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DIAGNOSTIC STUDY OF VARIOUSDISINFECTION TECHNIQUES FOR RECYCLED WASTEWATER USED IN TEXTILE WET PROCESSING

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Abstract

Human exposure to wastewater discharged into the environment has increased in the last fifteen to twenty years with the rise in population and the greater demand for water resources for recreation and other purposes. Wastewater is disinfected to prevent the transmission of infectious diseases and to ensure that water is safe for human contact and the environment.

Wastewater reclamation has become a viable alternative to supplement water supplies in water-short areas. Wastewater reclamation is the treatment of wastewater up to standards that make it reusable, and water reuse is the use of reclaimed wastewater. Industrial processes can use non-potable water for cooling, energy production, and rinsing, as well as for tasks specific to particular types of production. Disinfection in water reuse applications is accomplished most commonly by the use of chemical agents and irradiation.

This paper focuses on various methods of disinfection which can be used for disinfection of water and especially of treated wastewater.

KEYWORDS:
Disinfection methods, Pathogen, Recycled wastewater, Textile wet Processing.

1.INTRODUCTION

Disinfection is a very important unit process to deactivate coliform bacteria in treated wastewater. However, regrowth potential of coliform bacteria raises human health and safety concerns associated with reuse of treated wastewater in various applications.

In view of increasing use of recycled wastewater for reuse, it is necessary to address this phenomenon from both technical and regulatory standpoints[1]. Diseases caused by pathogenic bacteria, viruses, protozoa or helminthes are the most common and widespreadhealth risk associated with drinking-water. For this reason, the WHO Guidelines for drinking-waterquality place the greatest importance on the microbiological quality of drinking-water, and repeatedlyemphasize that the potential consequences of microbial contamination are such that its control must alwaysbe of paramount importance and never be compromised[2]. The direct disposal of treated or untreated municipal sewage into surface water bodies has deteriorated the water quality of major rivers of India. The status of disinfection of wastewater in India and most of other developing countries is essentially very different, where it still as a concept does not exist at large. A number of issues like selection of treatment process, risk associated with the presence of pathogens, and applicability of indicator microorganisms to represent pathogenicity of wastewater etc. is yet to be fully established[3].The disinfection agents commonly used both at drinking water and wastewater treatment plants are chlorine and its related compounds, such as sodium and calcium hypochlorite and chlorine dioxide, with chlorine being by far the most widely used disinfectant[4].Wastewater can be reclaimed and reused through treatment programs that reduce environmental degradation caused by sewage effluent disposal and provide an alternative water supply to help overcome shortages in potable water. Reclaimed water is used for agriculture, industry; drinking water and groundwater recharge[5].

2. COMMON MICROORGANISMS FOUND IN DOMESTIC WASTEWATER:

Disinfection has become one of the primary mechanisms for the inactivation/destruction of pathogenic organisms. In order for disinfection to be effective wastewater must be adequately treated. Table 1 summarizes the most common microorganisms found in domestic wastewater and the types of human diseases associated with them [15].

TABLE 1 INFECTIOUS AGENTS POTENTIALLY PRESENT IN UNTREATED DOMESTIC WASTEWATER

Organism	Disease Caused
Bacteria	
Escherichia coli	Gastroenteritis
Leptospira (spp.)	Leptospirosis
Salmonella typhi	Typhoid fever
Salmonella (=2100 serotypes)	Salmonellosis
Shigella (4 spp.)	Shigellosis (bacillary dysentery)
Vibrio cholerae	Cholera
Protozoa	
Balantidium coli	Balantidiasis
Cryptosporidium parvum	Cryptosporidiosis
Entamoeba histolytica	Amebiasis (amoebic dysentery)
Giardia lamblia	Giardiasis
Helminths	
Ascaris lumbricoides	Ascariasis
T. solium	Taeniasis
Trichuris trichiura	Trichuriasis
Viruses	
Enteroviruses (72 types) e.g. polio echo and coxsackie viruses)	Gastroenteritis, heart anomalies, meningitis
Hepatitis A virus	Infectious hepatitis
Norwalk agent	Gastroenteritis
Rotavirus	Gastroenteritis

3. TYPES OF DISINFECTION METHODS:

Generally, disinfection is applied on secondary or tertiary effluents. Using tertiary filtration has two benefits: Firstly, the concentration of particle associated pathogens, which makes up for the major number of organisms is held back, and secondly, the number of particles which represent a main obstacle for the disinfectant and a shelter for the microorganisms is reduced drastically[6].

Most widely used disinfection method in India is chlorine and allied products which is discussed at the end of other disinfectants described here.

