METHODS AND SYSTEMS FOR REDUCING SPREAD OF MICROBES

Inventors: Steven J. Laken, Pepperell, MA (US); Carlo Giovanni Traverso, Newton, MA (US); Richard L. Miller, Needham, MA (US)

Abstract

Methods and apparatus of the invention relate to reduction of a spread of microbes, in particular from a toilet into the environment. In one aspect, a method of reducing a spread of microbes is provided comprising: providing a pressurized water supply to a toilet bowl; providing an externally accessible reservoir containing an anti-microbial additive; providing a conduit comprising a first end in fluid communication with the pressurized water supply and a second end in fluid communication with the externally accessible reservoir; and administering the anti-microbial additive into the toilet bowl through the conduit, wherein the spread of microbes into an environment proximal to the toilet is reduced. In another aspect, a method of introducing an additive into a toilet is provided comprising: providing a pressurized water supply to a toilet bowl; providing an externally accessible reservoir containing an anti-microbial additive; providing a conduit comprising a first end in fluid communication with the pressurized water supply and a second end in fluid communication with the externally accessible reservoir; and administering the anti-microbial additive to the water at the level of the water supply when the toilet is flushed, wherein microbes are killed prior to the flush. Other aspects comprise apparatuses for reducing a spread of microbes and introducing an additive into a toilet.
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METHODS AND SYSTEMS FOR REDUCING SPREAD OF MICROBES

[0001] This application claims the benefit of and priority to U.S. provisional patent application Ser. No. 61/846,228, filed Jul. 15, 2013, the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

[0002] All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety. The patent and scientific literature referred to herein establishes knowledge that is available to those skilled in the art. The issued patents, applications, and other publications that are cited herein are hereby incorporated by reference to the same extent as if each was specifically and individually indicated to be incorporated by reference. In the case of inconsistencies, the present disclosure will prevail.

FIELD OF THE INVENTION

[0003] Methods and apparatuses of the invention relate to reduction of a spread of microbes, in particular from a toilet into the environment.

BACKGROUND

[0004] In 2007, about 14,500 Americans succumbed to diarrheal death putting it on par with deaths attributable to cancers of the ovary, brain or kidney. Diarrhea is the fifth leading cause of mortality worldwide, accounting for over 4.3% of all deaths.

[0005] In 2009, about 110,000 people were hospitalized with a primary cause of Clostridium difficile infections costing a total of $1.1 B at approximately $10,000 per case. In that same year, an additional 226,000 people contracted Clostridium difficile while in the hospital, accounting for an additional $1 B in expenses beyond their initial treatment costs.

[0006] In 2010, the people most at risk for developing this disease were people who received any healthcare (94% of infections). Of these, 75% contracted the disease without ever being hospitalized, e.g., recently discharged, outpatients, or nursing home residents. Ironically, those at highest risk of getting this infection experienced the most exposure to the spores that cause this disease.

[0007] Treatment for patients with Clostridium difficile consists of administration of antibiotics, fluids, and quarantine. Before entering a patient’s room, the hospital staff is expected to gown, wear gloves and then discard these items before exiting the room. Cleaning staff should use EPA (Environmental Protection Agency) cleared disinfectants shown to be effective against spores. However, research shows that the house staff cleans toilets inadequately, Clostridium difficile spores are still found on about 50% of the people after 9 days of being asymptomatic and antibiotics are becoming less effective.

[0008] The second leading cause of gut infection deaths is from norovirus and is likely mistaken for a mild case of influenza. Approximately, 800 Americans die each year and 20 million are infected. A sick person sheds billions of viruses in every gram of stool. Thus, cruise lines, dorms, schools, and public restrooms are likely sources of infections.

[0009] Despite the emphasis on bathroom hygiene, there has been little attention paid to the toilet as a contributor to infections. The toilet has changed little, is used by infected patients often and is a likely source contaminating the environment—possibly the primary source. For example, Best et al. found that spores are found in the air an hour after flushing and simply putting down the toilet seat reduces spores found in the environment after flushing by nearly 10-fold (Clinical Infectious Diseases 2010:50, 1450-1457; herein incorporated by reference in its entirety). However, because of gaps between the lid, seat and rim, a significant amount of microbes still escape into the environment even if the lid is closed. Even with the lid closed, the aerosols and droplets will still hit the toilet seat and may be transmitted to a worker, patient or bystander due to the high concentration.

[0010] Thus, a need exists for improvements in toilet design. Effective designs in controlling and reducing spread of microbes into the environment will result in significant global health improvement. A need also exists for devices and methods to control, mitigate, and/or reduce exposure to and/or spread of microbes.

SUMMARY OF THE INVENTION

[0011] Methods and apparatuses of the invention relate to reduction of spread of microbes, in particular from a toilet into the environment. The present invention demonstrates that bacteria, spores and other microbes released into the environment can be significantly reduced or eliminated by addition of an additive that is anti-microbial and/or anti-aerosol prior to and/or during flushing. It also has been surprisingly found that compositions and formulations of the present invention provide effective anti-microbial and/or anti-aerosol properties.

[0012] In one aspect, a method of reducing a spread of microbes is provided. The method comprises providing a pressurized water supply to a toilet bowl; providing an externally accessible reservoir containing an anti-microbial additive; providing a conduit comprising a first end in fluid communication with the pressurized water supply and a second end in fluid communication with the externally accessible reservoir, and administering the anti-microbial additive into the toilet bowl, through the conduit, wherein the spread of microbes into an environment proximal to the toilet is reduced.

[0013] In another aspect, a method of introducing an additive into a toilet is provided. The method comprises providing a pressurized water supply to a toilet bowl; providing externally accessible reservoir containing an anti-microbial additive; providing a conduit comprising a first end in fluid communication with the pressurized water supply and a second end in fluid communication with the externally accessible reservoir, and administering the anti-microbial additive to the water at the level of the water supply when the toilet is flushed; wherein microbes are killed prior to the flush.

[0014] In another aspect, a method of reducing an odor in a toilet is provided. The method comprises providing a pressurized water supply to a toilet bowl; providing an externally accessible reservoir containing an additive; providing a conduit comprising a first end in fluid communication with the pressurized water supply and a second end in fluid communication with the externally accessible reservoir, and administering the additive to the water at the level of the water supply when the toilet is flushed; wherein the additive reduces the odor.

[0015] In another aspect, an apparatus for reducing a spread of microbes from a toilet is provided. The apparatus comprises an externally-accessible reservoir and a conduit comprising a first end for disposal in fluid communication with a
pressurized water supply and a second end for disposal in fluid communication with the externally accessible reservoir; wherein the reservoir is configured to contain an effective amount of an anti-microbial additive to be added to the toilet, through the conduit.

[0016] In still another aspect, an apparatus for reducing a spread of microbes from a toilet is provided. The apparatus comprises a tube that replaces an existing non-pressurized vacuum breaker tube disposed downstream from a toilet flush valve, wherein the tube comprises a conduit or additive reservoir for introducing an additive, and wherein the additive mixes with the water when the water vacuum breaker tube fills with water. In some embodiments, the tube comprises a venturi tube, basket or an external conduit, wherein the external conduit comprises a first end in fluid communication with the tube and a second end in fluid communication with an externally accessible reservoir. In some embodiments, the tube comprises a basket. In some embodiments, the tube comprises an external conduit, wherein the external conduit comprises a first end in fluid communication with the tube and a second end in fluid communication with an externally accessible reservoir. In some embodiments, the tube replaces a portion of the vacuum breaker tube. In some embodiments, the tube is on a tankless toilet.

[0017] In yet another aspect, an apparatus for reducing a spread of microbes from a toilet is provided. The apparatus comprises a housing: an externally accessible reservoir disposed within the housing; a conduit comprising a first end for disposal in fluid communication with a pressurized water supply and a second end for disposal in fluid communication with the externally accessible reservoir; a check valve connector at the first end of the conduit; and a valve connection between the reservoir and the second end of the conduit; wherein the reservoir is configured to contain an effective amount of anti-microbial additive to be added to the toilet, through the conduit.

[0018] In yet another aspect, a method of reducing a spread of microbes from a toilet is provided. The method comprises: providing a venturi water supply to a toilet bowl; providing a housing; providing an externally accessible reservoir disposed within the housing and containing an anti-microbial additive; providing a conduit comprising a first end in fluid communication with the water supply and a second end in fluid communication with the externally accessible reservoir; and administering the anti-microbial additive into the venturi through the conduit, wherein the spread of microbes into an environment proximal to the toilet is reduced.

[0019] In some embodiments, the administering comprises delivering the additive into the pressurized water as it is supplied to the toilet bowl during a flush cycle. For example, such delivering can include releasing a dose of the additive from a refillable reservoir into the pressurized water. The refillable reservoir may contain a plurality of doses of the additive, and can be spring-loaded.

[0020] The additive comprises one or more of: osmotic pressure agents, phenolics, alcohols, halogens, oxidizing agents, surfactants, heavy metals, aldehydes, gaseous agents, enzymes and antimicrobials. For example, suitable phenolics comprise one or more of Lysol, triclosan, orthocresol, meta-cresol, paracresol, ortho-penylphenol, and hexachlorophene. Exemplary alcohols comprise one or more of isopropanol, ethanol and methanol. Exemplary halogens comprise one or more of iodine, isophor, chlorine, bleach, sodium hypochlorite, and calcium hypochlorite. In some embodiments, the additive is dry powder of calcium hypochlorite. Exemplary oxidizing agents comprise one or more of peroxide, permanganate, ozone and peracetic acid. Exemplary surfactants comprise one or more of sodium stearate, 4-(5-Dodecyl) benzenesulfonate, sodium dodecyl sulfate, cetrimonium bromide, and Triton X-100. Exemplary heavy metal ions comprise one or more of silver, gold and copper. Exemplary aldehydes comprise one or more of glutaraldehyde, formaldehyde and formalin. Exemplary gaseous agents comprise one or more of ethylene oxide, propylene oxide, ozone, hydrogen peroxide and beta-propiolactone. Exemplary enzymes comprise one or more of lysozyme and pronzyme. Exemplary antimicrobials comprise one or more of antibacterials, antifungals, and antivirals. Exemplary anti-aerosols comprise anything that reduces aerosol formation and increases surface tension. These include, for example, reducing temperatures, adding oils and other surfactants, or removing or eliminating soaps and detergents.

