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ELIMINATION OF *PSEUDOMONAS AERUGINOSA* FROM WATER SYSTEMS: A REVIEW

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ABSTRACT:
Pseudomonads free-living bacteria that live primarily in soil, seawater, and fresh water. They also colonize plants and animals. Pseudomonads can grow in distilled water also. *Pseudomonas* spp., ubiquitous Gram negative bacilli, are found in natural waters such as lakes and rivers. On account of their tolerance to a wide variety of physical conditions and minimal nutrition requirements, *Pseudomonas* also can colonize biofilms in manmade systems such as drinking water. *Pseudomonas aeruginosa* is a major human opportunistic pathogen species of this group, which can cause a wide range of infections. In this review we have discussed effect of Bacteria on human health and the methods to control the Pseudomonas aeruginosa in water system.
Keywords: Pseudomonas aeruginosa, Bacteriophages, water decontamination, Copper-silver ionization, Ozone, Pathogens.

INTRODUCTION

Pseudomonas aeruginosa was first isolated in 1882 by Carle Gessard. It is a rod-like monoflagellated, gram negative, tremendously adaptable bacterium with absurd nutritional resourcefulness. [1] *Pseudomonas* is a genus of gamma proteobacteria, belonging to the larger family of *Pseudomonads* and belongs to the class Gammaproteobacteria. Genus is *Pseudomonas Migula*. [2] It utilizes aerobic respiration as its central metabolism but can respire anaerobically on nitrate. *Pseudomonas aeruginosa* is found in various parts such as soil, stagnant water, humans, on the surfaces of animals and plants, sewage and on other moist environments [1, 2, 4] and is habitually found in nosocomial infections. [2, 5] It is an essential pathogen for humans. It is known as an opportunistic pathogen that rarely causes diseases in healthy persons. [1,2] Due to low outer membrane permeability and high infection, *Pseudomonas aeruginosa* is mainly resistant to many antimicrobials like antibiotics, antiseptics and disinfectants [3, 4, 8] and thus these infections becomes challenging. [5] The organism depends on flagellum to move around. It has pili that help it to adhere to the host cell surface. Water soluble pigments – Pyocyanin (blue) and Pyoverdin (fluorescent) gives blue-green color to *Pseudomonas* on solid media. [1] Biofilms which is present extensively enables for the survival and replication within medical devices such as catheter and human tissues and also plays important roles in many different environments. [6]

How *Pseudomonas aeruginosa* affects human beings

Pseudomonas aeruginosa is capable of causing infection in cystic fibrosis patients associated with lung diseases, once it enters the lung tissue, it cause pneumonia which can be life-threatening. [6, 7] Septic shock or even soft tissue damage can cause due to infection through burn wounds on the skin. [6, 8] Endotoxic shock is also caused when the refrigerated blood products get contaminated and is when transfused into the infected patients. If *Pseudomonas* enters into a gastrointestinal system, then it can lead to necrotising enterocolitis, which triggers the body tissues more drastically. [8]

Pseudomonas aeruginosa in water systems

These bacteria can also develop well in water systems, particularly large-scale ones such as those in big industrial buildings and hospitals. Microbes grow very rapidly in the water system, causing sticky bio-films on pipeworks, which allows them to swiftly multiply and take hold, affecting the drinking water giving it a strange taste as well as appearance. The walls of piping system makes it difficult for *Pseudomonas* to adhere to the walls and colonize. [4, 9]

Regular maintenance and flushing of the system is retained to prevent colonization as the water supply itself is concerned as these will have no stagnant water if the water systems are maintained, cleaned and disinfected properly. [9] Killing of *Pseudomonas* in water is more problematic.

Methods or ways to control the *Pseudomonas aeruginosa*

To keep control of *Pseudomonas,* it is usually preferable to use filtration devices, disinfection methods, continuous dosing of systems with chlorine dioxide, UV sterilization and ozone, installation of Copper-Silver ionization equipment. [9] Carbon filters need to be changed regularly in the household systems. Automatic backwashing carbon is used which keeps it much cleaner as they can self backwash and remove most of these bacteria.

Electrophoto catalytic method:

Application of electrophotocatalytic (EPC) methods for drinking water disinfection was broadly used in the recent years. These methods led to production of strong oxidant agents such ashydroxyl ($OH^{\cdot}$) radical. The application of this method is the removal of Pseudomonas aeruginosa from urban drinking water by batch EPC reactor with usage of zinc oxide (ZnO) nanoparticles immobilized on zinc (Zn) sheet-copper electrode, and lamp emitting dynode (LED) ultraviolet-A (UV-A) lamp.

