EFFECT OF VARIOUS DISINFECTION METHODS ON THE INACTIVATION OF CRYPTOSPORIDIUM pdf

1: Effectiveness on Pathogens | The Safe Water System | CDC

Effect of Various Disinfection Methods on the Inactivation of Cryptosporidium. Effects of Chlorite and Chlorate Effect of Various Disinfection Methods on the.

The system generates sufficient voltage potential at the anode to attract and damage the outer shell of the C. The system may also include programmable-logic-controller structure and feedback probe strcuture to enable the system to self-regulate. Provisional Patent Application Ser. The method and system of the invention may be thought of generally by the above title. It may also include the method specifically described below. In addition, it may be used to degrade and kill other viruses on the so-called CCL list. Development of innovative unit processes, particularly for small systems, for removal of contaminants such as arsenic, perchlorate, aluminum and pesticides, and pathogens such as Cryptosporidium and cyst-like organisms and emerging pathogens like caliciviruses, microsporidia, echoviruses, coxsackieviruses, adenoviruses, and others on the Drinking Water Contaminant Candidate List. Alternatives to chlorine disinfection for removing pathogenic microorganisms, including innovative applications of ultraviolet radiation and processes that improve overall effectiveness while using reduced amounts of disinfectant. Development of efficient, cost-effective treatment processes for removing disinfection by-product precursors and innovative methods that minimize their formation. System of the Invention The invention includes an electrolytic cell and control system which could serve either as a stand-alone product or as a subsystem of a small-water-supply-system i. The electrolytic system offers these advantages: The electrolytic process will use voltage and oxidation to be bactericidal. The electrolyzed water will not be toxic or irritating to humans. The electrolytic system will be inexpensive to own and operate. The electrolytic system will not require attention from personnel except during monthly maintenance. The electrolytic system will be able to operate successfully in remote field conditions and other non-traditional settings. The water exiting the system will provide better than 2-log degradation of the viability in C. No product available today can offer all these advantages to surface-water treatment systems. It has been known since but it was not formally recognized as a pathogen until when waterborne disease outbreaks of treated water from a conventional water treatment plant occurred. The disease Cryptosporidiosis is now recognized as a frequent cause of waterborne disease in humans. Cryptosporidiosis from surface water supplies has been documented in the United States, Canada, Great Britain, Australia and elsewhere1,2,3,4,5. Of the four species of Cryptosporidium recognized two are related to mammals, C. The illness Cryptosporidiosis in humans is related to C. The oocysts defined as a stage in the development of any sporozoan in which after fertilization a zygote is produced that develops about itself an enclosing cyst wall; zygote is the developing ovum , once ingested and reaching the small intestine, split open releasing sporozoites7. The oocyst occurs in two forms, one with a thin wall which is autoinfective within the host and is not believed to survive outside the host, and one with a thick wall which is capable of surviving for several weeks in the environment and is the main means for transmission of the parasite8. Incubation varies between days and symptoms are diarrhea, abdominal cramps, nausea, occasional vomiting, and low fever. The disease is more serious for the sensitive population infants, cancer patients and can be fatal for the immuno-suppressed and the sensitive population. The infective dose is not easily determined but it may vary between 10 and 50 oocysts. Presence of Giardia and Cryptosporidium in surface waters and effluents in Israel. Handbook of Drinking Water Quality. The Origins of the Problem Since the s water suppliers and regulators have learned that there are specific microbial pathogens, such as Cryptosporidium, that are resistant to traditional disinfection practices. In , Cryptosporidium caused , people in Milwaukee to experience intestinal illness. More than 4, were hospitalized, and at least 50 deaths have been attributed to the disease. There have also been cryptosporidiosis outbreaks in Nev. Both of these regulations amend the existing Surface Water Treatment Rule to strengthen microbial protection, including provisions specifically to address Cryptosporidium, and to address risk trade-offs with disinfection byproducts. The final rule includes treatment

