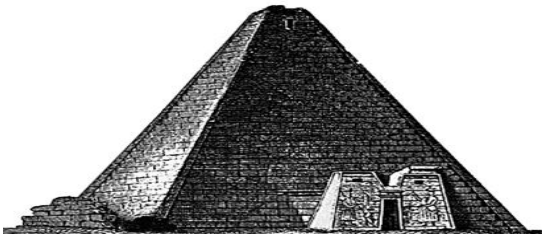
Sanitation & Hygiene
in Food Processing

Dr. Keith Warriner
Department of Food Science
University of Guelph
kwarrine@uoguelph.ca

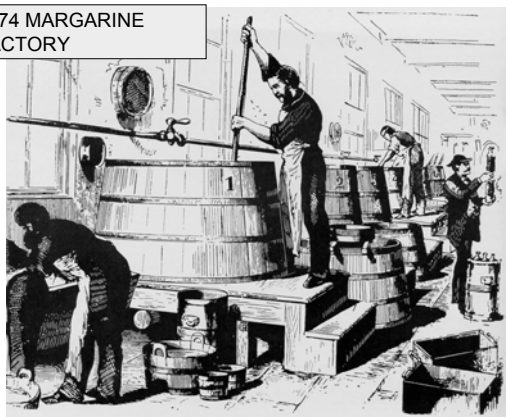
HACCP

Sanitation Control Procedures

Good Manufacturing Practices (GMP)



1874 MARGARINE FACTORY



Sanitation

- Equipment
- Environment
- Air
- Water

…modern sanitation was one of the greatest public health accomplishments of the late 19th and early 20th centuries.

Bilmar Foods 1998

- Frankfurters
- *Listeria monocytogenes*

80 Cases 21 deaths (6 stillbirths)

Recall: 17m kg of Product
Direct loss: $76m
Loss sales: $200m
Litigation: $5m

Pilgrim's Pride 2002

- deli meats
- *Listeria monocytogenes*
- 14m kg recall
- 46 cases 10 deaths (3 stillbirths)
- >$100m loss

Canadian Federal Food Safety Agencies

- CFIA (Can. Food Inspection Agency)
  - Inspection Services for HC, AAFC, and DFO
  - Food safety inspections and audits
- Health Canada (HC)
  - Health hazards in the food supply
  - Food safety policies and recalls
- Agriculture and Agrifood Canada (AAFC)
  - Research and regulatory support for agriculture and food production
- Department of Fisheries and Oceans
  - Sustainable use of fisheries resources, facilitate marine trade and commerce

John Tudor & Sons 2005

- Deli meats
- *Escherichia coli* O157
- >150 cases
- 1 death

Canadian Federal Food Legislations

- Legislations with focus on food safety
  - Canada Agricultural Products Act
  - Fish Inspection Act & Regulations
  - Meat Inspection Act & Regulations
  - Food and Drug Act & Regulations
  - Consumer packaging and labeling Act
  - http://www.inspection.gc.ca/english/reg/rege.shtml

Sanitation is Important

35% of foodborne illness cases attributed to poor sanitation

- 19% Poor personnel hygiene
- 16% contaminated equipment/environment

Provincial Food Inspection Agency (Ontario)

- Three ministries involved in food safety:
  - OMAFRA (Ont. Min. of Agriculture, Food, and Rural Affairs)
  - MOH (Min. of Health)
  - OMNR (Ont. Min. of Natural Resources)

Municipal Level

- Municipal By-Laws affecting food safety
  - Building codes with appropriate sanitary env.
  - Potable water
  - Environmental and health issues affecting the food industry (waste water, emissions etc.)
  - Food service establishments
  - Retail stores

Code of Practice

- Sanitary facilities
- Air quality
- Water quality
- Facility Construction
- Sanitation procedures
- Hygiene and Health requirements
- Training

Regulations

Food & Drugs Acts 1985

7. No person shall manufacture, prepare, preserve, package or store for sale any food under unsanitary conditions.

Facility

- Drains

Sufficient number and construction

- Floor slopes uniformly to the drain
- Walls
  Hard
  Smooth
  Constructed to enable cleaning
- Food contact Surfaces
  Non absorbent
  Free from pitting,crevices and loose scale
  Capable of withstanding repeated cleaning.