The study suggests that ZnO thin layer nanoparticles immobilized on Zn in an EPC process is a promising method for the inactivation of P. aeruginosa. It is affected by pH, the number of bacteria, the lamp intensity, radiation time, the distance between lamp and electrode Zn/ZnO, the number of layers ZnO nanoparticles catalyst, and current density. The EPC treatments are capable of removing P. aeruginosa at the pH value of 8, with a radiation time less than 7.5 min. Enhanced P. aeruginosa removal is obtained with an increase in the pH, the lamp intensity, radiation time, and current density(10).

Bacteriophages :

Bacteriophages are viruses that infect and lyse bacteria. Interest in the ability of phages to control bacterial populations has extended from medical applications into the fields of agriculture, pharmacy, aquaculture and the food industry. Here, the potential application of phage techniques in wastewater treatment systems to improve effluent and sludge emissions is the interest of study. Phage-mediated bacterial mortality has the potential to influence treatment performance by controlling the abundance of key functional groups. Phage treatments have the potential to control environmental wastewater process problems such as: foaming in activated sludge plants; sludge dewaterability and digestibility; pathogenic bacteria; and to reduce competition between nuisance bacteria and functionally important microbial populations. Successful application of phage therapy to wastewater treatment does though require a full understanding of wastewater microbial community dynamics and interactions.(11).

Water and wastewater filtration systems often house pathogenic bacteria, which must be removed to ensure clean, safe water(12).

The recent study showed the persistence of the model bacterium Pseudomonas aeruginosa in two types of filtration systems, and use P. aeruginosa bacteriophages to determine their ability to selectively remove P. aeruginosa. These systems used beds of either anthracite or granular activated carbon (GAC) , filtration systems were loaded with an instantaneous dose of P. aeruginosa at a total cell number of 2.3 (±0.1 [standard deviation]) x 107 cells. An immediate dose of P. aeruginosa phages (1 mL of phage stock at the concentration of 2.7 x107 PFU (Plaque Forming Units)/mL) resulted in a reduction of 50% (±9%) and >99.9% in the effluent P. aeruginosa concentrations in the clean anthracite and GAC filters, respectively.(12)

Copper-silver ionization:

Copper and silver ionisation involves the generation of copper and silver ions in water. This happens when water flows through the turbine of a flow sensor sending a signal to the system control unit, which then passes a low DC current between two copper and two silver electrodes located in an electrode chamber.

As a result of this, biocide tolerance is unlikely to occur when using copper and silver ionisation to control pathogens in water systems. This system effectively controls *Legionella*, *Pseudomonas* and other water borne pathogens.

Copper silver ionisation has a range of benefits that make a safe, approved and advanced water treatment method.

Copper-silver ionization systems have emerged as a long-term disinfection method for *Legionella* in hospital water systems [13,14].

Copper and silver ions have demonstrated *in vitro* efficacy against the waterborne pathogens.[15]

The study shows that copper-silver ionization is effective in controlling biofilms and plankton-associated waterborne pathogens. The regrowth may be due to the fact that these metallic ions are attached to the test organisms, remain attached throughout the experiment, and have no further killing effect on other organisms There are measurable decreases in the control populations (i.e., no disinfectants) of plankton-associated *P. aeruginosa* and *S. maltophilia*.. *P. aeruginosa* and *S. maltophilia* are more susceptible to the manmade model plumbing system than *A. baumannii*.[16]

Ozone in water decontamination:

Ozone is a well-known disinfecting agent that is used as an alternative for chlorine in many applications, including water decontamination. However, the utility of ozone in water decontamination is limited by high electrical power consumption and expensive, bulky equipment associated with ozone generation.[19]

The ozone concentration required for 4 log reduction of *Pseudomonas aeruginosa*

Ozone is an another alternative for free chlorine and chloramine disinfectant; with a higher thermodynamic oxidation potential, less sensitivity to organic material, and better tolerance for pH variations while retaining the ability to kill bacteria, fungi, viruses, as well as spores and cysts.[17,18]

The ozone concentration required for 4 log reduction of *Pseudomonas aeruginosa* was 0.1 mg/L (exposure time = 4 minutes). These results together indicate possible inactivation of other vegetative cells with ozone concentration in the range of 0.04 to 0.1 mg/L.

Conclusion:

Pseudomonas aeruginosa is a major human opportunistic pathogen species of this group, which can cause a wide range of infections. In this review we have discussed effect of Bacteria on human health and the methods to control the Pseudomonas aeruginosa in water system.

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