[0021] In some embodiments, the additive is provided in solid form at about 20-100 g per unit dose. The additive can further include a binding agent such as, for example, one or more of a dissolvable powder, gel and polymer. When introduced into water, the additive at least partially dissolves in the water and is present at about 1 to 10%, about 1 to 5%, about 1 to 3%, or about 1% by weight in the water. In some embodiments, at least a portion of the additive remains in the toilet bowl after the flushing.

[0022] In some embodiments, microbes whose spread can be reduced include one or more of bacteria, bacterial spores, and viruses. For example, spread of Clostridium difficile spores can be effectively reduced.

[0023] The methods described herein may further comprise reducing spread of aerosolized microbes. Aerosolized microbes may be reduced in the toilet and/or in the environment around the toilet. For example, aerosolized microbes can be reduced in the toilet bowl, in the environment on or above the toilet seat or, in the case of urinals, above the basin, or outside the bowl in the vicinity of the toilet. In some embodiments, aerosolized microbes are reduced in the toilet. In some embodiments, aerosolized microbes are reduced in the environment around the toilet. In some embodiments, aerosolized microbes are reduced in the toilet. In some embodiments, aerosolized microbes are reduced in the environment around the toilet. In addition, for example, one or more of an oil, sheet, powder, foam, spray and gel can be supplied into the water in the toilet bowl to reduce spread of aerosolized microbes. In some embodiments, the toilet bowl contains an inoculum and the method further comprises reducing infectivity of said inoculum. In some embodiments, the method further comprises reducing pressure in the pressurized water line, thereby reducing aerosolization.

[0024] Where desirable, probiotic bacteria can also be added into the water in the toilet bowl, providing health benefits.

[0025] Other aspects and embodiments of the present invention comprise methods and apparatus for modifying toilet water and reducing spread of microbes.

BRIEF DESCRIPTION OF THE FIGURES

[0026] The following figures are illustrative only and are not intended to be limiting.
FIG. 1. An illustrative embodiment showing an externally accessible reservoir in fluid communication with a pressurized water supply according to an embodiment of the invention.

FIG. 2. An illustrative embodiment showing a fluid communication between the externally accessible reservoir and a venturi design according to an embodiment of the invention.

FIG. 3. An illustrative embodiment showing a reservoir in fluid connection with a conduit according to an embodiment of the invention.

FIG. 4. An illustrative embodiment showing a reservoir with a check valve in fluid connection with a conduit according to an embodiment of the invention.

FIGS. 5A-5B. Illustrative embodiments showing (FIG. 5A) a vacuum break tube containing an additive reservoir according to an embodiment of the invention, and (FIG. 5B) an additive reservoir according to an embodiment of the invention.

FIGS. 6A-6B. Illustrative embodiments showing (FIG. 6A) a vacuum break tube with an additive reservoir according to an embodiment of the invention, and (FIG. 6B) an additive reservoir according to an embodiment of the invention.

FIGS. 7A-7B. Illustrative embodiments showing (FIG. 7A) a vacuum break tube with an additive reservoir and conduit according to an embodiment of the invention, and (FIG. 7B) an additive reservoir and conduit according to an embodiment of the invention.

FIG. 8. A graphical representation showing flow rate during a flush using an apparatus according to an embodiment of the invention.

FIG. 9. A graphical representation showing significant spore reduction with bleach additive relative to colonies with no bleach additive.

FIG. 10. A graphical representation showing non-significant spore reduction with bleach additive relative to colonies with no bleach additive.

FIG. 11. A graphical representation showing significant spore reduction in a first and second water control flush.

FIG. 12. A graphical representation showing significant spore reduction with 400 mL bleach additive relative to water control using an apparatus according to an embodiment of the invention.

FIG. 13. A graphical representation showing non-significant spore reduction with 100 mL bleach additive relative to control using an apparatus according to an embodiment of the invention.

FIG. 14. A graphical representation showing non-significant spore reduction with 100 mL starch additive relative to control using an apparatus according to an embodiment of the invention.

FIG. 15. A graphical representation showing non-significant spore reduction with 400 mL starch additive relative to control using an apparatus according to an embodiment of the invention.

FIG. 16. A graphical representation showing modification of aerosol distribution at ≥25 μm as a function of chemicals used using an apparatus according to an embodiment of the invention.

FIG. 17. A graphical representation showing modification of aerosol distribution detected between 0.3-0.5 μm as a function of chemicals used using an apparatus according to an embodiment of the invention.

FIG. 18. A graphical representation showing modification of aerosol distribution detected between 0.5-1 μm as a function of chemicals used using an apparatus according to an embodiment of the invention.

FIG. 19. A graphical representation showing modification of aerosol distribution detected between 1.0-5 μm as a function of chemicals used using an apparatus according to an embodiment of the invention.

FIG. 20. A graphical representation showing modification of aerosol distribution detected between 5.0-10 μm as a function of chemicals used using an apparatus according to an embodiment of the invention.

FIG. 21. A graphical representation showing the effect of aerosol collection time and spore concentration on bacterial germination.

FIG. 22. A graphical representation showing significant spore reduction with 1:10 dilution of bleach additive relative to control.

FIG. 23. A graphical representation showing significant spore reduction with 1:2 dilution of bleach additive relative to control.

FIG. 24. A graphical representation showing significant spore reduction with 1:10 dilution of hydrogen peroxide additive relative to control.

FIG. 25. A graphical representation showing non-significant spore reduction with 1:2 dilution of hydrogen peroxide additive relative to control.

FIG. 26. A graphical representation showing significant spore reduction with 1:10 dilution of canola oil additive relative to control.

FIG. 27. Shows significant spore reduction with 1:2 dilution of canola oil additive relative to control.

FIG. 28. A graphical representation showing non-significant spore reduction with 1:10 dilution of olive oil additive relative to control.

FIG. 29. A graphical representation showing non-significant spore reduction with 1:2 dilution of olive oil additive relative to control.

FIG. 30. A graphical representation showing significant spore reduction with adding bleach directly to the toilet bowl before the flush relative to control.

FIGS. 31A-31B. A graphical representation showing spore germination and colony formation at 0 cm height with spores added to the bowl relative to control without spores. FIG. 31A represents the control without spores added. FIG. 31B represents the flush with spores.

FIGS. 32A-32B. A graphical representation showing spore germination and colony formation at 5 cm height with spores added to the bowl relative to control without spores. FIG. 32A represents the control without spores added. FIG. 32B represents the flush with spores.

FIGS. 33A-33B. A graphical representation showing spore germination and colony formation at 10 cm height with spores added to the bowl relative to control without spores. FIG. 33A represents the control without spores added. FIG. 33B represents the flush with spores.

FIGS. 34A-34B. A graphical representation showing spore germination and colony formation at 20 cm height with spores added to the bowl relative to control without spores. FIG. 34A represents the control without spores added. FIG. 34B represents the flush with spores.

FIGS. 35A-35B. A graphical representation showing spore germination and colony formation at 30 cm height with spores added to the bowl relative to control without
spores. FIG. 35A represents the control without spores added. FIG. 35B represents the flush with spores.

0062 FIGS. 36A-36B. A graphical representation showing spore germination and colony formation at all heights (0, 5, 10, 20, and 30 cm) with spores added to the bowl relative to control without spores. FIG. 36A represents the control without spores added. FIG. 36B represents the flush with spores.

DETAILED DESCRIPTION

0063 As used herein and in the appended claims, the singular forms “a”, “an,” and “the” include plural references unless the content clearly dictates otherwise.

0064 The term “about” is used herein to mean approximately, in the region of, roughly, or around. When the term “about” is used in conjunction with a number it modifies that range by extending the boundaries above and below the numerical values set forth. The term “about” is used herein to modify a numerical value above and below the stated value by a variance of 20%.

0065 Microorganisms (or microbes) are microscopic organisms that include, for example, bacteria, viruses, fungi, archaea, protists, plants (e.g., green algae), parasites, and animals such as amoeba, plankton. In some cases, microbes may be harmful and lead to illness and disease in plants, animals or humans. Moreover, in addition to causing infections or diseases, undesired microbial growth may also occur in consumer products, such as food contamination.

0066 Microbes in and from toilets in particular pose a health hazard. Although toilets have been in use for over a century little is known about the fluid dynamics of the aerosols they generate. In a report entitled “Microbiological Hazards of Household Toilets: Droplet Production and the Fate of Residual Organisms” (Appl Microbiol. 1975 August; 30(2): 220-237; herein incorporated by reference in its entirety), Gerba et al. showed that flushing produced an aerosol harboring bacteria and viruses that stayed airborne for up to two hours and traveled six to eight feet up and out from the toilet.

0067 Toilets in commercial or public settings such as, for example, hospitals, nursing homes, long term care settings and public restrooms present a more significant health risk than household toilets. In general, commercial toilets are connected to pressurized water supply (e.g., about 50-80 pounds per square inch (PSI)) where water flows under pressure from the supply piping into the fixture. The pressurized flush produces a more powerful, cleansing flush than residential toilets which generally relies on gravity from water stored in a tank to flush. The pressurized flush, however, also produces a larger and stronger aerosol that travels higher and longer than residential toilets. Furthermore, health problems such as Clostridium difficile infection (CDI) are even more likely to arise when the toilet is flushed after acute episodes of diarrhea or vomiting.

0068 Clostridium difficile infection is a major burden to health care facilities, with increasing rates since 2002. C. difficile is the most serious cause of antibiotic-associated diarrhea and can lead to pseudomembranous colitis, a severe inflammation of the colon, often resulting from eradication of the normal gut flora by antibiotics. Clostridium difficile infection can range in severity from asymptomatic to severe and life-threatening, especially among the elderly. People are most often nosocomially infected in hospitals, nursing homes, or other medical institutions, and CDI in the community, outpatient setting is also increasing. The rate of C. diffic禧le acquisition is estimated to be 13% in patients with hospital stays of up to two weeks, and 50% in those with hospital stays longer than four weeks. With the recognition and emergence of virulent strains associated with Clostridium difficile infection outbreaks, such as ribotype 027/NAP1, it has become increasingly important to control and reduce C. difficile spread and transmission.