Code of Practice

- Guidelines to meet the regulatory requirements of the Food & Drugs Act

Codex Alimentarius Commission
Sanitary and Phyto sanitary (international) Standards

http://www.cfis.agr.ca/english/regcode/gpfh/gpfhc_e.shtml

Cold Stores

- Reduce the risk of condensation
- Relative humidity
- Air flow

- Sanitation Program

An effective sanitation program for equipment and premises is in place to prevent contamination of food.

- Each processor 'should' have and implement a written SSOP or similar document that is specific to each location

Sanitation Performance Standards (SPS)

- Standards based on The Food Code.
- Address the conditions within the facility
- Used in conjunction with SSOP's

SSOP plans

- Provide a schedule for sanitation procedures
- Provide a foundation to support a routine monitoring program
- Encourage prior planning to ensure that corrections are taken when necessary
- Identify trends and prevent recurrent problems

Sanitation Monitoring Program

"Each processor 'shall' monitor the conditions and practices during processing with sufficient frequency to ensure, at a minimum, conformance with these conditions and practices specified in the [GMP] that are appropriate to the plant and food being processed."

- Ensure that everyone, from management to production workers, understands sanitation
- Provide a consistent training tool for employees
- Lead to improved sanitation practices and conditions in the plant.

See http://foodsafety.unl.edu/html/sop.html#appendix-a

Sanitation Testing

- Monitoring: Elements of the sanitation program are being performed correctly (e.g sanitizer concentration, contact time).
- Verification: Long term effectiveness of the sanitation plan (e.g. microbiological testing).

- **Why Monitor Sanitation Control Procedures**
- " . . . to develop a culture throughout the food industry in which processors assume an operative role in controlling sanitation in their plants."

Monitoring

Visual inspection in good light
Protein residue tests

ATP bioluminescence
- Indirect measure of viable cells
- Automated logging

BioTrace
BioControl

Sanitation Monitoring Forms

- 1. Specific sanitation conditions or practices to be monitored
- 2. Space to record observations and measurements at the prescribed frequency
- 3. Space to document any necessary corrections.

Sanitation Verification

ATP (low risk areas)

Product contact surfaces
24 – 48 h to obtain results
- Contact plates
- Swab samples
- Sticky tape

Total Aerobic Count
Spoilage microflora
Fecal indicators

Monitoring

Detergent
Contact time
Sanitizer concentration
Excess
- Increased costs; Corrosion

Insufficient
- Low efficacy; Generation of tolerant mutants

Microbiological Criteria

- No specific criteria
- Trend analysis
- ATP tests: 0 – 5000 cps acceptable

Meat Processing Lines
- Total Aerobic Counts <10 cfu/cm^2
- Enterobactereaceae <1 cfu/cm^2

Sanitation Control Procedure

- Sanitation part of pre-requisite programs
- Can also be incorporated into HACCP plan
- Maintain sanitary conditions usually related to the entire processing facility or an area

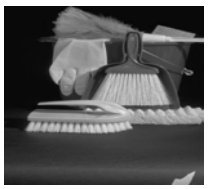
5 Steps

Five Steps of Cleaning and Sanitizing

1. Dry clean
2. Pre rinse
3. Apply detergent
4. Post rinse
5. Sanitize

SCP vs CCP's

Hazard	Control	Program
Pathogen Survival	Time & temperature for smoking fish	CCP
Contamination with pathogens	Wash hands before touching product	Sanitation
Contamination with pathogens	Clean and sanitize food contact surfaces	Sanitation



Physically removing soils

- Brushes-- proper stiffness
- Pads-- proper cutting properties
- Pressure spray -- moderate pressure

Training is Key to the Success of Sanitation

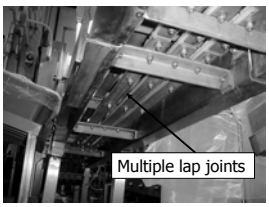
- Important to get staff involved
- Training must be focused and practical
- Records of training and incentives provided.
- Staff involved in developing plan, implementation, monitoring and verification.

Pads, brushes and brooms should be dedicated to tasks for which they are designed

- Optimizes cleaning effectiveness
- Minimizes cross contamination between areas of the plant

Pre Rinse

- Rinse until visually free of soils.
- Use lowest effective pressure to **minimize aerosols and condensation.**
- Lower pressure reduces risk of cross contamination and machine damage.



