WHAT TO ASK FOR AND LOOK FOR WHEN EVALUATING CLEANING/DISINFECTING PRODUCTS... IN 5 EASY STEPS

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OBJECTIVES

• ASSESS: TO BEST UNDERSTAND THE CURRENT STATE OF MICROBIAL CHALLENGES IN HEALTHCARE SETTINGS REQUIRING CLEANING/DISINFECTION.
• ANALYZE: TO BEST UNDERSTAND HOW TO INACTIVATE UNDESIRABLE MICROBES IN THE ENVIRONMENT.
• ACQUIRE: TO UNDERSTAND WHICH DISINFECTANTS AND CLEANING PRODUCTS ARE EFFECTIVE AGAINST THE TARGET PATHOGENS.
• APPLY: HOW TO READ LABELS, FOLLOW INSTRUCTIONS AND ENSURE THAT PROPER PROCEDURES ARE BEING USED.
• AUDIT: TO ENSURE THAT CLEANING/DISINFECTION PRODUCTS AND PROCEDURES BEING USED ARE IN FACT WORKING.

MICROBIAL CHALLENGES

• OVER 1,400 KNOWN PATHOGENS FOR HUMANS
• THE MEANS OF SPREAD OF SOME 200 SUCH PATHOGENS STILL UNKNOWN
• IN THE LAST 30 YEARS, SOME 300 NEW AND EMERGING INFECTIOUS DISEASE EVENTS HAVE OCCURRED
• MANY HAVE HAD IMPLICATIONS ON A GLOBAL SCALE
• SARS, H1N1, MRSA, C. DIFFICILE, MDR/XDR TB
• EACH PATHOGEN COMES WITH SPECIFIC PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES

BREAKDOWN OF KNOWN HUMAN PATHOGENS

538 BACTERIA (38%)
287 HELMINTHS (20%)
66 PROTOZOA (5%)
517 VIRUSES & PRIONES (15%)
307 FUNGI (22%)

UBIQUITOUS IN MANY ENVIRONMENTAL SETTINGS
• BIOFILMS ARE A PRIMARY CONCERN
• SEVERAL ENVIRONMENTAL PATHOGENS
• GRAM-POSITIVE BACTERIA
• GRAM-NEGATIVE
• GENERALLY EASY TO KILL WITH DISINFECTION AND ANTISEPTICS
• BIOFILMS MAY PROVIDE INCREASED RESISTANCE

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EVALUATING CLEANING/DISINFECTING PRODUCTS IN 5 EASY STEPS

MYCOBACTERIA

- Cause diseases such as tuberculosis
- Many non-tuberculous (environmental) types cause disease in the immuno-suppressed
- Many are slow & hard to grow in the lab
- Emerging food- & waterborne pathogens
- Biofilms harbour numerous mycobacterial species
- Higher resistance than normal bacteria to inactivation

BACTERIAL SPORES

- Produced by certain types of gram-positive bacteria (Bacillus, Clostridium)
- Spores survive well in the environment
  - Able to withstand heat, extremes of pH and other stressors
- Clostridium difficile is an important pathogen
- Tetanus & anthrax also caused by spore-formers
- One of the most difficult microbial forms to kill
- Commonly used as biocides
  - Gold standard to test physical/chemical sterilization

VIRUSES

- Two major forms of viruses
  - Enveloped viruses
    - Influenza, coronavirus and HIV
  - Non-enveloped viruses
    - Norovirus, poliovirus, adenovirus, rotavirus
- Enveloped viruses are easier to inactivate due to their lipid-containing envelope
- Non-enveloped viruses generally more resistant due to a tight protein coat which is more difficult to disrupt

FUNGI

- Uni-cellular or multi-cellular plants
- Cause many diseases
- A serious problem for the immuno-suppressed
  - Organ transplant, cancer treatment, etc.
- Fungi associated with publically known problems
  - Mold and mildew
  - Sick-building syndrome