0069 It has been estimated that a patient with CDI can excrete between 1 x 10^6 and 1 x 10^7 of C. difficile per gram of feces. C. difficile often form spores which are resistant to most routine cleaning methods such as disinfectants used on surfaces. Spores of these bacteria can remain viable outside of the human body for months or years, and this means the patients in a medical facility are often exposed to situations where they end up accidentally ingesting spores. Extremely rigorous infection protocols are required to decrease or eliminate this risk.

0070 Despite cleaning, environmental contamination with C. difficile spores occurs at as many as 34%-58% of sites, with surfaces of fomites being most frequently contaminated. Crucially, the hands of health care workers are significantly more likely to be positive for C. difficile if the environment is heavily contaminated with the bacterium.

0071 To determine effectiveness of C. difficile sporicidal products, EPA’s “Guidance for the Efficacy Evaluation of Products with Sporicidal Claims against Clostridium difficile,” incorporated herein by reference in its entirety, recommends the following test methods:

0072 1. Most recent version (2006) of AOAC Method 966.04: AOAC Sporicidal Activity of Disinfectants test, Method I for Clstridium sporogenes,

0073 2. AOAC Method 2008.05: Quantitative Three Step Method (Efficacy of Liquid Sporicides Against Spores of Bacillus subtilis on a Hard Nonporous Surface),

0074 3. ASTM E 2414-05: Standard Test Method for Quantitative Sporicidal Three Step Method (TSM) to Determine Efficacy of Liquids, Liquid Sprays, and Vapor or Gases on Contaminated Carrier Surfaces, or

0075 4. ASTM E 2197-02: Standard Quantitative Carrier Test Method to Evaluate the Bactericidal, Fungicidal, Mycobactericidal, and Sporicidal Potencies of Liquid Chemical Germicides.

0076 The above AOAC and ASTM protocols are useful for determining the effectiveness of the methods and systems in reducing spread of CD and CD spores and are all incorporated herein by reference in their entirety.

0077 Some aspects of the present invention provide a method for treating water used in flushing a toilet. Additives, such as chemicals and detergents may be used to pre-treat or treat a toilet to control spread of microbes such as, for example, bacteria, bacterial spores and/or viruses. The methods and apparatuses described herein are useful in hospitals, nursing homes, long term care settings, public restrooms, and areas where people are immunocompromised, where people share toilets, and/or where there is a potential source of contamination from aerosolized water containing microbes. The methods and apparatuses described herein allow for treatment of the water in the toilet either passively (e.g., treatment of the intake water with some additive) or through the passive treatment of the water. Exemplary additives are described in detail herein. In some embodiments, mechanical methods can also be used to sanitize or sterilize toilet water, such as ionizing radiation (e.g., x-rays, gamma rays, and/or electron
beams), nonionizing radiation (e.g., U.V. light), boiling water, high pressures, excess heat or cold, and/or burning.

In some embodiments of the present invention, one or more additive is provided to decontaminate, disinfect and/or sterilize toilet water, thereby reducing or preventing spread of microbes (e.g., bacteria, virus, mold, fungi and any other microbes) including spores.

As used herein, "sterilization" describes a process that destroys or eliminates all forms of microbial life and is carried out by physical or chemical methods. Steam under pressure, dry heat, ethylene oxide gas, hydrogen peroxide gas plasma, and liquid chemicals are exemplary sterilizing agents used, for example, in health-care facilities. When chemicals are used to destroy all forms of microbiologic life, they can be called chemical sterilants. These same germicides used for shorter exposure periods also can be part of the disinfection process (i.e., high-level disinfection).

"Disinfection" describes a process that eliminates many or all pathogenic microorganisms, except bacterial spores, on inanimate objects. In health-care settings, objects usually are disinfected by liquid chemicals or wet pasteurization. Each of the various factors that affect the efficacy of disinfection can nullify or limit the efficacy of the process. Factors that affect the efficacy of both disinfection and sterilization include, for example, prior cleaning of the object; organic and inorganic load present; type and level of microbial contamination; concentration of and exposure time to the germicide; physical nature of the object (e.g., crevices, hinges, and lumens); presence of biofilms; temperature and pH of the disinfection process; and in some cases, relative humidity in the sterilization process (e.g., ethylene oxide). Unlike sterilization, disinfection is not sporicidal. A few disinfectants (chemical sterilants) will kill spores with prolonged exposure times (e.g., 3-12 hours). At similar concentrations but with shorter exposure periods (e.g., 20 minutes for 2% glutaraldehyde), these same disinfectants will kill all microorganisms except large numbers of bacterial spores; they are called high-level disinfectants. Low-level disinfectants can kill most vegetative bacteria, some fungi, and some viruses in a practical period of time (<10 minutes). Intermediate-level disinfectants might be "cidal" for mycobacteria, vegetative bacteria, most viruses, and most fungi but do not necessarily kill bacterial spores. Germicides differ markedly, primarily in their antimicrobial spectrum and rapidity of action.

"Decontamination" is a process that removes pathogenic microorganisms from objects so they are safe to handle, use, or discard. Terms with the suffix "cide" or "cidual" for killing action also are commonly used. For example, a germicide is an agent that can kill microorganisms, particularly pathogenic organisms ("germs"). The term germicide encompasses both antiseptics and disinfectants. Antiseptics are germicides applied to living tissue and skin; disinfectants are antimicrobials applied only to inanimate objects. In general, antiseptics are used only on the skin and not for surface disinfection, and disinfectants are not used for skin antisepsis because they can injure skin and other tissues. Virucide, fungicide, bactericide, sporicide, and tuberculocide can kill the type of microorganism identified by the prefix. For example, a bactericide is an agent that kills bacteria.

Additives suitable for methods and apparatus of the present invention comprise one or more of: osmotic pressure agents, phenolics, alcohols, halogens, oxidizing agents, surfactants, heavy metal ions, aldehydes, gaseous agents, enzymes and/or antimicrobials. In some embodiments, the anti-microbial additive comprises at least one osmotic pressure agent, phenolic, alcohol, halogen, oxidizing agent, surfactant, heavy metal ion, aldehyde, gaseous agent, enzyme, probiotic, sporulation agent, vaccine, bacteriophage, oil, paper, or salt. In some embodiments, the anti-microbial additive comprises at least one phenolic, alcohol, oxidizing agent, surfactant, heavy metal ion, aldehyde, gaseous agent, enzyme, probiotic, sporulation agent, vaccine, bacteriophage, or salt. In some embodiments, the anti-microbial additive comprises at least one phenolic, alcohol, oxidizing agent, surfactant, heavy metal ion, aldehyde, gaseous agent, enzyme, probiotic, sporulation agent, vaccine, bacteriophage, or salt. In some embodiments, the anti-microbial additive comprises at least one phenolic, alcohol, oxidizing agent, heavy metal ion, aldehyde, or salt. In some embodiments, the anti-microbial additive comprises a phenolic. In some embodiments, the anti-microbial additive comprises a halogen. In some embodiments, the anti-microbial additive comprises a fluoride. In some embodiments, the anti-microbial additive comprises a heavy metal ion. In some embodiments, the anti-microbial additive comprises an aldehyde. In some embodiments, the anti-microbial additive comprises a fluoride.

The phenolic is selected from the group consisting of Lysol, triclosan, orthocresol, ortho-phenylenediamine, and hexachlorophene. In some embodiments, the phenolic is selected from the group consisting of triclosan, orthocresol, metacresol, paran cresol, ortho-phenylenediamine, and hexachlorophene. In some embodiments, the phenolic is triclosan or hexachlorophene. In some embodiments, the phenolic is triclosan. In some embodiments, the phenolic is hexachlorophene. In some embodiments, the phenolic is triclosan. In some embodiments, the phenolic is Lysol.

The alcohol is selected from the group consisting of isopropyl alcohol, ethanol and methanol. In some embodiments, the alcohol is selected from the group consisting of isopropyl alcohol and methanol. In some embodiments, the alcohol is ethanol.

In some embodiments, the halogen is selected from the group consisting of iodine, iodophor, bromide, chloride, hypochlorite, hypobromite, and calcium hypochlorite. In some embodiments, the iodine is methyl bromide. In some embodiments, the calcium hypochlorite is dry powder of calcium hypochlorite.

In some embodiments, the oxidizing agent is selected from the group consisting of oxygen, peroxide, ozone, permanganate and peracetic acid. In some embodiments, the oxidizing agent is peroxide, permanganate, or peracetic acid. In some embodiments, the oxidizing agent is oxygen or ozone. In some embodiments, the oxidizing agent is oxygen. In some embodiments, the oxidizing agent is ozone. In some embodiments, the oxidizing agent is peracetic acid. In some embodiments, the oxidizing agent is peroxide. In some embodiments, the peroxide is hydrogen peroxide. In some embodiments, the oxidizing agent is permanganate. In some embodiments, the permanganate is potassium permanganate.

In some embodiments, the surfactant is selected from the group consisting of sodium stearate, 4-(5-dodecyl)benzenesulfonate, sodium dodecyl sulfate, cetrimonium bromide, and Triton X-100. In some embodiments, the surfactant is selected from the group consisting of 4-(5-dodecyl)benzenesulfonate, sodium dodecyl sulfate, cetrimonium bromide, and Triton X-100. In some embodiments, the surfactant is selected from the group consisting of sodium stearate, 4-(5-dodecyl)benzenesulfonate, and sodium dodecyl sulfate. In some embodiments, the surfactant is cetrimonium bromide or sodium dodecyl sulfate.
Triton X-100. In some embodiments, the surfactant is cetrimonium bromide. In some embodiments, the surfactant is Triton X-100.

In some embodiments, the heavy metal ion comprises silver, gold, or copper. In some embodiments, the heavy metal ion comprises silver or copper. In some embodiments, the heavy metal ion comprises silver. In some embodiments, the heavy metal ion comprises copper. In some embodiments, the additive is silver nitrate. In some embodiments, the additive is copper nitrate.

In some embodiments, the aldehyde is selected from the group consisting of: glyoxal, formaldehyde, glutaraldehyde, and formalin. In some embodiments, the aldehyde is glutaraldehyde. In some embodiments, the aldehyde is formalin.

In some embodiments, the gaseous agent is selected from the group consisting of ethylene oxide, propylene oxide and beta-propiolactone. In some embodiments, the gaseous agent is selected from the group consisting of ethylene oxide and propylene oxide. In some embodiments, the gaseous agent is vaporized hydrogen peroxide, ethylene oxide, propylene oxide and beta-propiolactone. In some embodiments, the gaseous agent is vaporized hydrogen peroxide, ethylene oxide or propylene oxide.

