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### Introduction

Human waste can be a useful nutrient source for plant growth. However, the presence of pathogenic microorganisms can limit its safe reuse and pose risks to agricultural workers handling it. These risks can arise through contact with fertilizers, leading to the accidental ingestion of pathogens.

### Objectives :

- Assess these risks using a Quantitative Microbial Risk Assessment (QMRA).
- Propose measures to reduce these risks

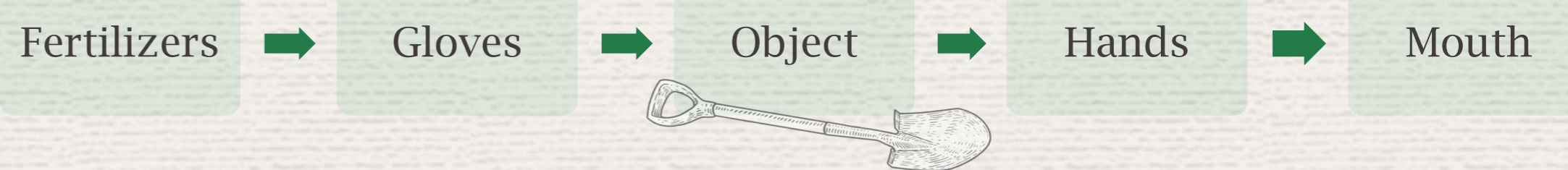
### Methods :

#### 1. Hazard Identification

- Identification of the main pathogens in these fertilizers causing severe diarrhea

Viruses	Bacteria	Protozoa
Adenovirus	Campylobacter jejuni	Giardia
Norovirus	Pathogenic Escherichia coli	Cryptosporidium spp
Rotavirus	Salmonella (NTS)	

- Identification of the pathway leading to the contamination of the workers



#### 3. Dose Response Assessment

INPUT : Number of organisms ingested by the worker

#### Dose Response Equation :

Beta Poisson model  $P_i = 1 - \left(1 + \frac{dose}{\beta}\right)^{-\alpha}$   
 Exponential model  $P_i = 1 - exp(-r \times dose)$

OUTPUT : Risk of infection  $P_i$  for the worker, for a one time exposure.

Conversion into annual probability of infection, with 2 fertilizer applications / year

$$P_{ann} = 1 - (1 - P_i)^n$$

### 2. Exposure Assessment

INPUT : Concentration of pathogen in the fertilizers  $C_{Ex}$

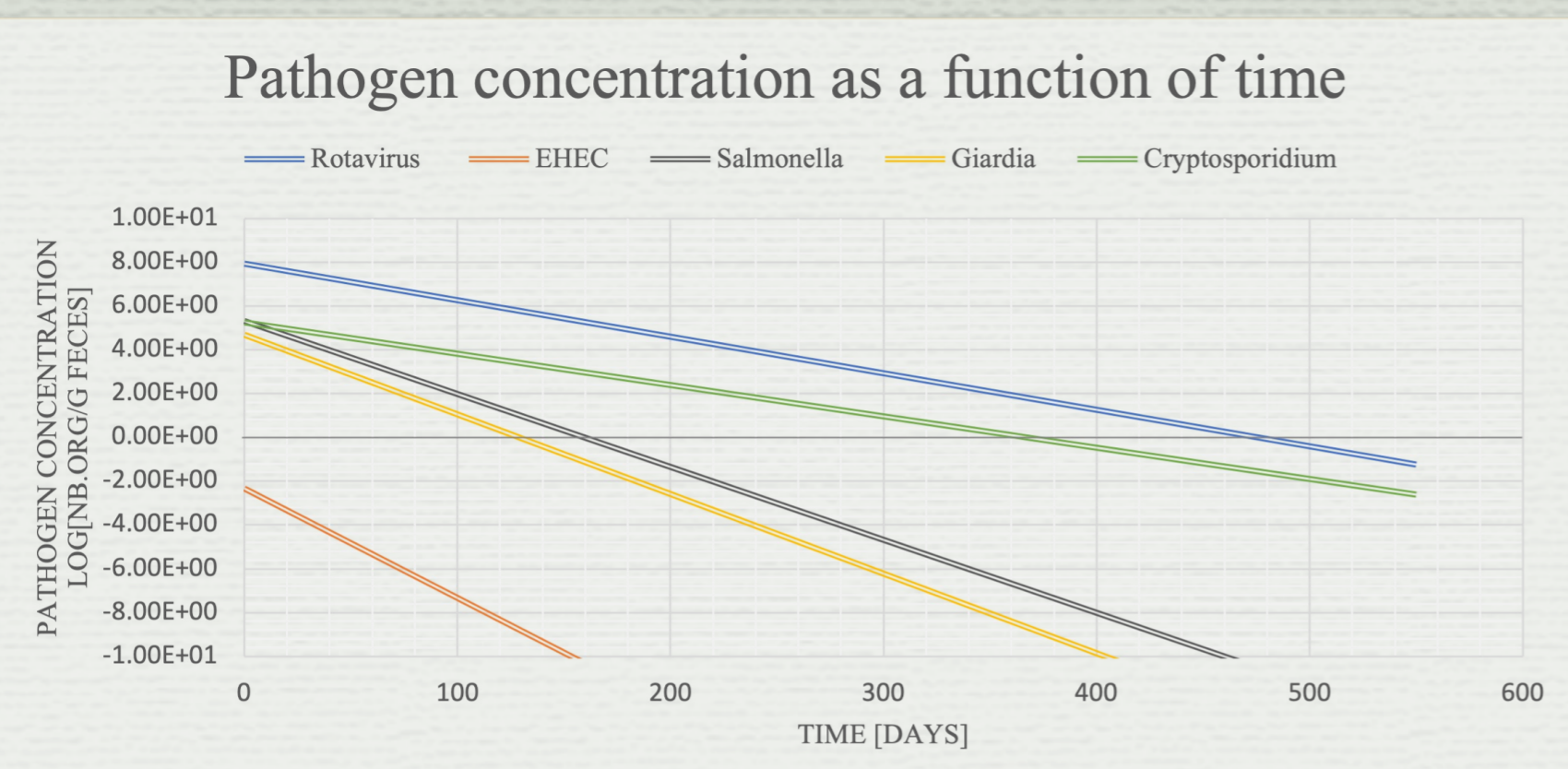
#### Exposure Model Equation :