5th Step !

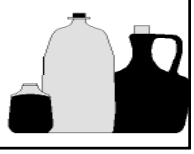
Sanitizing follows proper cleaning

1. Dry clean
2. Pre rinse
3. Detergent application
4. Post rinse
5. Sanitizing

Step 6 ?: Rinse
Pros: Remove residues and reduces the generation mutants
Cons: No residual anti-microbial activity

Types of Detergents

- General Purpose (GP)
- Alkaline
- Chlorinated (chlorinated alkaline)
- Acid
- Enzyme



Chemical Sanitation

- Effectiveness Based on:
  - Exposure Time
    - More microorganisms - Longer exposure time
    - Colonies die in logarithmic pattern
    - Different types of organisms die at different rates
  - Temperature
    - Generally, the hotter the temperature, the more effective the chemical sanitizer

Detergent application methods

- Soak tanks
- Foam
- Automated systems
  - CIP (clean in place)
  - parts washers
- Manual (pails)

Effectiveness of Chemical Sanitizers

- Concentration
  - Follow label
  - More not necessarily better
- pH
  - Differs depending of Type of Sanitizer
- Cleanliness
  - Soil can react with sanitizers and neutralize them

Effectiveness of Chemical Sanitizers

- Water Hardness
  - Calcium and Magnesium in hard water neutralize Quats
  - Can add chelating agent
- Bacterial Attachment
  - Attachment to surfaces make bacteria more resistant to sanitizers

Endospores

- Outer spore coat: Physical barrier
- Cortex, SASP: Glassy structure to protect DNA

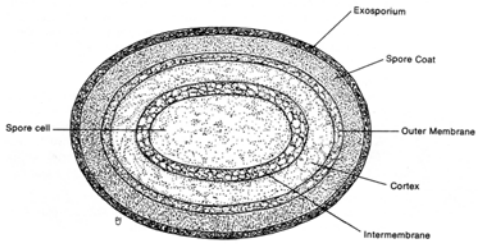
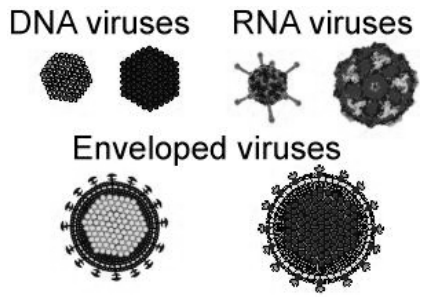


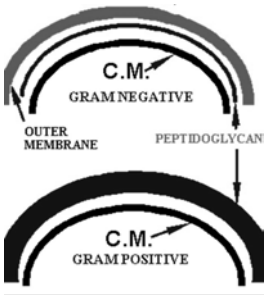
Fig. 8.1. Endospore

Viruses

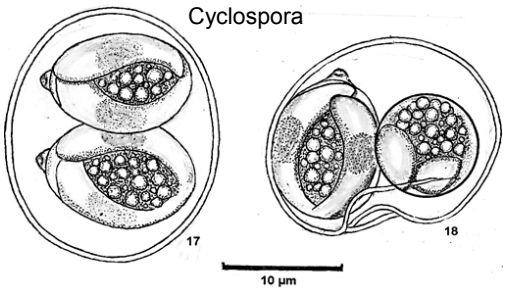


Sanitizer Resistance

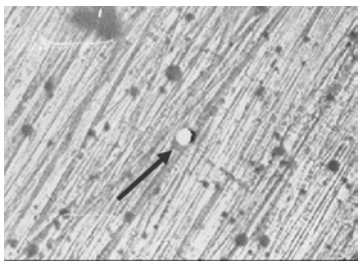
- Gram negative bacteria more tolerant to sanitizers.
- Outer membrane forms physical barrier
- Less stable at alkali pH



Protozoa

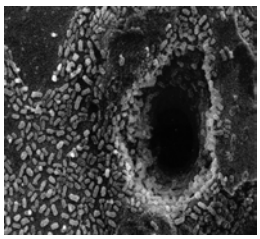


Pitting Provides Sites for Bacterial Attachment



HOLE IN A HEAT-EXCHANGER PLATE

Biofilms



Ideal Sanitizers

- Destroy vegetative microorganisms
- Work well in different environments
- Dissolve in water
- Inexpensive, easy to use, readily available
- Should not irritate skin
- Should not have offensive odor