In some embodiments, the gaseous agent is propylene oxide. In some embodiments, the gaseous agent is beta-propiolactone. In some embodiments, the gaseous agent is propylene oxide or ethylene oxide.

In some embodiments, the gaseous agent is propylene oxide or ethylene oxide. In some embodiments, the gaseous agent is propylene oxide or ethylene oxide or hydrogen peroxide.

In some embodiments, the gaseous agent is propylene oxide or ethylene oxide or hydrogen peroxide.

In some embodiments, the enzyme is lysozyme or prionzyme. In some embodiments, the enzyme is lysozyme. In some embodiments, the enzyme is prionzyme.

In some embodiments, the oil is selected from the group consisting of: vegetable, canola or olive oil. In some embodiments, the oil is olive oil or canola oil. In some embodiments, the oil is canola oil.

In some embodiments, aerosolized microbes are reduced. In some embodiments, the spread of aerosolized microbes is reduced. In some embodiments, spores are killed.

In some embodiments, the microbe is selected from the group consisting of a bacteria, bacterial spore, fungus, virus, protozoa and helminth. In some embodiments, the microbe comprises bacteria. In some embodiments, the microbe is a bacterial spore. In some embodiments, the bacterial spore comprises Bacillus or Clostridium. In some embodiments, the bacterial spore comprises Bacillus. In some embodiments, the bacterial spore comprises Clostridium. In some embodiments, the bacterial spore comprises Clostridium difficile, Escherichia coli (O157:H7, ETEC, EPEC), Helicobacter pylori, Listeria monocytogenes, Mycobacterium avium, Mycobacterium intracellulare, Mycobacterium tuberculosis, Salmonella enterica (serotype Typhi) aka S. typhi, Salmonella paratyphi A, Salmonella schottmuelleri (formerly S. Paratyphi B), Salmonella hirschfeldii (formerly S. Paratyphi A), Salmonella enteritidis, Campylobacter fetus, Bacillus anthracis, Bacillus cereus, Bacillus thuringiensis, Shigella dysenteriae (serogroup A, 12 serotype), Shigella flexneri (serogroup B, 6 serotype), Shigella boydii (serogroup C, 23 serotype), Shigella sonnei (serogroup D, 1 serotype), Yersinia enterocolitica, Yersinia pseudotuberculosis, Vibrio parahaemolyticus, methicillin-resistant Staphylococcus aureus, vancomycin-resistant enterococci, and carbapenem-resistant Enterobacteriaceae. In some embodiments the microbe is selected from a protozoa.

In some embodiments the protozoa is selected from Acanthamoeba, Balanidium coli, Brachiola algarea, Brachiola conori, Brachiola vesicularis, Balanoidesrichteri, Cryptosporidium canis, Cryptosporidium felis, Cryptosporidium hominis, Cryptosporidium muris, Cryptosporidium parvum, Cyclospora sp., Cyclospora catenans, Cystoisospora belli (Isospora), E. encephalitozoon, Encephalitozoon cuniculus, Encephalitozoon hellem, Encephalitozoon intestinalis, Encephalitozoon intestinalis, Entamoeba coli, Entamoeba dispar, Entamoeba histolytica, Enterococcus biari, Enterococcus biari, Giardia lamblia, Iodamebo butschlii, Microsporidium africanaum, Microsporidium ceylonensis, Naegleria fowleri, Nosema ocularum, Nosema species, Pleistophora sp., Retortamonas intestinalis, Sarcocystis hominis, Sarcocystis suihominis, Septata intestinalis, Strongyloides fulleborni, Strongyloides stercoralis, Toxoplasma gondii, Trachipleistophora anthropophthera, Trichomonas biari, Trichomonas hominis, Trypansom brucei gambiense, Trypanosoma brucei rhodesiense, Trypanosoma cruzi and Vittaforma corneae. In some embodiments the microbe is a helminth. In some embodiments the helminth is selected from Angiostrongylus costaricensis, Ankylostoma braziliense, Ankylostoma caninum, Ankylostoma ceylanicum, Anclyloasma duodenal, Ascaris lumbricoide, Capillaria philippinensis, Clonorchis sinensis, Dicrocoelium dendriticum, Diphyllobothrium cordatum, Diphyllobothrium dallas, Diphyllobothrium dendriticum, Diphyllobothrium latum, Diphyllobothrium pacificum, Diphyllobothrium ursi, Diphyllobothrium yangonis, Dipylidium caninum, Echinococcus granulosus, Echinostoma ortense, Echinostoma ilocanum, Echinostoma macrorchis, Echinostoma perfoliatum, Echinostoma revolutum, Eradumia vermiformis, European tapeworms, Fasciola hepatica, Fascioloasis buski, Fascioliga gigantica, Hepatores, Hymenolepis diminuta, Hymenolepis nana. Lutra braziliense (Paragonimus spp.), Macarantorhynchus hirudineous, Metastrongylus yokogawai, Moniliformis, Necator americanus, Oesopogostomum bifurcum, Opisthorchis felineus, Opisthorchis viverrini, Paragonimus falciform, Paragonimus hydatigena, Paragonimus marginatus, Paragonimus skrjabini, Paragonimus veucariou, Paragonimus westmanian, Schistosoma haematobium, Schistosoma haematobium, Schistosoma intercalatum, Schistosoma japonicum, Schistosoma japonicum, Schistosoma mansoni, Schistosoma mansoni, Schistosoma mekongi, Strongyloides stercoralis, Taenia saginata, Taenia solium, Toxocara canis, Toxocara cati, Trichinella spiralis, Trichostrongylus axei, Trichostrongylus colubriformis, Trichostrongylus orientalis, Trichuris trichiura and Uncinaria stenocephala. In some embodiments, the microbe is a fungus. In some embodiments, the fungus is selected from Candida sp. Aspergillus sp. Cryptococcus sp., Pneumocystis sp., and Saccharomyces chararum. Exemplary Aspergillus sp. include A. fumigatus and A. flavus. Exemplary Cryptococcus sp. include C. neoformans and C. gattii. Exemplary Pneumocystis sp. include P. jirovecii.

In some embodiments, the anti-microbial additive is selected from the group consisting of an anti-bacterial, anti-bacterial spore, anti-fungal, anti-protozoa, anti-helminth and anti-viral additive. In some embodiments, the anti-microbial additive is an anti-bacterial or anti-viral additive. In some embodiments, the anti-microbial additive is an anti-bacterial or anti-viral additive. In some embodiments, the anti-microbial additive is an anti-fungal additive. In some embodiments, the anti-microbial additive is an anti-protozoa additive. In some embodiments, the anti-microbial additive is an anti-helminthic additive. In some embodiments, the anti-microbial additive is an anti-viral additive.
Many antimicrobial agents are poisonous to microorganisms and, therefore, destroy micro-organisms with which they are contacted. Examples of this type of antimicrobial agent include hypochlorites (bleaches), phenol and compounds thereof, quaternary ammonium compounds and inorganic salts of heavy metals such as silver, copper or tin. Other antimicrobial agents comprise antibiotic type compounds. Antibiotics disrupt the biochemistry within microorganisms, for example by selectively diluting solutions to destroy or inhibit the growth of harmful microorganisms. Another antimicrobial method involves the use of materials such as quaternary ammonium compounds that act as lytic (bursting) agents for the microbial cell.

In some embodiments, the anti-microbial additive comprises an anti-aerosol. In some embodiments, the anti-microbial additive is activated by contact with water.

In some embodiments, administering comprises delivering the anti-microbial additive into water as it is supplied to the toilet bowl during a flush cycle. In some embodiments, delivering further comprises releasing an effective anti-microbial dose of the additive from a refillable reservoir into the pressurized water. In some embodiments, the refillable reservoir contains a plurality of effective anti-microbial doses of the additive.

In some embodiments, calcium hypochlorite can be used as an effective additive against bacteria, algae, slime, fungi and other harmful or objectionable microorganisms. In some embodiments, calcium hypochlorite can be provided in dry powder form into the toilet water, which can at least partially dissolve in water and form a solution of about 1 to 10%, about 1 to 5%, about 1 to 3%, or about 1% by weight. Calcium hypochlorite granules, tablets, or solutions can also be used, for example, continuous chlorination and disinfection.

In some embodiments, calcium hypochlorite may be more advantageous than other hypochlorites. Calcium hypochlorite is commercially available and inexpensive. Once entering the environment, calcium hypochlorite is decomposed (by water with evolution of chlorine gas and heat) more readily than other hypochlorites, and thus, causes less environmental problems over time.

The additive may be solid, liquid, gel, or in concentrated form. The additive may be packaged in unit dose, and multiple doses can be included in a single system. In some embodiments, the additive can be provided in solid form at about 20-100 g (e.g., calcium hypochlorite granulates or powder) per unit dose.

In some embodiments, an effective amount of anti-microbial additive is administered. In some embodiments, an effective anti-microbial dose of the anti-microbial additive is administered. In some embodiments, the effective anti-microbial additive is delivered at about 20-100 g per unit dose. In some embodiments, the effective anti-microbial additive is delivered at about 40-100 g per unit dose. In some embodiments, the effective anti-microbial additive is delivered at about 80 g per unit dose.

In some embodiments, the effective anti-microbial additive is delivered at about 10% of the toilet bowl volume. In some embodiments, the additive is delivered from about 1:2 to about 1:20 dilution. In some embodiments, the additive is delivered from about 1:2 to about 1:15 dilution. In some embodiments, the additive is delivered from about 1:5 to about 1:15 dilution. In some embodiments, the additive is delivered from about 1:5 to about 1:20 dilution. In some embodiments, the additive is delivered from about 1:2 to about 1:15 dilution. In some embodiments, the additive is delivered at about 1:2 dilution. In some embodiments, the additive is delivered at about 1:10 dilution.

The additive can further comprise a binding agent such as one or more of a dissolvable powder, gel and polymer. The additive may also comprise at least one non-ionic, anionic, cationic and/or amphoteric surfactant. When introduced into water, the additive can at least partially dissolve in the water and can be present at about 1 to 10%, about 1 to 5%, about 1 to 3%, or about 1% by weight in the water.