requirements for waterborne pathogens, e. In addition, systems must continue to meet existing requirements for Giardia lamblia and viruses. Specifically, the rules include: Maximum contaminant level goal MCLG of zero for Cryptosporidium 2-log Cryptosporidium removal requirements for small systems that use surface water or groundwater under the direct influence of surface water Strengthened combined filter effluent turbidity performance standards Individual filter turbidity monitoring provisions Disinfection profiling and benchmarking provisions Systems using ground water under the direct influence of surface water now subject to the new rules dealing with Cryptosporidium Inclusion of Cryptosporidium in the watershed control requirements for unfiltered public water systems Requirements for covers on new finished water reservoirs Sanitary surveys, conducted by States, for all surface water systems regardless of size Current technologies that address these pathogens can be costly both in capital and operating costs, and typically require large areas and man hours to function. The conventional technology of water chlorination has been shown to be largely ineffective on Cryptosporidium. The revised drinking water rules evaluate CT concentration of disinfectant multiplied by time of contact for viruses and other pathogens but may underestimate the time needed for chlorination to have the desired kill effect i. CT requirements are too low. Haloacetic Acids HAAs , previously unregulated, are now regulated at 60 ppb. Furthermore, the use of ozone as a disinfectant generates bromate from bromide as a by-product which is subject to new limitations in the proposed rule. It identifies many of the actions that small and large systems can take to achieve the required reductions in the earlier rules. In the face of these economic and technology challenges U. EPA has asked for assistance on technology development for treating more efficiently these known protozoan problems and on the pathogens in the Drinking Water Contaminant Candidate List. Disinfection by Electrolysis Electrolysis is a method of breaking water down into molecular hydrogen and molecular oxygen. This reaction occurs at the cathode: Rupturing of Cell Membranes at the Anode Many species of bacteria have a negatively charged surface. The positively charged electrode will attract these species. This outer membrane of an oocyst can be damaged or degraded by the electrical current leaving it susceptible to attack by the other active agents at the anode such as oxygen, hydroxyl-like components, and chlorine. The Action of Molecular Oxygen Molecular oxygen, a vigorous electron acceptor, can kill anaerobic micro-organisms in water. Strategies of microbial life in extreme environments, p. Hydroperoxide ions can also destroy bacteria. Bacteria and organisms with electron rich outer layers self generate hydroperoxide. It is speculated that this oxygen mechanism will be available and potentially effect on the sporozoids once the membrane of the oocyst has been damaged or breached. Generation of Hypochlorite and Other Active Halide Compounds All natural water contains trace quantities of salts in solution. Potable water supplies generally contain chloride salts in concentrations of 10 to ppm. Both are produced at the cathode in the electrolytic cell. Both are available to perform reduction reactions. Hydrogen present will be available to reduce damaged sporozoid or membrane surfaces and is expected to improve the effectiveness of the process. Environmental Benefits Available The environmental benefits available to disinfection by electrolysis are numerous. When compared to conventional technologies, electrolysis, if capable of achieving the stated objectives, would: Invention Test Method Design the electrolytic cell Month 1. Build and bench test the electrolytic system of cells Month 2. Integrate an electrolytic system into a test apparatus and inoculate water with C. Investigate the ability of the test apparatus to reduce C. Investigate the range of conditions for electricity and water flow rate in the test apparatus that significantly reduce C. Write a Final Report Month 6. Questions to Answer When we introduce Cryptosporidium into the electrolytic system, what voltage and flow conditions enable attraction of the oocysts to the electrodes that then produces a significant reduction in viability? Does generation of hypochlorite in a second electrolytic cell further improve the reduction or is it advantageous to operate a second cell? How successfully can the electrolyzed water inhibit or degrade C. Does the electrolytic process contain the characteristics necessary to denature and degrade viruses and other Drinking Water Contaminant Candidate List pathogens? The System of the Invention The system of the invention is designed as an electrolytic system that can continuously treat raw surface water sources and disinfect them for