Antimicrobial Tests

(Required for EPA Registration)

Product	Test	Required Organisms
General disinfectant	AOAC Use Dilution	*Sal. cholerasuis* ATCC 10708 *Staph. aureus* ATCC 6538
Hospital disinfectant	AOAC Use Dilution	*S. cholerasuis* ATCC 10708 *S. aureus* ATCC 6538 *P. aeruginosa* ATCC 1542
Sporicidal	AOAC Sporicidal	*B. subtilis* ATOC 19659 *Cl. sporogenes* ATCC 3584

Sanitizer Concentrations Commonly Used in Food Plants

Sanitizer	Food Contact Surface	Non-Food Contact Surfaces	Plant Water
Chlorine	100 200 ppm	400 ppm	3 10 ppm
Iodine	25 ppm	25 ppm	
Quats	200 ppm	400 800 ppm	
Chlorine dioxide	100 200 ppm	100 200 ppm	1 3 ppm

Food Contact Surface Sanitizer

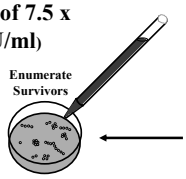
AOAC Germicidal Detergent Sanitizer Test

99 ml Sanitizer Solution 25ºC

(minimum of 7.5 x 10^7 CFU/ml)

Add 1 ml of *E.coli* or *S. aureus*

30 second Contact Time



Required Efficacy: 99.999% Kill in 30 seconds at 25ºC

CFIA Approved List

Neutralize **1 ml**

http://www.inspection.gc.ca/english/ppc/reference/v2e.shtml

Types of Sanitizers

- Chlorine
- Chlorine dioxide
- Ozone
- Iodophores
- Quaternary ammonium compounds
- Trisodium phosphate
- Peroxyacetic acid

Chlorine

- Sodium or Calcium Hypochlorite
- Cheap
- Well established in the food industry
- Chlorous acid antimicrobial form

Chlorine Dioxide (ClO_2)

Powerful oxidizing agent (2.5 x greater than chlorine)

- Relatively stable in the presence of organics.
- Does not form chloroamines as a side reaction.

- pH dependent

pH 6 8Chlorous acid

pH < 6 Chlorine gas (toxic)

- Sequestered by organic material
- Carcinogenic chloroamines can be produced.
- Unstable at high temperatures
- Corrosive

- Limited efficacy against viruses
- Unstable at temperatures > 30˚C
- Used to decontaminate Post-Office affected by anthrax letters.

- Effective against vegetative cells, spores and fungi.
- Limited efficacy against viruses
- Can leave chlorine odor
- Mechanisms still unknown but primarily oxidation of proteins.

Ozone

- Generated on site via passing air through high voltage fields.
- Powerful oxidizing agent.
- Poor solubility (max 6ppm in water)
- Negligible residues (used for treating bottled water)

Iodine Compounds

- Iodophors
  - Iodine alcohol solutions and Aqueous iodine solutions
- Less germicidal than chlorine, but broader effective pH range (2-5).
- Low concentrations pass chambers test
- More effective on viruses than other sanitizers

Ionic Compounds

- Trisodium Phosphate
- Quaternary Ammonium Compounds (QAC's or QUAT's)
- Organic Acids

Iodine Compounds - Advantages

- Less corrosive than Chlorine
- Stable when Concentrated
- Effective in hard water
- Can prevent mineral deposits
- Good Hand-dipping agent
- Amber color - Good indicator of active iodine

Trisodium Phosphate (TSP)

- TSP inactivates bacteria by pH effect.
- 8% w/v TSP: pH 12
- Strips membranes from cells
- Gram positive bacteria more resistant than Gram negative.