In some embodiments, the additive at least partially dissolves in water. In some embodiments, the additive at least partially dissolves in water and is present at about 1 to 10%, about 1 to 5%, about 1 to 3%, or about 1% by weight in the water. In some embodiments, the additive at least partially dissolves in water and is present at about 1 to 10% by weight in the water. In some embodiments, the additive at least partially dissolves in water and is present at about 1% by weight in the water. In some embodiments, the additive at least partially dissolves in water and is present at about 1% by weight in the water.

In some embodiments, at least a portion of the additive remains in the toilet bowl after the flushing. In some embodiments, the anti-microbial additive is effective for a plurality of days following administration thereof.

The additive can be administered before, during or after the flush to control spread of microbes. In some embodiments, the additive is administered prior to flushing. In some embodiments, the additive is administered during flushing. In some embodiments, the additive is administered after flushing. In some embodiments, it may be advantageous to supply the additive prior to and/or simultaneously with flushing, e.g., to disinfect or decontaminate microbe-containing water, in particular aerosolized water from fecal matter in the toilet. In some embodiments, microbes whose spread can be reduced comprise one or more of bacteria, bacterial spores, and viruses. In some embodiments, the various additives and/or mechanical means described herein are useful in killing spores from the genera Bacillus or Clostridium, and/or killing live or vegetative bacteria. For example, spread of Clostridium difficile spores can be effectively reduced. In some embodiments, the methods further comprise further comprise addition of at least one germinating agent. Representative germinating agents are discussed, for example, in Cadmus, J. et al., “A Sensitive and Selective Culture Medium for Detection of Environmental Clostridium difficile without the Requirement for Anaerobic Culture Conditions,” J. Clin. Microbiol. 2014, doi:10.1128/JCM.00793-14; PloS ONE 2012 7(2): e32381; PloS ONE 2013 8(9): e73653; PloS ONE 2013 9(5): e1003356; each herein incorporated by reference in its entirety. In some embodiments, the germinating agent thiglycollic acid, a bile salt, or a bile acid. Further, the methods of the present invention are also useful against viruses (e.g., norovirus) and antibiotic resistant bacteria such as vancomycin-resistant Enterococcus, carbapenem-resistant Enterobacteriaceae, and methicillin-resistant Staphylococcus aureus.

Agents that increase efficacy of the anti-microbial additive may also be added. For example, acids may be added along with hypochlorites to enhance activity of the hypochlorite. Thus, in some embodiments, at least one agent that increases efficacy of the anti-microbial is added. In some embodiments, the agent comprises an acid. In some embodiments, the agent is added during flushing. In some embodiments, the agent comprises an acid and the anti-microbial comprises a hypochlorite.

Addition of paper, paper products, foams, sprays, and/or gels can be provided to a toilet, for example, after the addition of stool or feces, to form barriers on the surface of the toilet water before flushing. Such barrier-forming materials can be provided together with the additive described herein, or be provided separately (e.g., via a dispenser by user/operat-
The barriers can then be flushed down the toilet while remaining on top of the fecal matter or water.

In some embodiments, the conduit is mounted in fluid communication with a vacuum breaker tube. In some embodiments, the conduit is mounted downstream from the pressurized water supply. In some embodiments, the conduit is mounted in fluid communication with a vacuum breaker tube. In some embodiments, the conduit is mounted downstream from the pressurized water supply. In some embodiments, the conduit is mounted downstream from the pressurized water supply.

In some embodiments, the apparatus comprises a tube that replaces an existing non-pressurized water redirection tube after a toilet flush valve. The tube may comprise a conduit, a receptacle, or reservoir for introducing chemicals, wherein the chemicals mix with the water when the water redirection tube fills with water. In some embodiments, the tube comprises a venturi tube, basket, or external conduit. In some embodiments, the tube replaces a portion of the redirection tube. In some embodiments, the tube is on a tankless toilet.

In some embodiments, the apparatus comprises a plurality of reservoirs. In some embodiments, the apparatus further comprises a mixing valve disposed downstream from the reservoirs.

In some embodiments, the water pressure alone during flushing may be sufficient to mix the additive with the water. In some embodiments, flushing dynamics in the toilet remain about constant. In some embodiments, flushing dynamics comprise volume and pressure of water.

Where desirable (e.g., large quantity of additives or difficult to dissolve additives), electrical, mechanical (e.g., wheel or lever) and/or additive methods may also be used to aid in the mixing or distribution. In some embodiments, modifications in water pressure can also reduce the amount of aerosols formed during flushing. Any of the methods for introducing the additive may also reduce the pressure and therefore have a commensurate reduction in aerosols. In some embodiments, pressure is reduced in the pressurized water supply.

In some embodiments, the apparatus further comprises a second externally-accessible reservoir for disposal in fluid communication with the conduit. In some embodiments, the apparatus further comprises a second externally-accessible reservoir for disposal in fluid communication with the pressurized water supply. In some embodiments, the apparatus further comprises a reservoir for disposal in fluid communication with the pressurized water supply. In some embodiments, the apparatus further comprises a mixing apparatus disposed in fluid communication with the first and second reservoirs. In some embodiments, the mixing apparatus comprises a valve.

In some embodiments, the mixing apparatus comprises a titrating mechanism. In some embodiments, concentration of the anti-microbial additive is titrated to the pressure of the water supply. In some embodiments, concentration is not dependent on changes in volume or pressure from the water supply.

One exemplary embodiment is shown in FIG. 1. A receptacle housing (101) the additive reservoir (102) may contain a window to enable viewing of the amount of additive or a weighing mechanism to measure weight of the additive in the receptacle housing (101). The additive reservoir (102) may be mounted above, below or at the same height of the toilet. The additive may be disposed in a bottle or bag, e.g., a collapsible bag. Thus, the reservoir may comprise, e.g., a bottle, bag, or cartridge. A conduit (103) comprising a first
end in fluid communication with the water supply and a second end attached to and in fluid communication with the additive reservoir (102) routes the additive into the venturi device (105) through the venturi principle. The venturi principle draws solids, liquids and/or gases into the venturi device (105). A valve (104) is used to flush the toilet (106). This embodiment shows an automatic flush system, however it will be appreciated that mechanical flushing mechanisms can also be incorporated.

[0125] FIG. 2 shows an illustrative embodiment of the venturi configuration. The water supply entry (201) may be connected to the plumbing supply or, in a preferred embodiment, is supplied after the flush valve. The water supply entry is connected to a water entry tube (202), in which the pressure is higher than that in the conical divergent tube (207), but the water speed is lower than that in the conical divergent tube (207). Water flow is constricted (203), resulting in changes in pressure and water speed. A cylindrical throat (204) provides for constriction of water thereby changing pressure. A connector (205) between the throat (204) and the conduit (210) allows gas, liquids and/or gels to be pulled into the water supply (201). Water and the additive mix in the upper end of the conical divergent tube (206) and exit (208) to the toilet, wherein the pressure is lower than that in the water entry tube (202), but water speed is higher in the lower end of the conical divergent tube (207). In the lower end conical divergent tube (207) water flow is relieved, resulting in changes in pressure and water speed. The fluid exit (208) is in fluid communication with the conical divergent tube (207). A check valve (209) prevents backflow of supply water into the additive conduit (210).

[0126] FIG. 3 is an illustrative embodiment showing an additive reservoir (301) containing the additive (302) and a cross section of the connection (303) between the additive reservoir (301) and the conduit (304). The connection can be any type of connection that prevents gas, liquid, and/or gel from leaking from the additive reservoir, and may be made of, for example, puncturable material, gaskets, flappers, one way valves, etc. In the embodiment shown, the connection opens a one way valve when the reservoir is fully seated on the connection, allowing the additive to be drawn into the conduit.

[0127] FIG. 4 is an illustrative embodiment showing a cross-section of an additive reservoir (401) and a cross section of a one way valve connection (402) between the additive reservoir (401) and the conduit. A check valve (403) provides for inflow of air into the additive reservoir (401). It will be appreciated that the connection can be any type of connection that prevents gas, liquid, and/or gel from leaking from the additive reservoir, and may be made of, for example, puncturable material, gaskets, flappers, one way valves, etc.

[0128] In some embodiments, the mixing apparatus comprises some, or all of the additive(s) mixing in the toilet flush valve, the vacuum breaker tube, or the clean water supply line. Introducing additive(s) in one, or all three of these three areas results in adequate mixing of the additive(s) prior to being introduced into the toilet bowl. In some embodiments, the mixing results in remnants of the additive(s) in the bowl sufficient to begin killing microbes prior to the flush. In some embodiments, the additive comprises one anti-microbial. In some embodiments, the additive comprises a plurality of anti-microbials.

[0129] In some preferred embodiments, the mixing apparatus comprises some, or all of the chemical mixing in the vacuum breaker tube. The chemical mixing occurs downstream or distal to the flush valve but prior to the bowl of the toilet. This ensures that mixing takes place before the chemicals reach the effluent in the toilet. In some embodiments, the entire tube downstream or distal to the flush valve mechanism and before the toilet is replaced. In some embodiments, this entire tube contains the apparatus. In some embodiments, the tube contains a portion of the apparatus that interfaces with a chemical supply container.

[0130] In some preferred embodiments, the apparatus replaces the entire vacuum breaker tube. This is a relatively easy replacement as there is no water in the vacuum breaker tube, the vacuum breaker tube is easily removed by unscrewing of two nuts connecting the vacuum breaker tube to the flush valve at one end and the toilet bowl at the other, and the vacuum breaker tube is intended to be cut to accommodate variable lengths of plumbing configurations between the supply line located in the wall and the rim of the toilet.

[0131] In tanked toilets, the water device is fitted between the water supply line located on the wall and the toilet tank. The additive can be introduced prior to the tank and the additive supply conduit can sit on the ground, above the tank, or attach to the side of the tank.

[0132] One exemplary embodiment is shown in FIG. 5A and FIG. 5B. The vacuum breaker tube (501) directs water from the valve (503) into the toilet (504). Inside the vacuum breaker tube (501) there is an additive reservoir (502). The additive reservoir (502) allows for solid additive to be added and get trapped in the additive reservoir. When the toilet is flushed, the water passes through the holes (513) in the additive reservoir (512) mixing with additive contained in the additive reservoir.

