Disinfection of Sewage and Its Importance In Future

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ABSTRACT:
The present study was carried out to evaluate the appropriate doses of chlorine as disinfectant on secondary treated sewage to reduce the formation of disinfection by products which are carcinogenic. The disinfectant used was Calcium hypochlorite and it was observed that free form of chlorine was more effective than the combined form. Dechlorination was also carried out using Sodium thiosulphate An attempt has been made to administer chlorine doses in steps so as to derive the maximum benefit of free chlorine. This paper presents the initial results of the step feeding of chlorine on disinfection efficiency.

1. INTRODUCTION

The world is facing the problem of water crisis due to tremendous increase in population. Water bodies are polluted due to rapid industrialization and unsafe disposal of waste and climate change. Wastewater reuse after its treatment and disinfection is being increasingly emphasized as a strategy for conservation of limited resources of freshwater and as a mean of safeguarding the aquatic environment due to contaminants present in wastewater (Banu et al., 2006). Raw sewage may contain millions of bacteria per millilitre and is a major carrier of disease (from human waste) and toxins (from industrial wastes).The removal of microbiological pollutants from wastewater is essential in order to limit the contamination of surface waters and of water used for irrigation, recreation and drinking (Clark et al.,1984) For these purposes, the conventional primary and secondary treatments are generally insufficient and supplementary disinfection is therefore necessary. Sewage has to be disinfected to meet regulatory microbial limits or to meet coliform discharge standards in order to preserve the biological quality of the receiving water bodies (Galki et al., 2007).

The process of killing pathogenic bacteria in the wastewater effluent is known as disinfection. Disinfection is the final step in the treatment process and is necessary to provide a measure of bacteriological safety to the public, who use the receiving waters for recreational purposes or for drinking water. Disinfection is now required for most wastewater systems. Disinfection efficacy is often measured using “indicator organisms” that coexist in high quantities where pathogens are present. The most common indicator organisms used in the evaluation of drinking water is Total Coliforms (TC) and the most common indicator organism for wastewater evaluation is fecal coliform (Geroge & Servais 2002).

The effectiveness of disinfection depends on quality of the water being treated; the type of disinfection being used; the disinfectant dosage (concentration and time); and contact time. Generally, short contact time, low doses and high flows all militate against effective disinfection. Common methods of disinfection are: Chlorine, Ozone, Ultraviolet radiations etc. (Arianna et al., 2011)

Chlorination is the most common form of waste water disinfection. Residual chlorine or chloramines are also capable of chlorinating organic material. Chlorine is highly valuable because it has broad spectrum germicidal potency and it shows a good degree of persistence in water distribution system. The feeding equipment is simple, reliable and inexpensive. Chlorine and chlorine based compounds are abundantly found in nature. This method is economic and cost effective too. Chlorine when added to waste water undergoes hydrolysis and forms hypochlorous acid (HOCl) (Eq. 1).

$$Cl_2 + H_2O = H^+ + Cl^- + HOCl \qquad (1)$$

The hypochlorous acid further splits into hydrogenous ions (H^+) and hypochlorite ions (OCl^-) (Eq. 2).

$$HOCl = H^+ + OCl^- \quad (2)$$

Hypochlorous acid and hypochlorite ion are the disinfecting agents. Hypochlorous acid has greater efficiency than hypochlorite ions (Donald et al., 1952). For effective disinfection the pH of the chlorinated water should be < 8. When chlorination of water contaminated with sewage is carried out in initial conditions, readily oxidizable substances such as Fe, Mn, H_2S and organic matter react with chlorine and reduce most of it to chloride ion as exemplified by point A in figure 1. After meeting the immediate demand, the chlorine continues to react with ammonia to form chloramines (combined available chlorine from point A to B). Between point B and the break point, chlorine is reduced to chloride ion and some chloramines are oxidized to nitrogen trichloride and others. Further continued addition of chlorine past the beak point will result in a directly proportional increase in the free available chlorine (unreacted hypochlorite). The amount of chlorine that must be added to reach a desired level of residual is called the chlorine demand.

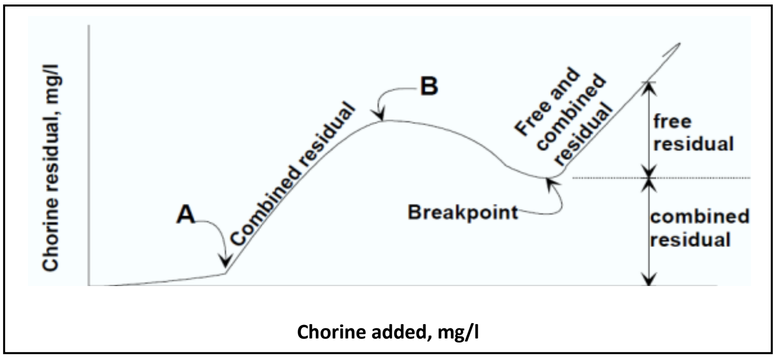

Figure 1. Chlorine break down curve (White, 1999)

Residual chlorine or chloramines may also be capable of chlorinating organic material in the natural aquatic environment but the formation of disinfection by-products, many of which are carcinogenic, is becoming a worldwide issue.