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Cryptosporidium while producing a drinkable quality of water at the end of the process for oxidants such as hypochlorite. The system of the invention does not segregate the anolyte from the catholyte nor will it treat only a sidestream of the raw water. In treating all the water through the series of electrolytic cells, the invention generates sufficient voltage potential at the anode to attract and damage the outer shell of the C. The process generates oxygen and low levels of hypochlorite in the water chloride is typically in concentrations of 10 ppm in surface water. These soluble oxidants will perform disinfection by secondary oxidation. This approach to the product design minimizes the cost, the size, and the maintenance requirements of the system, while maximizing simplicity, reliability, and ease of use. The system will operate using programmable-logic-controller structure one example of this structure is plural Programmable Logic Controllers PLCs and feedback probe structure which may take the form of one or more feedback probes that will enable the system to self-regulate necessitating virtually no attention from personnel other than monthly cleaning and maintenance. Then, the electrolytic cell is activated, the desired kill parameters are set, and samples of the electrolyzed water are taken for biological testing. Technical Objectives The invention achieves these objectives: Design the electrolytic cell system. Build and bench test an electrolytic system. Integrate an electrolytic system into an innoculated water testing apparatus. Investigate the ability of the test apparatus to degrade Cryptosporidium viability in the water. Investigate the range of conditions for electricity and water flow rate in the test apparatus that significantly degrade Cryptosporidium viability in the water. Write a Final Report. Details of System and Method Design Objective 1: Design the Electrolytic Cells A detailed set of specifications are set for two prototype electrolytic cells high voltage and low voltage. These two cell types will be used in series to achieve the desired kill effect on C. These are the most important design specifications: We want to be able to vary the voltage without making substantial changes in the amperage. To this end, we will change the overall resistance of the water by varying the gap between the electrodes. We propose to design and build two electrolytic cells with different electrode spacing. We will design the electrolytic cell in collaboration with Water Star, Incorporated, an electrolytic cell technology company in Cleveland, Ohio. After we complete the specifications, we will write a detailed design document. These are the primary design issues which we will address:

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2: USA1 - Method for electrolytic disinfection of water - Google Patents

These different purification methods and their effect on disinfection sensitivity should be more thoroughly evaluated. In addition to different sensitivities to chlorine dioxide between isolates from different suppliers, some studies have shown that different lots of the same isolate may respond differently to the same disinfection process.

Page, Angela Project Period: Drinking Water , Water Objective: Ultraviolet UV radiation is recognized to be an inexpensive and relatively easy means to achieve disinfection of Cryptosporidium parvum and does not appear to produce disinfection byproducts at practical doses. The germicidal effects of UV against emerging pathogens and challenges related to application of UV disinfection for filtered and unfiltered surface waters needs to be assessed. The objective of this research project was to evaluate the susceptibility, repair potential, and resistance of select Contaminant Candidate List CCL and other pathogens and indicators to UV disinfection from low and medium pressure UV sources. The extent to which microbes are associated with water treatment particles typical in unfiltered systems and the effects of this particle association and other water quality parameters on UV disinfection also was investigated. Our research approach integrated the expertise and experience of the co-investigators in environmental microbiology and UV dosimetry and disinfection process design to address these important questions and others. Specifically, numerous organisms, some of which are on the U. The relative wavelength effectiveness of UV irradiation for a virus and spore and the potential for repair and reactivation under light and dark conditions for a bacteria and cyst also were studied. To elucidate the roles of physical and chemical properties of viruses and their sensitivity to UV radiation, the kinetics and extent of inactivation of some waterborne pathogenic viruses and bacteriophages with different virion sizes and genomic composition by monochromatic, low pressure UV was determined in phosphate buffered saline or a filtered drinking water. Therefore, the inactivation of human enteric viruses and bacteriophages by UV irradiation is proven not predictable by the type and size of the virus or its nucleic acid genome. The UV inactivation of murine norovirus, feline calicivirus, and echovirus12 was studied in phosphate buffer at room temperature using a low pressure UV source. Bacteriophage MS2 was more UV resistant than any of these viruses tested. Additionally, UV disinfection experiments were carried out using cell-associated echovirus Compared to monodispersed echovirus 12, the cell associated virus required two to three times greater UV dose for a given level of log reduction. Because adenovirus is the most UV resistant virus known, it was selected for more extensive study. As part of the adenovirus work, we developed a rapid and reliable cell culture-mRNA reverse transcription-polymerase chain reaction RT-PCR assay to detect and quantify adenovirus infectivity. This method was used to assess adenovirus type 41 Ad41 infectivity. Treatment of approximately Ad41 with different doses of nm germicidal UV radiation resulted in a dose-dependent loss of infectivity. The comparative effects of low and medium pressure UV irradiation on adenovirus 5 Ad5 and Ad41 were studied in model waters. Low and medium pressure UV applied to dispersed Ad41 in buffered laboratory water resulted in log10 reductions of 0. Thus, at the same UV doses the polychromatic medium pressure lamps inactivated adenoviruses more effectively than did the low pressure lamps. Overall, bacteriophage MS2 was a good conservative surrogate for representing the UV inactivation of many viruses, with the exception of adenovirus. These data will be helpful for utilities and regulatory officials to evaluate the efficacy of UV irradiation for viruses and plan for levels of disinfection that will help ensure public health in drinking water. UV inactivation and subsequent dark and photo-repair was examined for Mycobacterium terrae, a surrogate for Mycobacterium avium complex MAC and M. Low pressure monochromatic, nm and medium pressure polychromatic UV output Hg lamps were used for UV irradiation resulting in inactivation, and was followed by dark or photo-repair experiments. There was no difference in inactivation between monochromatic or polychromatic UV lamps. Photorepair resulted in recovery from inactivation by approximately 0. Cangelosi at the University of Washington. The inactivation kinetics ofMAC by several different doses of both low pressure and medium pressure UV irradiation in phosphate-buffered

