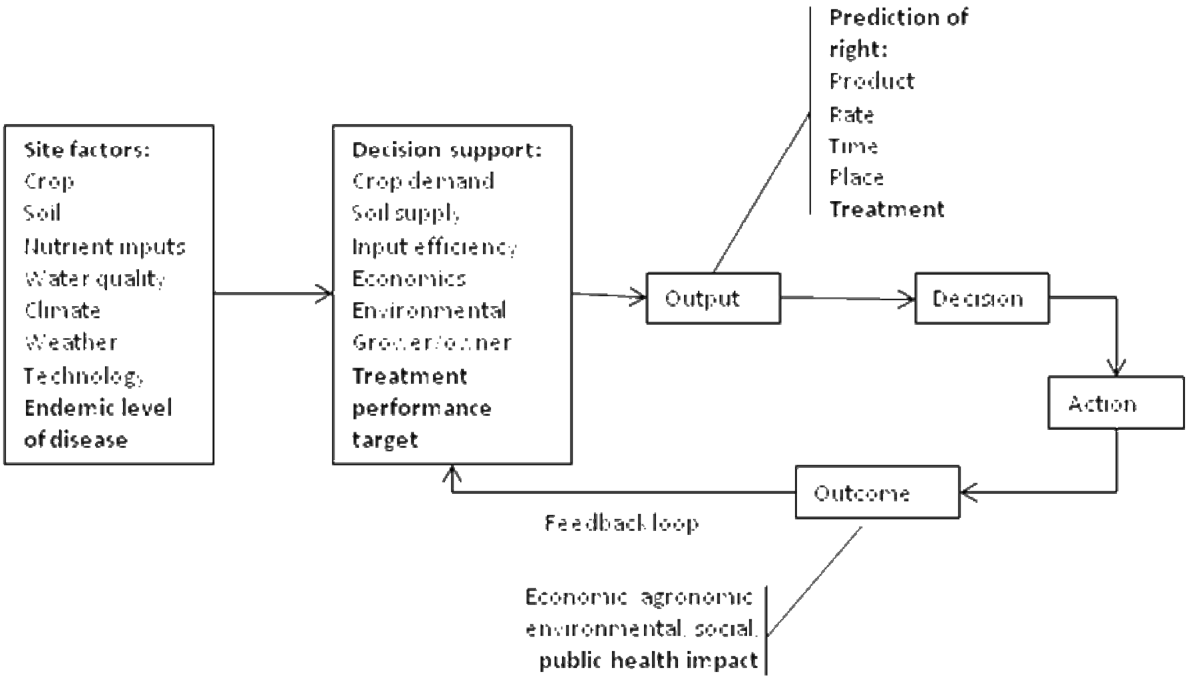

FIGURE 3 **Decision support including public health indicator (adapted from Fixen 2005).**

4 CONCLUSIONS

In a sustainable society, agricultural and urban waste must be recycled to productive land. This can open up for new transmission routes for pathogens and therefore public health is an important indicator to take into account. One suggestion is to use QMRA as a tool to provide decision support from a hygienic point of view, describing the abovementioned risk in quantitative terms for different recycling system solutions. QMRA can also, as described, be used to provide decision makers and other actors involved in the planning process with guidance of treatment needs of waste streams in order to improve public health in spite of new transmission routes for pathogens. In the models there is also the possibility to adjust for weather changes predicted to occur, for example more frequent flooding, higher temperatures etc. and the outcome in relative terms between alternative system solutions and the present situation. In this sense (comparing system solutions in relative terms), limited data availability can be overcome, but it also points at another important function of risk assessment, to address the need for the scientific society to fill in data gaps to improve future risk models.

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