3.1Solar disinfection:

Solar disinfection, or SODIS as it is known, is one of the simplest and least expensive methods for providing acceptable quality drinking water. It is an ideal method for use when economic and sociocultural conditions in the community are not amenable to other treatment or disinfection alternatives, such as filtration or chlorination, even though these are also acknowledged to be simple and inexpensive[7].

3.2 Disinfection by ultraviolet radiation:

UV light can be categorized as UV-A, UV-B, UV-C or vacuum-UV, with wavelengths ranging from about 40 to 400 nm. The UV light effective for inactivating microorganisms is in the UV-B and UV-

C ranges of the spectrum (200–310 nm), with maximum effectiveness around 265 nm. Thymine bases on DNA and ribonucleic acid (RNA) are particularly reactive to UV light and form dimers (thymine–thymine double bonds) that inhibit transcription and replication of nucleic acids, thus rendering the organism sterile. Thymine dimmers can be repaired in a process termed 'photoreactivation' in the presence of light, or 'dark repair' in the absence of light. As a result, the strategy in UV disinfection has been to provide a sufficiently high dosage to ensure that nucleic acid is damaged beyond repair.

3.3 Slow sand filtration:

Slow sand filtration (SSF) is the world's oldest known water treatment system. It emulates nature's purification process when rainwater seeps through the layers of the earth's crust and forms aquifers or underground rivers. Slow filtration is used mainly to eliminate water turbidity, but can be considered a water disinfection system if it is properly designed and operated.

3.4 Ozone:

Ozone disinfection consists of the addition to the water source of sufficient quantities of ozone as rapidly as possible, in order to satisfy the demand and maintain an ozone residual during a long enough period of time to ensure microorganism inactivation or destruction. Most water supply systems require a larger amount of ozone than of chlorine, because of its high oxidation potential. Ozone disinfection is generally aimed at maintaining a minimum residual of 0.4 to 0.5 ppm after 10 to 20 minutes of contact with the water.

3.5 Minifiltration:

Although minifiltration methods are effective for removing pathogens, they are not often used in cities in developing countries because of the high investment and operating and maintenance costs involved. The treated water produced by the few plants using these systems in Latin America is excellent and, because they are almost fully automated, the operators do not necessarily have to be trained. These plants operate like efficient robots that take in dirty water and produce an excellent quality effluent.

3.6 Disinfection with bromine:

As a member of the halogen family, bromine is very similar to chlorine and operates in the same way: once dissolved in water, it produces hypobromous acid (HOBr), a first cousin to hypochlorous acid (HOCl). The disinfecting power of HOBr is very high, although slightly less than that of hypochlorous acid.

3.7 Disinfection with silver:

Most metals are “Oligodynamic;” this means that “with only a small amount, they can produce an effect.” Metals like silver, copper, mercury, manganese and iron, among others, are all potential water disinfectants. However, of all of these metals, only silver, for several reasons, has been used to some extent to disinfect water for human consumption.

3.8 Disinfection with iodine:

Iodine belongs to the halogen family and is solid at normal temperature. It has low solubility in water and is the least aggressive substance in the family (chlorine + bromine).

3.9 Disinfection with sodium dichloroisocyanurate (NaDCC):

Sodium dichloroisocyanurate, often called “sodium isocyanurate,” and recognized by the abbreviation “NaDCC,” is a compound that frees chlorine in very precise concentrations. It is easily handled and contains a high concentration of active chlorine (60%). Its use is highly practical and it does not leave the usual telltale odor and taste of other chlorine treatments. It is stable over long periods of time, making it appropriate for storage over much longer periods than any other chlorine compound. If conditions are optimum, it can be stored for over five years without losing its strength.

3.10 Disinfection using mixed oxidant gases:

The use of mixtures of oxidants for microbial inactivation has gained attention as a way to maximize the efficiency of current disinfectants. The chemistry of mixed oxidant production is complex, resulting in a solution of free chlorine, chlorine dioxide, ozone and various oxidation states of chlorine. There was an interesting development in the research carried out on these systems. In an effort to escape the numerous patent restrictions placed on sodium chloride electrolysis, researchers played around with the placement of the electrodes, particularly with the dimensionally stable anodes (DS anodes) and produced equipment that generates not only chlorine, but also, as a result of the electrode arrangements, other high oxidizing species, including radicals of different types: ozone, nascent oxygen, atomic oxygen and others. PAHO generically calls this mixture of oxidant gases MOGGOD (mixed oxidant gases generated on-site for disinfection purposes). Because of their production in an electrolytic cell divided into separate & independent chambers, these gases constitute a highly concentrated and oxidant mix.