[0133] Another exemplary embodiment is shown in FIG. 6A and FIG. 6B. The vacuum breaker tube (601) directs water from the valve (603) into the toilet (604). Inside the vacuum breaker tube (601) there is an additive reservoir (602) containing a plurality of doses of additive. The flushing of the toilet (604) results in revolution of the additive reservoir (602). Each revolution results in the introduction of a new supply of additive into the vacuum breaker tube (601). The additive reservoir (612) contains one, or a plurality doses of additive contained in each of the cylinders (613). The flushing of the toilet revolves the cylinders (613) into the vacuum breaker tube (601) which replenishes the supply of additive into the toilet (604).

[0134] Another exemplary embodiment is shown in FIG. 7A and FIG. 7B. The vacuum breaker tube (701) directs water from the valve (705) into the toilet (706). Inside the vacuum breaker tube (701) there is a valve (704) that opens when the toilet (706) is flushed. The valve (704) is connected via conduit (702) to an additive reservoir (703). The flushing of the toilet (706) results in the opening of the valve (714) via an interacting line (715) to the valve (705) mechanism. The interacting line (715) opens a valve (714) allowing additive to flow from the additive reservoir (713) through the conduit (712) and into the vacuum breaker tube (701).

[0135] Other variants, modifications and improvements of the above designs are also within the scope of the present invention.

[0136] As will be apparent to one of ordinary skill in the art from a reading of this disclosure, further embodiments of the present invention can be presented in forms other than those specifically disclosed herein. The particular embodiments described are, therefore, to be considered as illustrative and
not restrictive. Those skilled in the art will recognize, or be able to ascertain, using no more than routine experimentation, numerous equivalents to the specific embodiments described herein. Although the invention has been described and illustrated in the illustrative embodiments, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the details of implementation of the invention can be made without departing from the spirit and scope of the invention, which is limited only by the claims that follow. Features of the disclosed embodiments can be combined and rearranged in various ways within the scope and spirit of the invention. It will be recognized that one or more features of any embodiments disclosed herein may be combined and/or rearranged within the scope of the invention to produce further embodiments that are also within the scope of the invention. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. Such equivalents are also intended to be within the scope of the present invention. The scope of the invention is as set forth in the appended claims and equivalents thereof, rather than being limited to the examples contained herein.

EXAMPLES

[0137] The examples provided below facilitate a more complete understanding of the invention. The following examples illustrate exemplary modes of making and practicing the invention. However, the scope of the invention is not limited to specific embodiments disclosed in such examples, which are illustrative only, since alternative methods can be utilized to obtain similar results.

[0138] General Experimental Set-Up:

[0139] Flushing experiments were performed using a commercial toilet and a Sloan 111 Flushometer. Water was pressurized using a pressurized water tank. In the majority of experiments, the toilet was flushed when the water pressure reached 80 PSI. Experiments either consisted of adding 500 mL of water with live Bacillus bacteria or with Bacillus spores. Petri plates were taped to a board and inverted over the toilet. The toilet flushed, and the plates were incubated at 37°C. After 24 hours, the colonies counted on the plates. Colonies appeared yellow due to mannitol fermentation, and colonies that were not yellow in appearance were not covered. Controls consisted of flushing the toilets with the added bacteria.

[0140] Water is supplied to a tank that pressurizes the water. The water pressure is monitored with a pressure gauge and when the pressure reaches an acceptable pressure the toilet is flushed. The toilet is flushed using a Sloan 111 Flushometer (http://www.sloanvalve.com/Customer_Care/Technical_Downloads.aspx). Spores are added directly into the toilet prior to flushing. Petri plates are placed on a board and inverted above the toilet and left for a period of time (2 minutes is acceptable). The tops are placed on the plates and then incubated. Colonies are counted and enumerated. The number of colonies indicates the number of aerosolized spores released from the toilet. Other methods for counting spores include aerosol counters, quantitative PCR, microbial air sampling, video and radiographic methods.

[0141] All levels of significance were compared using NCSS (Hintze, J. (2013). NCSS 9. NCSS, LLC. Kaysville, Utah, USA. www.ncss.com). Comparisons were made using a Wilcoxon Rank Sum Test for differences in location. Comparisons made were looking for mean differences using a two-sample, corrected test. Accepted differences were determined if the p-value was <0.05. Some comparisons were made using a two-sample t-test in Excel.

[0142] In all the experiments, the device means the device as shown in FIGS. 1-4. The device relies on the venturi principle and draws chemicals into the toilet when it is flushed using the suction created by the water flowing through the flushometer and into the toilet.

Example 1

Flow Rate and Flush Time Measurements with the Device Shown in FIGS. 1-4 (See FIG. 8 for Results)

[0143] The water flow rate to the toilet during a flush cycle was measured over time both with and without the device (shown in FIGS. 1-4). The volume of water that went through the supply line during the flush when the device (shown in FIGS. 1-4) was used was 2.46, 2.44 and 2.36 gallons. The average volume of water that went through the supply line when the device (shown in FIGS. 1-4) was not used was 2.38 gallons, and the flow rate vs. time curves were identical. Therefore, the device did not alter the amount of water used during flushing or the flow rate vs. time profile, and therefore flushing performance is not affected when the device (shown in FIGS. 1-4) is attached.

Example 2

Device (Shown in FIGS. 1-4) Flushing with Bleach

[0144] Experimental set-up: This experiment consisted of adding Bacillus subtilis spores at a concentration of 10^4 spores per flush prior to flushing the toilet. The spores would sit in the toilet water for a total of 2 minutes, which was pretreated with chemicals. After 2 minutes of incubation, the toilet was flushed. Two minutes was estimated to be the amount of time a person would relieve their bowels prior to the toilet being flushed. Using the device (shown in FIGS. 1-4) chemicals were introduced into the toilet during flushing in addition to the chemicals remaining in the bowl from the previous flush. Plates were placed directly above the toilet and colonies counted after incubation. Three flushes were used without chemicals as a blank and compared to the subsequent flushes which included chemicals. The experiment was repeated twice.

[0145] Results: Using two-sided Wilcoxon Ranks-Sum Tests were compared to each other. There was a significant reduction in colonies when comparing the first flush with blanks to the first flush with bleach. Bleach resulted in a significant reduction of viable spores aerosolized from the toilet. The second time the experiment was performed, the results were not significant. This may be due to residual chemicals in the toilets that reduced the numbers of spores ejected in the second no-chemical control flush.

[0146] Water Control Versus Bleach Using Device (Shown in FIGS. 1-4)—First Flush

[0147] First flush comparing no-chemical added to sodium hypochlorite (bleach). This resulted in a mean reduction in the number of bacterial colonies that grew when chemical was added (see FIG. 9 and results (Table 1). Using a Wilcoxon Rank-Sum Test and looking for two-tailed differences the results were significant (two-tailed p-value=0.000001).
TABLE 1

Mann-Whitney U or Wilcoxon Rank-Sum Test for Difference in Location

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mann Whitney U</th>
<th>W Sum Ranks</th>
<th>Mean of W</th>
<th>Std Dev of W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additive = Blank 1</td>
<td>8187.5</td>
<td>12282.5</td>
<td>9360</td>
<td>427.0208</td>
</tr>
<tr>
<td>Additive = Bleach 1</td>
<td>2342.5</td>
<td>9245.5</td>
<td>12168</td>
<td>427.0208</td>
</tr>
</tbody>
</table>

Number of Sets of Ties = 42, Multiplicity Factor = 8418

<table>
<thead>
<tr>
<th>Alternative Hypothesis</th>
<th>Reject HO (α = 0.05)</th>
<th>Z-Value</th>
<th>Reject HO (α = 0.050)</th>
<th>Z-Value</th>
<th>Reject HO (α = 0.050)</th>
<th>Z-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff ≠ 0</td>
<td>6.8439</td>
<td>0.000001</td>
<td>Yes</td>
<td>6.8428</td>
<td>0.000001</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Exact probabilities are given only when there are no ties and the sample sizes in both groups are ≥20.

[0148] Water Control Versus Bleach Using Device (Shown in FIGS. 1-4).—Second Flush

[0149] Second flush comparing no-chemical added to sodium hypochlorite (bleach). This result was not significant from the control (see FIG. 10) and results (Table 2) (two-tailed, p-value=0.909150). Blank 2 is the second flush without bleach and with spores. This is compared to the next flush with bleach and spores added. The lack of difference here may be a reflection of residual bleach killing spores in the toilet and, thus, a reduction in the total number of spores ejected from the toilet during the flushing of the blank.

TABLE 2

Mann-Whitney U or Wilcoxon Rank-Sum Test for Difference in Location

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mann Whitney U</th>
<th>W Sum Ranks</th>
<th>Mean of W</th>
<th>Std Dev of W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additive = Blank 2</td>
<td>5360.5</td>
<td>9355.5</td>
<td>9405</td>
<td>429.4078</td>
</tr>
<tr>
<td>Additive = Bleach 2</td>
<td>5359.5</td>
<td>12380.5</td>
<td>12331</td>
<td>429.4078</td>
</tr>
</tbody>
</table>

Number of Sets of Ties = 33, Multiplicity Factor = 27924

<table>
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<tr>
<th>Alternative Hypothesis</th>
<th>Reject HO (α = 0.05)</th>
<th>Z-Value</th>
<th>Reject HO (α = 0.050)</th>
<th>Z-Value</th>
<th>Reject HO (α = 0.050)</th>
<th>Z-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff ≠ 0</td>
<td>0.1153</td>
<td>0.908227</td>
<td>No</td>
<td>-0.1141</td>
<td>0.909150</td>
<td>No</td>
</tr>
</tbody>
</table>

*Exact probabilities are given only when there are no ties and the sample sizes in both groups are ≥20.

[0150] Water control flush 1 versus water control flush 2 using device (shown in FIGS. 1-4).

[0151] When comparing the two controls, it was clear that there was a reduction in the number of spores released in the second set of flushes which may be a consequence of residual bleach in the second flush (see FIG. 11 and Table 3). Blank 1 refers to the flush with spores and no chemicals and blank 2 refers to the second flush with spores and no chemicals. Blank 2 was followed by the addition of bleach. The controls were significantly different from each other (two-tailed, p-value<0.000001).