saline at room temperature were evaluated. The inactivation of G. The ability of UV-irradiated G. The UV inactivation of T. Dubey at the U. Department of Agriculture and Dr. Using a mouse infectivity test protocol carried out by Dr. Dubey, the inactivation of T. Polychromatic UV irradiation from a medium pressure UV system provided a similar level of inactivation. Thus in addition to the known effectiveness of UV toward Cryptosporidium oocysts and Giardia cysts, UV is very effective for inactivation of Toxoplasma oocysts at low UV doses. The inactivation of indigenous natural aerobic spores followed first-order kinetics with an inactivation coefficient ranging between 0. Thus, naturally occurring Bacillus spores are more UV resistant than adenovirus. These spores may be useful as surrogates for adenovirus or as biodosimetry test organisms for UV reactor validation. Wavelength Effectiveness of UV Irradiation The microbicidal UV fluence under polychromatic radiation from UV lamps is typically measured using the DNA absorbance spectrum as a weighting factor for the relative wavelength effectiveness. However, this DNA-based weighting does not necessarily match the spectral sensitivity of the microorganism being tested. Bacillus subtilis spores are often used for UV reactor validation in Europe, whereas MS2 coliphage is typically used for validation testing in the United States. These organisms were exposed to quasimonochromatic UV irradiation across the microbicidal spectrum at wavelengths of , , , , , , and nm. MS2 was three times more sensitive to wavelengths near nm compared to the nm output of low pressure lamps, whereas B. Use of these action spectra, compared to the DNA-based weighting, resulted in differences in the calculated polychromatic UV fluence. Consequently, the action spectrum, which is specific for each microorganism, has implications on the uncertainty of UV fluence determination during validation of reactors with polychromatic UV lamps. Furthermore, these data indicate that for some microorganisms, a polychromatic medium pressure UV source may be more germicidally effective than a low pressure source, but these effects need to be tested in a microorganisms specific basis. Water Quality Impacts on UV Disinfection Based on studies of the UV inactivation kinetics of indigenous aerobic spores in surface water compared to their laboratory-cultured spore isolates a relationship between physicochemical characteristics and UV inactivation kinetics of spore isolates was developed. Cultured isolated spores exhibited a three-stage inactivation curve consisting of shoulder, first order, and tailing regions, whereas indigenous spores exhibited only one stage of linear kinetics. Hydrophobicity of the Bacillus spore isolates was inversely related to the extent of UV inactivation before tailing occurred. Therefore, tailing in the UV inactivation curves results from aggregation of a portion of the spore population because of hydrophobic interactions, supporting the link between aggregation of spores, hydrophobicity, and UV inactivation. Aggregation of microbes with particles can also reduce the effectiveness of UV disinfection. Aggregates that were induced by flocculation with alum were protected from UV irradiation compared to nonaggregated spores, and the difference between these systems was found to be statistically significant throughout the UV dose range tested. Electron microscopy analysis suggested that aggregate composition was nonhomogeneous with respect to the ratio of spores and clay particles among aggregates. It was estimated that 30â€”50 percent of the spores in the aggregates tested were protected from UV irradiation. The impact of light scattering of particle aggregated microbes on UV disinfection was evaluated by comparing standard spectrophotometer and integrating sphere absorbance measurements for UV fluence determination. Coagulated systems significantly decreased the UV inactivation effectiveness compared to the noncoagulated system with the effects more pronounced for raw natural water. Absorbance measurement of suspensions and aggregates using standard spectrophotometry in the calculations of fluence resulted in overdosing, whereas the use of integrating sphere spectroscopy did not. The results demonstrated that aggregation protected spores from UV disinfection, and that use of proper absorbance measurement techniques, accounting for particle scattering, is essential for correct interpretation of the results. Journal Articles on this Report:

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