3.11 Disinfection by special types of radiation:

Regular ultraviolet disinfection is consists merely of placing a substance, (in this case, water) where it can be radiated with a certain wavelength. There are two other types of radiation that have only been used experimentally, but that could potentially be employed in the future with a good capacity for disinfection. These are "gamma" and "X"-rays.

3.12Synergic disinfection methods:

The term "synergy" means "the interaction and combined activity of two or more biological beings, substances or components to produce something that is qualitatively and quantitatively different from the sum of their individual capacities." In other words, the formula for a synergy is: $1 + 1 \neq 2$ and the result can be, for example: 0.7 or 3.

In the specific case of the substances used as disinfectants, if, by adding together the individual capacities of each of them, we were to obtain a capacity larger than the sum of the two (in the case of the example, if by adding 1 + 1 we were to obtain 3), this would mean the discovery of a new, much more powerful substance with better qualities than either of the two individual substances and even than the combined qualities of the two. That is precisely what happens in certain special cases and what is called "disinfection synergy."

Not many of these synergies exist, but those that are mentioned below are promising and suggestive of a new field that will be broadened and enriched by new research, experiences and discoveries.

The synergic cases that have been most studied are the following: Silver/hydrogen peroxide, Silver/copper, Silver/copper/chlorine, Iodine/chlorine, Ozone/UV, Ozone/hydrogen peroxide.

3.13 Chlorine and associated products:

Chlorine is a powerful oxidizing agent and has been used as an effective disinfectant in water and wastewater treatment for a century. Chlorine may be added to water as a gas (Cl2) or as a liquid or solid in the form of sodium or calcium hypochlorite, respectively[8].Chlorination is a common disinfection treatment for wastewater treatment, although it has considerable drawbacks in terms of transportation, handling and storage of hazardous and corrosive chemicals[9].Chlorine is the most widely used wastewater disinfectant in the U.S., and it kills most bacteria, viruses, and other microorganisms that cause disease[10].

Household chlorination systems may provide a higher free chlorine concentration than the typical 0.3-0.5 PPM (parts per million) concentration used for chlorination of public water supplies[11].Although chlorination does have some drawbacks, it continues to be the most popular, dependable, and cost-effective method of water disinfection[12].NaOCl has been demonstrated to be an effective disinfectant agent[13].Chlorine demand of tap water in was found to be about 0.5 mg/L and thus a sodium hypochlorite dose of three drops per liter (about 1.5 ml/L) proved adequate to provide a free residual chlorine level above 0.2 mg/L[14].

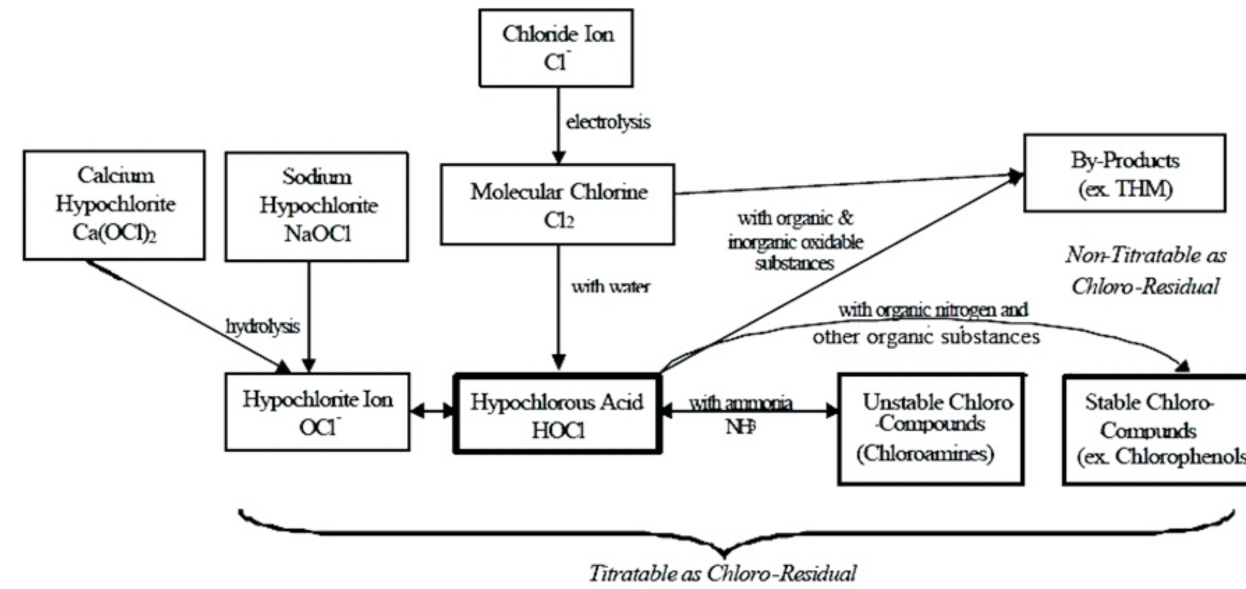

Figure 1 – Chlorine compounds involved in disinfection processes [14]