PROTOZOA

- Microscopic, single-celled animals
  - Many have complex life cycles
  - E.g. cysts, trophozoites
- Emerging as water- & foodborne pathogens
  - Giardia & Cryptosporidium
  - Toxoplasma gondii
  - Acanthamoeba spp.
- Gastrointestinal, eye infections
- “Oocysts” are very difficult to inactivate by chemicals
  - Relatively sensitive to drying and heat

PRIONS

- Cause many slowly progressive diseases of the central nervous system
  - Kuru
  - Creutzfeldt-Jakob Disease (CJD)
  - Iatrogenic cases
  - New variant CJD
- Once thought to be highly resistant to disinfection but evidence suggests otherwise
  - 134 degrees C for 10 min or 121 degrees C for 30 min
  - 1N sodium hydroxide for 15 min
  - Enzymatic cleaners
  - Phenolic disinfectant

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ANALYZE

HOW CAN WE MAKE OUR ENVIRONMENT SAFE?

PRINCIPLES OF MICROBICIDE USE

- DISINFECTANTS VS ANTISEPTICS
  - DIFFERENCE IS TARGET
  - DISINFECTION FOR DECONTAMINATION OF SURFACES AND OBJECTS
  - ANTISEPSIS FOR DECONTAMINATION OF SKIN & MUCOUS MEMBRANES

- ISSUES FOR CONSIDERATION ARE THE SAME
  - CLAIMS
  - PHYSICAL ENVIRONMENT
  - MICROBIAL RESISTANCE

- APPLICATION ENVIRONMENT
  - OBJECTS; FREQUENTLY TOUCHED SURFACES, SKIN

PHYSICAL FACTORS

- pH
  - MICROBICES HAVE SPECIFIC pH OPTIMAL LEVELS
    - BLEACH IS BEST ACTIVE AT LOW pH ~5.0
    - ALDEHYDES ARE BEST AT HIGHER pH ~8.0

- TEMPERATURE
  - ACTIVITY SHOULD BE OPTIMAL AT ROOM TEMPERATURE
  - FOR ANTISEPTICS, ACTIVITY SHOULD BE OPTIMAL AT SKIN TEMPERATURE (~33°C)

- RELATIVE HUMIDITY (RH)
  - ENVELOPED VIRUSES PREFER LOWER RH
  - NON-ENVELOPED VIRUSES PREFER HIGHER RH
  - BACTERIA & FUNGI PREFER HIGHER RH
  - SPORES CAN SURVIVE WELL UNDER A WIDE RANGE OF RH
  - OPTIMAL RANGE OF USE SHOULD BE 40-60%

MICROBIAL RESISTANCE

- RESISTANCE IS A MAJOR ISSUE TO CONSIDER
  - NEED A GOOD KNOWLEDGE OF THE TARGET ORGANISMS
  - NEED TO DETERMINE THE HIGHEST LEVEL OF AN ACTIVE
  - ALWAYS ERR ON THE SIDE OF CAUTION

- RESISTANCE CAN BE GENERALIZED BASED ON THE NATURE OF THE ORGANISM
  - BACTERIA AND ENVELOPED VIRUSES ARE EASIER TO KILL
  - NON-ENVELOPED VIRUSES ARE MID-RANGE
  - PROTOZOA CYSTS AND SPORES HAVE HIGH RESISTANCE
  - PRIONS ARE THE MOST DIFFICULT TO INACTIVATE

RELATIVE MICROBIAL RESISTANCE
Principals of Disinfection, Antisepsis, and Chemical Sterilization
Jason A. Tetro, University of Ottawa
Sponsored by Virox Technologies Inc. (www.virox.com)

EVALUATING CLEANING/DISINFECTING PRODUCTS IN 5 EASY STEPS

DISINFECTION LEVELS

• COLD STERILANT
  • KILLS ALL ORGANISMS AND ENSURES STERILITY

• HIGH-LEVEL DISINFECTANT
  • KILLS ALL ORGANISMS, EXCEPT HIGH LEVELS OF BACTERIAL SPORES

• INTERMEDIATE-LEVEL DISINFECTANT
  • KILLS MYCOBACTERIA, MOST VIRUSES, AND BACTERIA WITH A CHEMICAL MICROBICIDE REGISTERED AS A "TUBERCULOCIDE"

• LOW-LEVEL DISINFECTANT
  • KILLS SOME VIRUSES AND BACTERIA WITH A CHEMICAL MICROBICIDE

FACTORS IN CHOOSING AN ACTIVE

• MATERIALS COMPATIBILITY
  • PLASTICS, STAINLESS STEEL, METAL ALLOYS, SKIN, ETC.