Disadvantages of Iodine compounds

- More expensive than Chlorine
- Off- flavors in Foods
- Vaporize at 50^{o}C
- Stain and discolor equipment
- Not as effective as Chlorine in low temperature environments
- Foam formation (CIP)

QACs

- Non-corrosive
- Stable at high temperature
- Effective against yeast, molds and Gram positive bacteria.
- Less effective against Gram negative and viruses.
- Inactivated by surfactants
- Residual activity

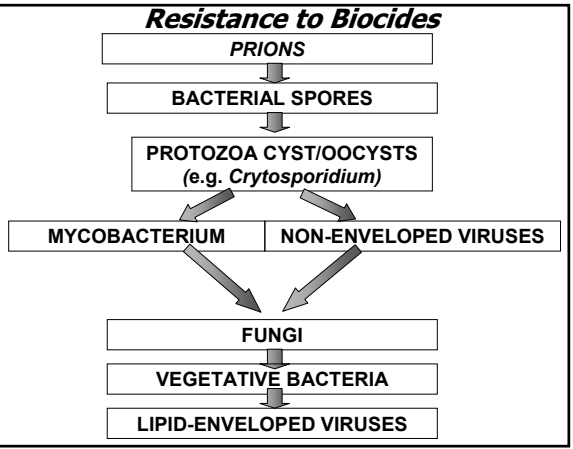
QACs : MODE OF ACTION

1. Adsorption to bacterial cell surface
2. Diffusion through outer layers of cell
3. Binding to cytoplasmic membrane
4. Disruption of cytoplasmic membrane
5. Release of cell constituents (K^+, large Mol.Wt. materials)
6. Coagulation of cell contents and cell inactivation

Peroxy acid compounds

- Low Foam - CIP
- Antimicrobial activity over broad temperatures
- Combine sanitizing and acid rinsing in one step
- Non-corrosive
- Tolerant to organic matter
- Effective against Biofilms

- Gram positive bacteria sensitive
- Potential problem of generating resistant mutants.



QAS Pumps

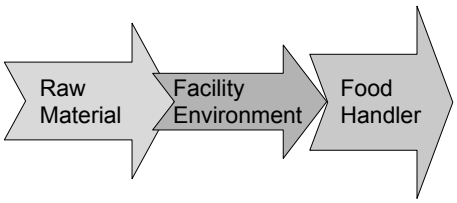
- Trans-membrane efflux pump
- Linked to drug resistance
- Sanitizer rotation

Romanova et al., (2002) Appl Environ Microbiol. 68: 6405–6409.

Relative Biocidal Activity

Endospores Mycobacterium Non-enveloped viruses Protozoa oocysts	**Peroxyacids, glutaraldehyde, formaldehyde, chlorine dioxide, ethylene oxide**
Mycobacterium Non-enveloped viruses Fungi	**Phenolics, Iodophors, Hypochlorites**
Vegetative cells Enveloped viruses	**Quaternary Ammonium Compounds, Organic Acids**

Sources of Contamination



Ready-to-Eat

- *Listeria monocytogenes*
- Raw materials
- Endemic: Drains, cold stores, difficult to clean areas

Fresh Cut Produce

- *Listeria monocytogenes*
- *Salmonella*
- *E. coli* O157

- Hepatitis A
- *Cyclospora*
- *Cryptosporidium*

Environment vs Raw Material

Traditional view

- Post-process contamination

Listeria monocytogenes

- Raw material

Salmonella

E. coli O157

Meat

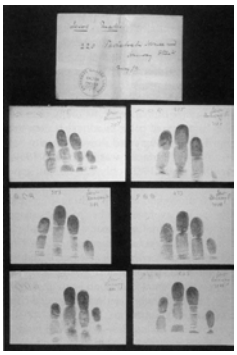
- *Salmonella*
- *Campylobacter*
- *E. coli* O157

Molecular Epidemiology

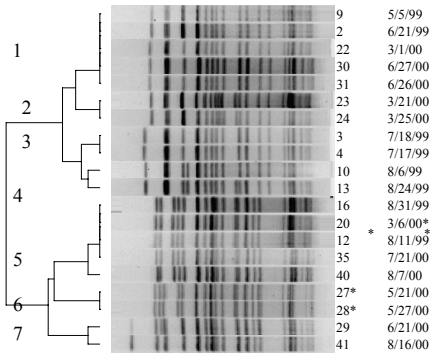
- Track and Trace Sources of microbial contamination.
- DNA typing of isolates taken from different sites.