TABLE 3

Mann-Whitney U or Wilcoxon Rank-Sum Test for Difference in Location

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mann Whitney U</th>
<th>W Sum Ranks</th>
<th>Mean of W</th>
<th>Std Dev of W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additive = Blank 1</td>
<td>6232.8</td>
<td>10423</td>
<td>8145</td>
<td>349.3433</td>
</tr>
<tr>
<td>Additive = Blank 2</td>
<td>1772</td>
<td>5867</td>
<td>8145</td>
<td>349.3433</td>
</tr>
</tbody>
</table>

Number of Sets of Ties = 37, Multiplicity Factor = 6420
TABLE 3-continued

<table>
<thead>
<tr>
<th>Alternative Hypothesis</th>
<th>Reject HO (α = 0.050)</th>
<th>Approx. Without Correction</th>
<th>Approx. With Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff ≠ 0</td>
<td>6.5208</td>
<td>0.000001</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Exact probabilities are given only when there are no ties and the sample sizes in both groups are ≥20.

[0152] Conclusions: The device (shown in FIGS. 1-4) reduces the number of bacterial spores that grow on the plates after flushing. Residual chemicals may reside in the toilet that provides additional benefits even after the toilet has been cleaned.

Example 3

Device (Shown in FIGS. 1-4) Flushing with Bleach

[0153] Experimental set-up: This experiment consisted of adding $10^{11}$ *Bacillus subtilis* spores in to the toilet bowl prior to flushing the toilet. The spores remain in the toilet water, which was pretreated with chemicals for a total of 2 minutes. After 2 minutes, the toilet was flushed. Two minutes was estimated to be the amount of time a person would relieve their bowels prior to the toilet being flushed. Using the device (shown in FIGS. 1-4) chemicals were introduced into the toilet during flushing. Chemicals consisted of 8.25% bleach or 150 g of corn starch dissolved in a total volume of 1000 mL of water. The volume of chemicals tested consisted of 400 mL and 100 mL for each flush. Plates were placed directly above the toilet and colonies counted after incubation. Each volume was tested in triplicate and compared to controls that preceded the flushes of each chemical.

[0154] Results: Using a Wilcoxon Sum Rank Sum Test the following statistical analyses were performed:

[0155] a. Water blank with spores versus 400 mL of bleach* (FIG. 12)

[0156] b. Water blank with spores versus 100 mL of bleach (FIG. 13)

[0157] c. Water blank with spores versus 100 mL of starch (FIG. 14)

[0158] d. Water blank with spores versus 400 mL of starch* (FIG. 15)

The addition of 400 mL of bleach resulted in significant reductions in viable spores aerosolized from the toilet as denoted by the '*' above.

[0159] 400 mL of bleach versus water blank using device (shown in FIGS. 1-4): The 400 mL of bleach versus water blank showed a significant reduction in germinating spores. This result was significant from the control (see FIG. 12) and results (Table 4) (two-tailed, $p$-value=0.000011).

TABLE 4

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mann Whitney U</th>
<th>W Sum Ranks</th>
<th>Mean of W</th>
<th>Std Dev of W</th>
</tr>
</thead>
<tbody>
<tr>
<td>1S = Bleach 400 mL</td>
<td>2519.5</td>
<td>6614.5</td>
<td>8145</td>
<td>347,5047</td>
</tr>
<tr>
<td>1S = Water blank</td>
<td>5580.5</td>
<td>9675.5</td>
<td>8145</td>
<td>347,5047</td>
</tr>
</tbody>
</table>

Number Sets of Ties = 29, Multiplicity Factor = 67566

<table>
<thead>
<tr>
<th>Alternative Hypothesis</th>
<th>Reject HO (α = 0.050)</th>
<th>Approx. Without Correction</th>
<th>Approx. With Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff ≠ 0</td>
<td>-4.4043</td>
<td>0.000011</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Exact probabilities are given only when there are no ties and the sample sizes in both groups are ≥20.

[0160] 100 mL of bleach versus water blank using device (shown in FIGS. 1-4): 100 mL of bleach versus water blank was not significant in showing a reduction in germinating spores. This result was not significant from the control (see FIG. 13) and results (Table 5) (two-tailed, $p$-value=0.060511). However, the results demonstrate a reduction in viable spores being aerosolized from the toilet after flushing.
TABLE 5
Mann-Whitney U or Wilcoxon Rank-Sum Test for Difference in Location

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mann Whitney U</th>
<th>W Sum Ranks</th>
<th>Mean of W</th>
<th>Std Dev of W</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS = Bleach 100 mL</td>
<td>3396</td>
<td>7491</td>
<td>8145</td>
<td>348,1517</td>
</tr>
<tr>
<td>IS = Water blank 1</td>
<td>4704</td>
<td>8799</td>
<td>8145</td>
<td>348,1517</td>
</tr>
</tbody>
</table>

Number of Sets of Ties = 29, Multiplicity Factor = 46080

<table>
<thead>
<tr>
<th>Alternative Hypothesis</th>
<th>Exact Probability*</th>
<th>Approx. Without Correction</th>
<th>Approx. With Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reject</td>
<td>Z-Value Level</td>
<td>Reject</td>
</tr>
<tr>
<td>Diff ≠ 0</td>
<td>-1.8785</td>
<td>0.060511</td>
<td>No</td>
</tr>
</tbody>
</table>

*Exact probabilities are given only when there are no ties and the sample sizes in both groups are ≥20.

[0161] 100 mL of starch versus water blank using device (shown in FIGS. 1-4): 100 mL of starch versus water blank was not significant in showing a reduction in spores. This result was not significant from the control (see FIG. 14) and results (Table 6) (two-tailed, p-value=0.050993). However, the results demonstrate a reduction in viable spores being aerosolized from the toilet after flushing.

TABLE 6
Mann-Whitney U or Wilcoxon Rank-Sum Test for Difference in Location

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mann Whitney U</th>
<th>W Sum Ranks</th>
<th>Mean of W</th>
<th>Std Dev of W</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS = Starch 100 mL</td>
<td>3367.5</td>
<td>7462.5</td>
<td>8145</td>
<td>349,468</td>
</tr>
<tr>
<td>IS = Water blank 2</td>
<td>4732.5</td>
<td>8827.5</td>
<td>8145</td>
<td>349,468</td>
</tr>
</tbody>
</table>

Number of Sets of Ties = 44, Multiplicity Factor = 2250

<table>
<thead>
<tr>
<th>Alternative Hypothesis</th>
<th>Exact Probability*</th>
<th>Approx. Without Correction</th>
<th>Approx. With Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reject</td>
<td>Z-Value Level</td>
<td>Reject</td>
</tr>
<tr>
<td>Diff ≠ 0</td>
<td>-1.9530</td>
<td>0.050823</td>
<td>No</td>
</tr>
</tbody>
</table>

*Exact probabilities are given only when there are no ties and the sample sizes in both groups are ≥20.

[0162] 400 mL of starch versus water blank using device (shown in FIG. 1-4): The 400 mL of starch versus water blank showed no significant reduction in spores. This result was not significant from the control (see FIG. 15) and results (Table 7) (two-tailed, p-value<0.770388).

TABLE 7
Mann-Whitney U or Wilcoxon Rank-Sum Test for Difference in Location

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mann Whitney U</th>
<th>W Sum Ranks</th>
<th>Mean of W</th>
<th>Std Dev of W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical = Starch 400 mL</td>
<td>3947.5</td>
<td>8042.5</td>
<td>8145</td>
<td>349,4745</td>
</tr>
<tr>
<td>Chemical = Water blank 2</td>
<td>4152.5</td>
<td>8247.5</td>
<td>8145</td>
<td>349,4745</td>
</tr>
</tbody>
</table>

Number of Sets of Ties = 41, Multiplicity Factor = 2034

<table>
<thead>
<tr>
<th>Alternative Hypothesis</th>
<th>Exact Probability*</th>
<th>Approx. Without Correction</th>
<th>Approx. With Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reject</td>
<td>Z-Value Level</td>
<td>Reject</td>
</tr>
<tr>
<td>Diff ≠ 0</td>
<td>-0.2993</td>
<td>0.769295</td>
<td>No</td>
</tr>
</tbody>
</table>

*Exact probabilities are given only when there are no ties and the sample sizes in both groups are ≥20.
Conclusion: Bleach reduced the number of bacterial spores aerosolized from toilets. Starch at 100 mL showed a small reduction in the aerosolization of spores from toilets.

Example 4

Evaluation of Chemicals Versus Particle Sizes Using the Device (FIGS. 1-4)

Experimental set-up: The experiment consisted of adding different chemicals to toilets using the device (FIGS. 1-4) and then measuring aerosols generated after the first 20 seconds of flushing. For particle measurements, a Laskair III Particle Counter from Particle Measuring System was used. The particle counter measures particles sized less than 0.3, 0.5, 1.0, 5.0, 10.0 and 25.0 μm. The purpose of these experiments is to demonstrate that aerosols released from a toilet and may be found above the seat and on the floor surrounding the toilet. In addition, 3-5 μm beads were placed into the toilet. These beads should change the size ranges detected from the particle counter above the 3 μm range, but not below. Two sample, paired-tests were used comparing the aerosol sizes before and after flushing.

Results: Table 8 represents the fold increase of aerosol sizes compared with no flushing. Results with statistically different results are indicated with an asterisk (*).

<table>
<thead>
<tr>
<th>Sizes</th>
<th>Floor versus blank</th>
<th>Seat versus blank</th>
<th>Seat with beads versus blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>1.00, 0.0003</td>
<td>1.01, 0.313</td>
<td>1.00, 0.929</td>
</tr>
<tr>
<td>0.5</td>
<td>1.07, 0.1333</td>
<td>1.07, 0.044*</td>
<td>1.03, 0.178</td>
</tr>
<tr>
<td>1.0</td>
<td>1.23, 0.1560</td>
<td>1.29, 0.007*</td>
<td>1.17, 0.022*</td>
</tr>
<tr>
<td>5.0</td>
<td>1.79, 0.1326</td>
<td>1.53, 0.004*</td>
<td>1.74, 0.004*</td>
</tr>
<tr>
<td>10.0</td>
<td>1.28, 0.2208</td>
<td>1.28, 0.005*</td>
<td>2.37, 0.001*</td>
</tr>
<tr>
<td>25.0</td>
<td>2.42, 0.4612</td>
<td>1.51, 0.313</td>
<td>2.82, 0.015*</td>
</tr>
</tbody>
</table>

Conclusions: There was a significant increase in aerosols detected on the seat versus on the floor. The increase seen on the seat is statistically different for the 0.5-10 μm particle sizes. The addition of beads results in significant increases in the 1-25 μm ranges and results in an almost 3 fold increase in particles above 25 μm in size.