• DOSAGE & RATE OF APPLICATION
  • LEAST AMOUNT OF ACTIVE AS INFREQUENT AS POSSIBLE

• TRAINING AND EASE OF USE
  • PERSONAL PROTECTION, OPEN VS. CLOSED ENVIRONMENT, DILUTION CONSIDERATIONS

• SAFETY OF PERSONNEL & ENVIRONMENT
  • ODOR, ENVIRONMENTAL POLLUTION, EXPOSURE LIMITS

LIST OF ACTIVES

• MANY ACTIVES KNOWN AND AVAILABLE COMMERCIALY
  • ONLY A FEW ARE RELEVANT TO THIS SCOPE

• FOCUS WILL BE ON THE MECHANISM AND THE CLAIMS
  • CHEMICAL STRUCTURE
  • GENERAL CONCEPTS ON ACTIVITY
  • CLAIMS THAT ARE KNOWN FOR THE ACTIVE

• ISSUES REGARDING ANY CONTROVERSIES WILL BE MENTIONED BUT NOT THOROUGHLY DISCUSSED

CHLORINE: GAS, LIQUID OR POWDER

• MOST WIDELY USED MICROBICIDE

• EFFECTIVE AGAINST MOST PATHOGENS
  • DISRUPTION OF CELL WALLS, MEMBRANES AND PROTEINS
  • AMOUNT OF CHLORINE NEEDED DEPENDS ON
    • NATURE OF THE PATHOGEN
    • ORGANIC DEMAND FOR CHLORINE
    • pH OF THE ENVIRONMENT (LOWER = MORE ACTIVE)

• SODIUM HYPOCHLORITE (BLEACH) IS MOST COMMON
• CHLORINE GAS USED FOR WATER & SEWAGE DISINFECTION
• CHLORINE DIOXIDE & MONOCHLORAMINE ALSO USED FOR WATER DISINFECTION

PHENOLIC COMPOUNDS

• LONG-STANDING MICROBICIDAL AGENTS
  • VARIETY OF USES DEPENDING ON MODIFICATIONS
  • RESORCINOL – LOZENGES
  • P-CHLORO-M-XYLENOL (PCMX) – DISINFECTANT (DETTOL)
  • TRICLOSAN - ANTIBACTERIAL

• USED FOR LIPID AND PROTEIN DISRUPTION
  • LIPID NATURE OF PHENOLICS DISRUPT MEMBRANES

• GOOD BACTERICIDES & MYCOBACTERICIDES BUT LIMITED ACTIVITY AGAINST NON-ENVELOPED VIRUSES

• TOXICITY NEEDS TO BE FULLY UNDERSTOOD
  • PHENOL IS A HUMAN TOXIN IN NATURAL FORM
EVALUATING CLEANING/DISINFECTING PRODUCTS IN 5 EASY STEPS

**SURFACTANTS**

- Possess one hydrophobic and one hydrophilic tail
- Most common are quaternary ammonium compounds
- Cause membrane disruption
- Excellent against bacteria and enveloped viruses
- Poor against non-enveloped viruses, mycobacteria and spores
- Environmental concerns because of low biodegradability

**ALDEHYDES**

- Alkylating agents
  - Formaldehyde
  - Glutaraldehyde
  - Ortho-phthalaldehyde (OPA)
- Used in low concentrations to 'fix' proteins
  - Requires high pH (>8) for optimal activity
  - Highly lipophilic
- Good against most pathogens except prions and some protozoan cysts
- Formaldehyde and glutaraldehyde are toxic
  - OPA is less so but still requires care