Forensic Science

- Fingerprints can be used to differentiate individuals



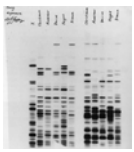
Genetic relatedness (dendrogram) analysis



Source: A. Noller and M.C. McEllistrem

Forensic Science

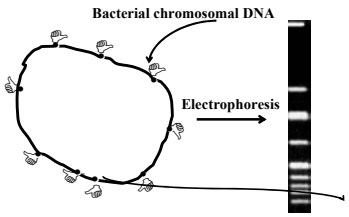
- Dr Alec Jeffreys
- DNA fingerprinting



Molecular Typing of Pork and Beef Chain

- Surfaces contaminated in the first 30 mins of processing
- Contamination derived from holding area and transporter
- Sanitizer resistance predicted by genetic lineage

Molecular subtyping using restriction endonucleases



= Restriction endonuclease ("molecular scissors")

• = DNA sequence recognized by restriction endonuclease

Holding Area and Transporter

- Difficult to sanitize
- Short-lived benefits
- Increased sanitation decreases endemic populations

Fresh-Cut Produce

- Field acquired contamination
- Wash water
- Bagging station

Hand washing

- most common source of contamination leading to illness is the fecal – oral route
- contaminated after using the restroom
- bacteria and viral contamination transferred via contaminated food or utensils

Food Handler

- *Salmonella*
- *E. coli* O157
- *Staphylococcus aureus*
- Enteric viruses (Norwalk, rotavirus)
- Hepatitis A

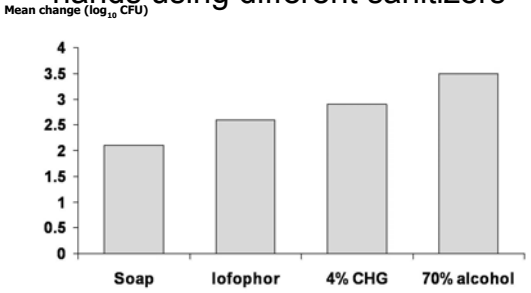
Hand Washing Standards

- designated sink in the food preparation area for hand washing
- Hot and cold running water
  - hot water must have a minimum temperature of 43 °C
  - Liquid soap is preferred
  - Fingernail brush
- Only disposable paper towels or air dryer are authorized for drying hands

Personal Hygiene and Identifying Unhealthy Personnel

- Supervisors
  - must identify unsanitary and unhealthy personnel
  - Observation is an effective means of identifying health risks
  - look for cuts/burns on fingers, hands, and arms; oozing sores, pimples, or boils; and significant coughing or sneezing
  - Workers not allowed around food if they are experiencing fever, vomiting, or diarrhea

Reduction in microbial loading on hands using different sanitizers



Hand rubs for lightly soiled hands

Gloves

- Advantages

Minimize direct bare hand contact with product.

Easier to monitor/ enforce than hand washing

- Disadvantages

Discourage hand washing

Failure to change gloves may enhance risks

HANDWASHING

WHEN TO WASH HANDS

- AFTER TOUCHING THE BODY (NOSE, MOUTH, HAIR, ETC.)
- AFTER USING THE RESTROOM
- AFTER EATING, DRINKING, OR SMOKING
- AFTER HANDLING SOILED EQUIPMENT
- AFTER TOUCHING RAW MEAT
- BEFORE AND AFTER PUTTING ON GLOVES
- AFTER TAKING OUT THE GARBAGE

Hand washing by food handlers

- 52% supervisors could describe the hand washing procedure
- 48% of workers could demonstrate code-compliant hand washing

Allwood *et al., (2004) Journal of Food Protection:* Vol. 67, No. 12, pp. 2825–2828.

Future Prospects

- Anti-microbial contact surfaces (e.g. silver zeolite)

- Biological control

Bacteriophage

Competitive exclusion

Competitive Exclusion

- *Enterococcus durans*
- *Lactococcus lactis* subsp. lactis
- Inhibit growth of *Listeria monocytogenes* in drains

Other Webber Training Teleclasses

- February 23 – *The Building as a Source and Vector of Problematic Microorganisms*
- March 9 – *Pandemic Influenza*
- March 21 – *Leadership in a Healthcare Environment*
- March 30 – *Critical Design for Acute Care*

For more information refer to www.webbertraining.com
or paul@webbertraining.com

On-farm Sanitation

Protect water sources from manure contamination.
Clean, sanitize and chlorinate frequently.

Summary

- Sanitation is key to reducing foodborne illness outbreaks.
- Success depends on SSOP, SAP and staff training
- Novel sanitation methods to decontaminate reservoirs of contamination