Example 6

Concentration and Time Dependence on Viable Spore Recovery

Experimental set-up: Bacteria were added to the toilet and then flushed. The time that plates were suspended above the toilet was set at 20 minutes or 5 minutes. The concentration of spores from *B. subtilis* used was 10^11 or 10^12. The number of colonies that grew on Petri plate after flushing was compared.

Results: FIG. 21 represents the number of colonies seen for three flushes. The x20_min represents the plates sitting above the toilet inverted for 20 minutes after a flush, the x5_min represents the plates sitting above the toilet inverted for 5 minutes, and the X10x_20 min represents the first flush using 10 times as many spores. There is no significant difference leaving the plates inverted for 20 minutes versus 5 minutes (Wilcoxon Rank-Sum Test, p-value=0.544). Using ten times as many spores was statistically significant from 20 minutes and 5 minutes (Wilcoxon Rank-Sum Test, p-value=0.00001).

Conclusions: The time that the plates are inverted and directly facing the toilet bowl is less important than spore concentration in the toilet. The number of colonies from aerosolized spores may be significantly changed by using higher spore concentrations.
Example 7

1:2 and 1:10 Dilutions of Bleach, Peroxide, Canola Oil and Olive Oil

Experimental set-up: $10^{11}$ spores were added directly to the toilet and either 500 mL of water, 50 mL of chemicals and 450 mL of water, or 250 mL of chemical and 250 mL of water was added to the bowl. The chemical and spores would sit in the toilet for 10 minutes and then the toilet flushed. Petri plates would remain on the top of the toilet for 2 minutes and then the total number of colonies on the plates would be counted. Chemicals tested were sodium hypochlorite (8.5%), 3% hydrogen peroxide, grocery store olive oil and canola oil.

Results: The results (FIG. 22) demonstrate the reduction in aerosol spore germination of a 1:10 dilution of bleach versus blank. The result is significant using a Wilcoxon Rank-Sum Test (p-value=0.000598). The addition of bleach resulted in a 0.5 log reduction in spore formation.

The results (FIG. 23) demonstrate the reduction in aerosol spore germination of a 1:2 dilution of bleach versus blank. The result is significant using a Wilcoxon Rank-Sum Test (p-value=0.002306). The addition of bleach resulted in a 2.1 log reduction in spore formation.

The results (FIG. 24) demonstrate the reduction in aerosol spore germination of a 1:10 dilution of hydrogen peroxide versus blank. The result is significant using a Wilcoxon Rank-Sum Test (p-value=0.000002). The addition of peroxide resulted in a 0.6 log reduction in spore formation.

The results (FIG. 25) demonstrate the reduction in aerosol spore germination of a 1:2 dilution of hydrogen peroxide versus blank. The result is not significant using a Wilcoxon Rank-Sum Test (p-value=0.594058). The addition of peroxide resulted in a 0.1 log reduction in spore formation.

The results (FIG. 26) demonstrate the reduction in aerosol spore germination of a 1:10 dilution of canola oil versus blank. The result is significant using a Wilcoxon Rank-Sum Test (p-value=0.000000). The addition of olive oil resulted in a 0.4 log reduction in spore formation.

The results (FIG. 27) demonstrate the reduction in aerosol spore germination of a 1:2 dilution of canola oil versus blank. The result is significant using a Wilcoxon Rank-Sum Test (p-value=0.000003). The addition of olive oil resulted in a 0.4 log reduction in spore formation.

The results (FIG. 28) demonstrate the reduction in aerosol spore germination of a 1:10 dilution of olive oil versus blank. The result is not significant using a Wilcoxon Rank-Sum Test (p-value=0.937482). The addition of canola oil resulted in a 0.0 log reduction in spore formation.

The results (FIG. 29) demonstrate the reduction in aerosol spore germination of a 1:2 dilution of olive oil versus blank. The result is not significant using a Wilcoxon Rank-Sum Test (p-value=0.820151). The addition of canola oil resulted in a 0.0 log reduction in spore formation.

Conclusions: Canola oil, sodium hypochlorite and hydrogen peroxide all demonstrated the ability to reduce aerosol spore germination. Olive oil did not provide any benefit in reducing aerosols containing spores.

Example 8

Reduction in Aerosolized Spores with Bleach

Experimental set-up: $10^{11}$ Bacillus subtilis spores were deposited into the toilet bowl and then 160 mL of 8.25% sodium hypochlorite (bleach) was added directly to the toilet bowl. After 10 minutes of incubation, the toilet was flushed. Petri plates were placed upside down over the toilet bowl prior to the flush and stayed unmoist for 20 minutes after the flush. The plates were then incubated at 20 minutes and colonies counted.

Results: The results (FIG. 30) demonstrate that adding bleach directly to the bowl results in a significant reduction in the number of spores recovered from the air after flushing. The results demonstrate a 3 fold reduction in spore formation which is statistically significant (Wilcoxon Rank-Sum Test, p-value=0.002321).

Conclusions: The addition of as little as 160 mL of bleach reduces the number of aerosolized spores.

Spore Ejection from Toilets as a Function of Height

Experimental set-up: $10^{11}$ spores were placed in a toilet and flushed. Plates were placed over the toilet and the number of colonies that subsequently grew was counted. The distance from the height of the rim of the toilet varied from right at the height of the toilet (height=0) to 30 cm above the toilet. The x and y coordinates of each colony was accessed allowing for the generation of a three-dimensional map at each height.

Results: Shown in FIGS. 31-36 are the number of colonies which grew (larger circles represent more colonies) as a function of height: 0 cm (FIG. 31), 5 cm (FIG. 32), 10 cm (FIG. 33), 20 cm (FIG. 34), 30 cm (FIG. 35). FIG. 36 represents a composite of all heights combined. The left of each figure (FIGS. 31A-36A) represents the control without spores added and the right (FIGS. 31B-36B) the flush with spores. Each spore flush was repeated five times and compared to the first flush of the day that did not contain spores.

Conclusions: Bacteria may be ejected from toilets and quantitatively measured. Bacterial spores may be found as far away as 30 cm from the rim of the toilet.

1. A method of reducing a spread of microbes from a toilet comprising:
   (a) providing a pressurized water supply to a toilet bowl;
   (b) providing an externally accessible reservoir containing an anti-microbial additive;
   (c) providing a conduit comprising a first end in fluid communication with the pressurized water supply and a second end in fluid communication with the externally accessible reservoir; and
   (d) administering the anti-microbial additive into the toilet bowl, through the conduit;
   wherein the spread of microbes into an environment proximal to the toilet is reduced.

2. The method of claim 1, wherein the anti-microbial additive comprises an anti-aerosol.

3. The method of claim 1, wherein flushing dynamics in the toilet remain constant.

4. The method of claim 1, further comprising introduction of an anti-odor agent into the toilet.

5. The method of claim 1, wherein the pressurized water supply comprises a vacuum breaker tube, flushometer, a valve, or water inlet.
7. The method of claim 1, wherein the first end of the conduit is disposed in fluid communication with a venturi tube.
8. The method of claim 1, wherein aerosolized microbes are reduced.
9. The method of claim 1, wherein spores are killed.
10. The method of claim 1, further comprising supplying at least one oil, sheet, foam, spray or gel into the toilet bowl water, wherein spread of aerosolized microbes is reduced.
11. The method of claim 1, wherein the toilet bowl contains an inoculum and the method further comprises reducing infectivity of said inoculum.
12. The method of claim 1, further comprising reducing pressure in the pressurized water supply.
13. The method of claim 1, further comprising administering at least one anti-odor agent, starch or dye.
14. The method of claim 1, wherein the toilet is selected from the group consisting of a tanked toilet, tankless toilet or urinal.
15. A method of introducing an additive into a toilet comprising:
   (a) providing a pressurized water supply to a toilet bowl;
   (b) providing an externally accessible reservoir containing an anti-microbial additive;
   (c) providing a conduit comprising a first end in fluid communication with the pressurized water supply and a second end in fluid communication with the externally accessible reservoir; and
   (d) administering the anti-microbial additive to the water at the level of the water supply when the toilet is flushed; wherein microbes are killed prior to the flush.
16. The method of claim 15, wherein the anti-microbial additive comprises an anti-aerosol.
17. The method of claim 15, wherein flushing dynamics in the toilet remain about constant.
18. The method of claim 17, wherein the flushing dynamics comprise volume and pressure of water.
19. The method of claim 15, wherein the pressurized water supply comprises a vacuum breaker tube, flushometer, a valve, or water inlet.
20. The method of claim 15, wherein the first end of the conduit is disposed in fluid communication with a venturi tube.
21. The method of claim 15, wherein the anti-microbial additive is activated by contact with water.
22. The method of claim 15, wherein the administering comprises delivering the anti-microbial additive into water as it is supplied to the toilet bowl during a flush cycle.
23. An apparatus for reducing spread of microbes from a toilet comprising:
   (a) an externally accessible reservoir; and
   (b) a conduit comprising a first end for disposal in fluid communication with a pressurized water supply and a second end for disposal in fluid communication with the externally accessible reservoir;
   wherein the reservoir is configured to contain an effective amount of anti-microbial additive to be added to the toilet, through the conduit.
24. The apparatus of claim 23, wherein the conduit is mounted downstream from the water supply.
25. The apparatus of claim 23, comprising a plurality of reservoirs.
26. The apparatus of claim 25, further comprising a mixing valve disposed in the conduit.
27. The apparatus of claim 23, wherein the pressurized water supply comprises a vacuum breaker tube, flushometer, a valve, or water inlet.
28. The apparatus of claim 23, wherein the first end of the conduit is disposed in fluid communication with a venturi tube.
29. The apparatus of claim 23, wherein the reservoir is refillable.
30. A method of reducing spread of microbes from a toilet comprising:
   (a) providing a venturi water supply to a toilet bowl;
   (b) providing a housing;
   (c) providing an externally accessible reservoir disposed within the housing and containing an anti-microbial additive;
   (d) providing a conduit comprising a first end in fluid communication with a venturi water supply and a second end in fluid communication with the externally accessible reservoir;
   (e) administering the anti-microbial additive into the venturi through the conduit, wherein the spread of microbes into an environment proximal to the toilet is reduced.

* * * * *