**METALS**

- Dose-dependent action
  - Toxic for all organisms in high doses
  - At lower doses, some demonstrate antimicrobial properties
  - Heavy metals are bactercidal and fungicidal
  - Have little effect on viruses and spores
- Copper is now a registered antimicrobial in the U.S.
  - Copper surfaces shown to kill and resist microbial growth
  - Causes damage to thiol (-SH) groups preventing growth
  - Compatibility with oxidizer-based disinfectants an issue
- Silver has been used as an antimicrobial for centuries
  - Silver nitrate (AgNO₃) interacts with membranes and DNA
  - Elemental silver is used for impregnation
  - Now considered as a bacteriostatic agent in textiles
  - Silver resistance in bacteria has been known to exist

**PEROXYGENS**

- Strong oxidizing agents
  - Produce free radicals that damage cells
  - Hydrogen peroxide, peracetic acid
- Effective against most pathogens including spores at higher concentrations
  - Conc. depends on activity required
  - Detergents, organic acids & anti-corrosives added
- Issues with peroxygens
  - Peroacetic acid is highly corrosive and only used in controlled environments
  - Peroxide requires stabilization for long-term use
  - No residue; environmentally safe

**ALCOHOLS**

- Fixative action through disruption of protein structure
- Two major alcohol types
  - Ethanol (usually 62-80%) – good wide-spectrum microbicidal
  - Isopropanol (60-95%) – only good bactericide
- Both are ineffectiver against spores
- Concerns over best concentration for use
  - 62%, 70%, 80%, 95%
  - Studies in our lab show that 62% may be the best as antiseptic

**COLD STERILIZATION**

- Only three are approved by the FDA
  - Ethylene oxide
  - Ozone
  - Hydrogen peroxide
- Must be used under highly controlled environments
  - More modern uses include autoclave-like models that sterilize medical devices in hospitals
- Only trained individuals may work with cold sterilants
  - Working with dangerous agents brings higher risk
  - More controlled machinery helping

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EVALUATING CLEANING/DISINFECTING PRODUCTS IN 5 EASY STEPS

OZONE
- STRONG OXIDIZER
- HIGHLY TOXIC
- THRESHOLD FOR HUMANS < 0.1 PPM/DAY
- USUALLY 1-3 PPM ARE USED

ETHYLENE OXIDE
- STRONG ALKYLATOR
- HIGHLY TOXIC
- THRESHOLD FOR HUMANS IS < 5 PPM/DAY
- SOME COMPANIES USE UP TO 1500 PPM
- REQUIRED AERATION TIMES MAY TAKE HOURS

GASEOUS HYDROGEN PEROXIDE
- IN GASEOUS/PLASMA OR VAPORIZED FORM
- OXIDATION IS AS POTENT AS OR BETTER THAN IN LIQUID FORM
- INCREASED POTENTIAL WHEN CHARGED (PLASMA)
- COMPATIBILITY WITH ALMOST ALL MATERIALS
- EASILY AERATED
- USED AT ROOM TEMPERATURE AND RH BETWEEN 35-80%
- TOXICITY IS LOW AS ONLY 10 PPM REQUIRED FOR USE
- LONGER TIMES NEEDED OVER OTHERS
- CONTROLLED SETTINGS ALSO NEEDED
- NUMBER OF MODELS USING HYDROGEN PEROXIDE INCREASING