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4. PERFORMANCE OBJECTIVES OF A DISINFECTION SYSTEM:

The following environmental performance objectives have been created for the disinfection of treated wastewater. Disinfection should:

1.reduce microbial pathogens to below the minimum criteria.
2.not result in an increase in the discharge toxicity of the wastewater;
3.be reliable and cost effective;
4.not result in incremental risks to human health or the environment due to the transport, storageor handling of disinfection chemicals or byproducts [16].

5. PRETREATMENT AND DISINFECTION STANDARDS

There are two key control steps for producing an effluent that depending on the enduses, will be of sufficient quality that it poses no unacceptable risk to the environment, livestock or human health. The first control step is the adequate pre-treatment of effluent to ensure that selected disinfection processes work efficiently.Table2 provides indicative wastewater quality criteria required to ensure effective pathogen reduction for each disinfection method. These values may vary depending on other wastewater qualities and as such are only a guide.

Table 2: Recommended wastewater quality (median) pre-disinfection [16]

Disinfection Method	SS (mg/l)	BOD (mg/l)	Turbidity (NTU)	Nitrate (mg/l)	Ammonia (mg/l)	P^H
Chlorination	< 20	< 20	< 10	NA	See Note 2	6.0 -9.0
Ozone	< 10-15	< 20	< 5	Maximised	< 1	6.0 -9.0
UV	< 10	< 20	< 5	Maximised		NA
Microfiltration	NA	NA	< 10	NA	NA	Neutral
Detention Lagoons	NA	NA	NA	NA	NA	Neutral

6. SELECTING THE DISINFECTION PROCESS:

The optimal disinfection process for a specific site will depend on a variety of issues including:
1.The beneficial uses protected at the location, when discharging to surface waters;
2.The uses of the effluent and associated risks, when reused on land;

3.The existing treatment processes and effluent quality;
4.The available land, effluent volumes and funding regime; and
5.The extent to which risk minimisation and maximisation of future options is required

Table 3: Comparison of disinfection methods

Consideration	Chlorine	Ozone	UV	Microfiltration	Detention lagoons
Effective Against					
Bacteria	High	High	High	High	Medium-High
Viruses	Low to medium	High	High	Medium to High	High if detention >14 days
Parasites	Low	High	Not fully assessed	High	High if detention >30 days
Practically					
Process control	Well Developed	Developing	Developing	Developing	Well Developed
Complexity	Simple to moderate	Complex	Simple to moderate	Simple to moderate	Simple
Maintenance and cleaning	Low to moderate	Moderate to Intensive	Intensive	Intensive	Low to moderate
Reliability					
	High	High	Medium	Medium	Medium to high
Costs (Dependant on size of the plant)					
Operation	Medium	Medium	Medium	High	Low
Capital (Small to Medium Plant)	Medium	High	Low to Medium	High	Low to Medium (Reflects Land Value)
Capital (Medium to Large Plant)	Low to Medium	High	Medium to High	High	Medium to High (Reflects Land Value)

7. CONCLUSION:

There is no perfect disinfectant. However, there are certain characteristics to look for when choosing the most suitable disinfectant such as ability to penetrate and destroy infectious agents under normal operating conditions; lack of characteristics that could be harmful to people and the environment; safe and easy handling, shipping, and storage; absence of toxic residuals, such as cancer-causing compounds, after disinfection; and affordable capital and operation and maintenance (O&M) costs. Despite of few drawbacks Chlorine and its compounds are the principal chemical compounds employed for the disinfection of reclaimed water in all parts ofworld.Chlorine is a well-established technology for disinfection because of following points-

Presently, chlorine is more cost-effective than other disinfection methods.
The chlorine residual that remains in the discharged wastewater can prolong disinfection even after initial treatment and also provides a measure of the effectiveness.
Chlorine disinfection is reliable and effective against a wide spectrum of microorganisms.
Flexible dosing enables greater control over disinfection since wastewater characteristics vary from time to time and Chlorine can eliminate noxious odors while disinfecting.

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