$$C_{Mf} = T_{H \rightarrow M} \times T_{F \rightarrow H} \times T_{G \rightarrow F} \times T_{Ex \rightarrow G} \times A_{GEx} \times C_{Ex}$$

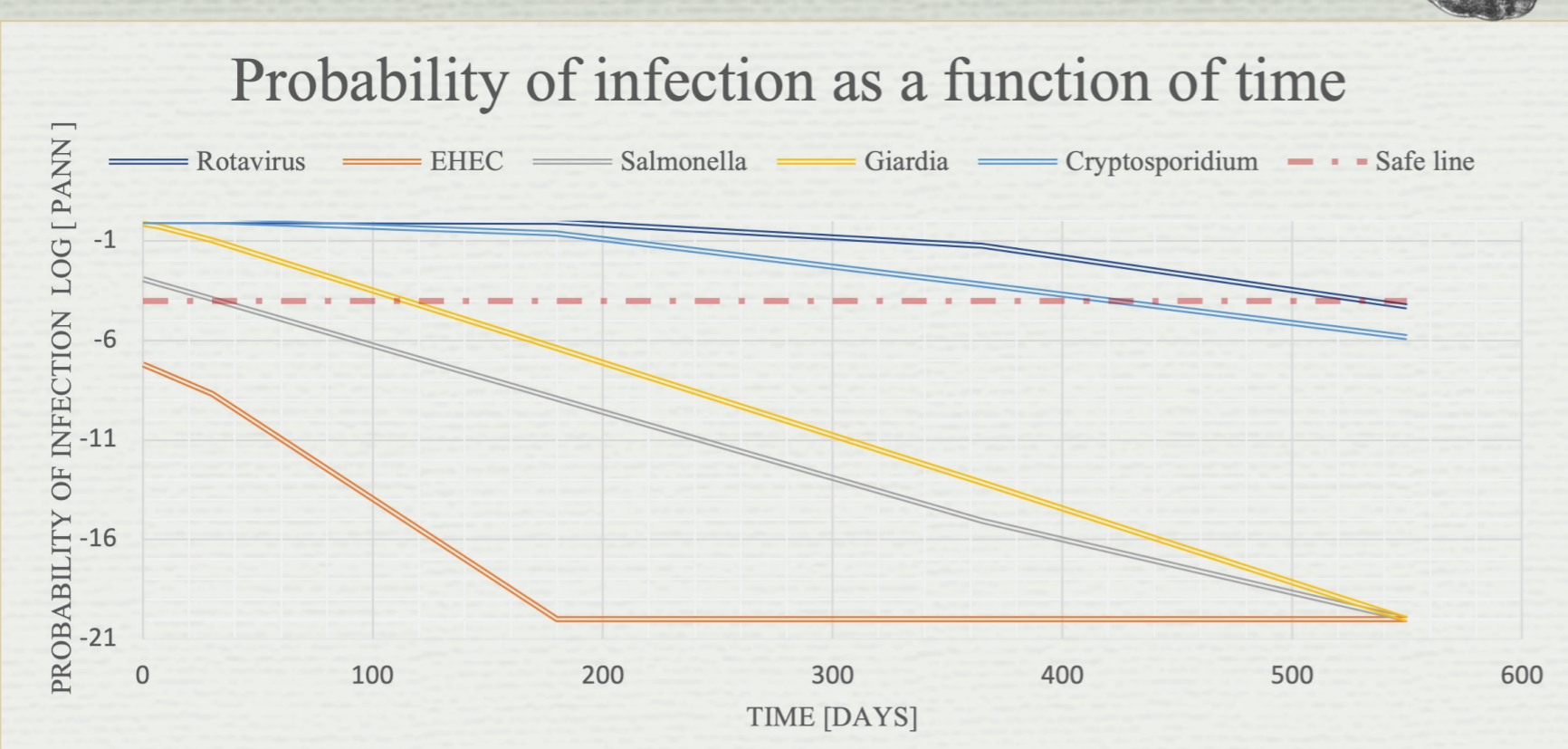
OUTPUT : Number of organisms getting transferred into the mouth of the worker  $C_{Mf}$

### Mitigation Measures :

The number of pathogens decreases over time when fertilizers are stored:



Need of 18 months of storage to ensure a safe use of the fertilizers :



### Results :

- 100% of risk of being infected by the majority of pathogens studied
- Need of mitigation measures

Pathogen	$P_{ann}$
Adenovirus	100 %
Norovirus	100 %
Rotavirus	100 %
Campylobacter	100 %
Pathogenic Escherichia coli	$6.48 \times 10^{-6}$ %
Salmonella	0.121 %
Giardia	75.2 %
Cryptosporidium	100 %

### REFERENCES :

Brooks, J. P., McLaughlin, M. R., Gerba, C. P., & Pepper, I. L. (2012). Land application of manure and class B biosolids: an occupational and public quantitative microbial risk assessment. *Journal of Environmental Quality*, 41(6), 2009-2023. World Health Organization. (2016). Quantitative microbial risk assessment: application for water safety management.