OVERVIEW OF ACTIVITIES

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<tr>
<th>ACTIVE INGREDIENT</th>
<th>ACTIVITY AGAINST</th>
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<tbody>
<tr>
<td>SOD. HYPOCHLORITE (1 PPM)</td>
<td>B</td>
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<tr>
<td>SOD. HYPOCHLORITE (1000 PPM)</td>
<td>B, EV, NEV, F</td>
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<tr>
<td>O-PHENYLPHENOL (200 PPM)</td>
<td>B, EV</td>
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<tr>
<td>QUATERNARY AMMONIUM COMPOUNDS (100-3000 ppm)</td>
<td>B, EV, F</td>
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<tr>
<td>ALKALINE GLUTARALDEHYDE (2%)</td>
<td>B, EV, NEV, F</td>
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<tr>
<td>HYDROGEN PEROXIDE (3%)</td>
<td>B</td>
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<tr>
<td>ACCELERATED HYDROGEN PEROXIDE (7.5%)</td>
<td>B, EV, NEV, F</td>
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<td>PERACETIC ACID (1-1000 PPM)</td>
<td>B, EV, NEV, F</td>
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<td>ETHANOL 62% (V/V)</td>
<td>B, EV, NEV, F</td>
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APPLY

- READ THE LABELS,
- FOLLOW INSTRUCTIONS AND
- ENSURE THAT THE PROPER PROCEDURE IS USED

DIRECTIONS ARE NOT AS THEY SEEM

- LABELS MAY CAUSE CONFUSION
  - WATER AS A DILUENT (MEANS DISTILLED WATER)
  - TAP WATER IS NORMALLY USED IN THE FIELD
  - CONTACT TIME
    - A FEW SECONDS IN APPLICATION VS. A FEW MINUTES ON THE LABEL
    - DIFFERENT DILUTIONS
      - SEPARATE DILUTIONS FOR DIFFERENT CLASSES OF PATHOGENS (TARGET UNKNOWN IN THE FIELD)
- DIRECTIONS ARE BASED ON EXTENSIVE TESTING OF THE ACTIVE IN LABORATORY ENVIRONMENTS
  - LABORATORY TESTS ARE INDIATIVE OF FIELD USE
  - ASSESSMENT OF ENVIRONMENT IS KEY TO PROPER USE

CENTER FOR FOOD SECURITY AND PUBLIC HEALTH, IOWA STATE UNIVERSITY
LABORATORY-BASED CLAIMS

• CLAIMS ARE VALIDATED USING VARIOUS TESTING METHODS
  - TESTS METHODS ARE STANDARDIZED (AOAC, ASTM, EU)
  - METHOD USED DEPENDS ON LOCATION (EU, US, CAN)
  - ACTIVES MUST MEET REDUCTION LEVELS TO VALIDATE A CLAIM

• SPORICIDAL, MYCOBACTERICIDAL & BACTERICIDAL ACTIVITY
  - PRODUCT REQUIRED TO REDUCE THE VIABILITY TITRE OF TEST ORGANISMS BY A REQUIRED LEVEL (1 TO ≥ 5 LOG10)

• VIRUCIDAL ACTIVITY
  - PRODUCT REQUIRED TO REDUCE THE VIABILITY TITRE OF THE TEST ORGANISMS BY AT LEAST 3 LOG10

• FUNGICIDAL ACTIVITY
  - A MINIMUM REDUCTION OF 5 LOG10 IS REQUIRED

ISSUES WITH TESTING CLAIMS

• LEVELS OF ACTIVE
  - DIFFERENT CONCENTRATIONS OFFER DIFFERENT CLAIMS
  - HYPOCHLORITE, PEROXIDE, ETHANOL

• TEST PROTOCOL ISSUES
  - SUSPENSION TESTS
  - CARRIER TESTS
  - SKIN-BASED TESTS (IN VIVO)

• CONTACT TIMES
  - REQUIRES 'WET CONTACT' BETWEEN ACTIVE AND ORGANISM
  - MOST CONTACT TIMES ARE NOT IN LINE WITH REALITIES OF USE

• RESIDUAL/PERSISTENT ACTIVITY
  - HOW IS THE ACTIVITY MEASURED OVER SEVERAL HOURS?

FACTORS TO CONSIDER

• WHAT IS THE LOADING IN THE ENVIRONMENT?
  - HOW MUCH SOIL IS PRESENT IN THE TARGET ENVIRONMENT?
  - BODILY FLUIDS, ORGANIC/INORGANIC MATERIAL

• MANUAL PRE-CLEANING
  - MANY DISINFECTANTS REQUIRE A STEP INVOLVING CLEANING
  - IS THAT CLEANING COMPATIBLE WITH THE TARGET ENV?

• DILUENT
  - IN WHAT LIQUID SHOULD THE PRODUCT BE DILUTED?
  - HARD WATER/STERILE WATER/TAP WATER

• FRESH VS. REUSABLE
  - DOES THE ACTIVIE HAVE A SHELF-LIFE AFTER PREPARATION
  - COST VS. BEnEFIT

AUDIT

HOW CAN YOU TELL YOU'RE DOING A GOOD JOB?

AUDITS REQUIRE COLLABORATION

• AN AUDIT OF DISINFECTION/ANTISEPSIS REQUIRES INVOLVEMENT OF NUMEROUS DEPARTMENTS
  - ENVIRONMENTAL SERVICES
  - INFECTION CONTROL
  - ADMINISTRATION

• AUDITS SHOULD BE CONDUCTED WITH DEFINED OBJECTIVES
  - CLEAN VS. DISINFECTED
  - ROUTINE VS. TERMINAL
  - ACCEPTABLE RESIDUAL LOADS

• REPORTS ON AUDITS SHOULD REFLECT GOALS OF HOSPITAL
  - WORK PLANS ARE DEFINED AND OBJECTIVES MUST NOT BE NEGLECTED
  - AUDITS SHOULD REFLECT THESE OBJECTIVES

METHODS FOR AUDITING

• EACH HOSPITAL WILL HAVE A SPECIFIC METHOD FOR AUDITING
  - BENEFITS AND DRAWBACKS

• MICROBIAL CULTURE & LAB ANALYSIS
  - SWABBING FOLLOWED BY LAB ANALYSIS
  - LOW-COST BUT TIME-CONSUMING

• ATP (ADENOSINE TRIPHOSPHATE)
  - USED TO DETECT ANY POTENTIAL ORGANIC/BIOLOGICAL PROCESSES
  - RAPID RESULTS THAT ARE QUANTIFIABLE

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A NOVEL FORM OF AUDIT

• FLUORESCENT TARGETING METHOD
  • FLUORESCENT “GOO” TO HELP MONITOR CLEANING
  • USED FOR BOTH TRAINING AND EVALUATION

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In-Kind Grant? Evaluation of the DAZO Fluorescent Marker Method for Monitoring Environmental Cleaning, SHEA 2011

JASON A. TETRO

EVALUATING CLEANING/DISINFECTING PRODUCTS IN 5 EASY STEPS

A DIFFERENT KIND OF AUDIT

• SATISFACTION
  • DO PATIENTS FEEL SAFER?
  • DO VISITORS FEEL MORE COMFORTABLE IN THE HOSPITAL SETTING?
  • WILL VISITORS ADOPT BETTER HYGIENE AS A RESULT?
  • INCREASED USE OF HAND SANITIZERS AT ENTRANCES

LAST THOUGHTS

• DISINFECTION AND ANTISEPSIS ARE NO LONGER JUST AN ENVIRONMENTAL SERVICES ISSUE
• REQUIREMENTS FOR MANY DEPARTMENTS
• FRAMEWORK FOR DECISION-MAKING IS FUNDAMENTAL TO SUCCESS
• THE FIVE A’s PROVIDE THE BACKBONE TO THIS FRAMEWORK
• INFORMATION NEEDS TO BE AVAILABLE AND ACCESSIBLE
• THE FIVE A’s POINT TO HOW DECISION TREES AND DATA CAN BE CLASSIFIED AND DISPLAYED
• PATHOGENS REPRESENT ONE OF THE GREATEST THREATS TO HEALTH IN THE HOSPITAL
• PATIENTS, VISITORS, HEALTHCARE STAFF (SARS)
• THE EASIER THE MODEL, THE FASTER THE ADOPTION ONCE A DECISION IS MADE (KISS RULE)

THANK YOU

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