There are no set standards for coliform in the secondary treated sewage water in several developing countries of Asia including India, but it is imminent to establish such norms in near future due to ever growing biological pollution of the water sources.

In a recent research, experiments were carried out on disinfection of secondary treated wastewater of STP Jaipur North, using chlorine as a disinfectant. The efficiency of chlorine were conducted at 2.5 , 5, 7.5,10, 12.5, 15,17.5 and 20 ppm of chlorine doses for contact time of 5, 10, 15 and 20 minutes. From this experiment it was observed that at 17.5 and 20 ppm of chlorine dose, maximum number of microbial count of microbes reaches to zero but generation of chlorinated organic compounds at such high dose that may be carcinogenic or harmful to the environment is worldwide issue (White, 1999). Further, because residual chlorine is toxic to aquatic species, the treated effluent must also be chemically dechlorinated. Dechlorination is the process of removing the free and combined chlorine residuals to reduce residual toxicity after chlorination and before discharge.

The main objective of this paper is to reduce the chlorine doses (lower than 20 ppm) for disinfection of wastewater by applying chlorine in step doses at regular period of time in the sample (collected from STP, North Jaipur) deriving the maximum benefit of free forms of chlorine.

2. MATERIALS AND METHODS

In this study, first of all the Secondary Treated Waste Water Sample was collected from the outlet of Secondary Clarifier STP Delawas for the evaluation of Total Coliform Counts. Microbiological analysis for Total coliform was carried out within 4 - 6 hours of Sample collection .Sample was collected in air tight bottles and care was taken to obtain a sample that truly it is not deteriorate during carrying from STP to PHE Lab. All the work has been carried out in the PHE Laboratory MNIT JAIPUR.

2.1. Enumeration of Total Coliform

Bacteriological analysis of collected secondary treated sample was done after and before the disinfection through spread plate technique. In this method, original sample was diluted serially to reduce the microbial population sufficiently to obtain separate colonies during plating, in the range of 30 to 300 cells per plate (Robertson et al., 1999). One ml of diluted sample was transferred to the centre of an agar plate and spreaded evenly over the surface with a sterile bent-glass rod or spreader (Buck et al., 1960). After colonies were grown, they were counted and the number of bacteria in the original samples was calculated. For this study, EMB Agar media (Eosin Methylene Blue Agar) were used.EMB Agar was used for the identification and enumeration of gram negative coliform such as E.coli, Serratia, Enterobacter and Klebsiella. Diluted samples of raw water were spread on the EMB Agar in duplicates to confirm out the reproducibility (EPA, 1999). Petri plates were incubated at 350C and observed between 24-48 hours and colonies were counted with the help of colony counter.

2.2. Chlorination

Chlorination was carried out using calcium hypochlorite solution to study the effect of contact time and applied dose of chlorine on Total Coliform removal profile of secondary treated effluent. Liquid form of chlorine was appropriate choice during wet weather treatment because it was easy to handle relative than other forms of chlorine, such as gaseous chlorine (EPA, 1999). Secondary Waste Water Disinfection Experiments were carried out with calcium hypochlorite which contained 33% available free chlorine and was readily soluble in water. Subsequently, the feasibility of chlorine disinfection in batch process was examined for contact times of 5, 10, 15 and 20 minutes. To determine the effect of chlorine efficiency, above set of experiments were conducted at 2.5, 5 and 7.5 ppm of chlorine doses in the form of calcium hypochlorite. After 20 minutes of chlorination, samples were dechlorinated with 10% sodium thiosulphate solution to stop the action of residual disinfectant. A step dose experiment was carried out with very first dose of 5 ppm; in this dose 2.5 ppm has been given to zero contact time and 2.5 ppm again given after 5 minutes of contact time. After 20 minutes sample is dechlorinated with 10% sodium thiosulphate (Robertson et al., 1999).

3. RESULT AND DISCUSSION

3.1. Quantitative Analysis of Secondary Treated Effluent of STP North

Five different types of coliform were isolated from water contaminated with secondary treated sewage, namely, Escherichia coli, Enterobacter, Klebsiella, Serratia / Hafnia and Citrobacter (Poswal et al., 2010).

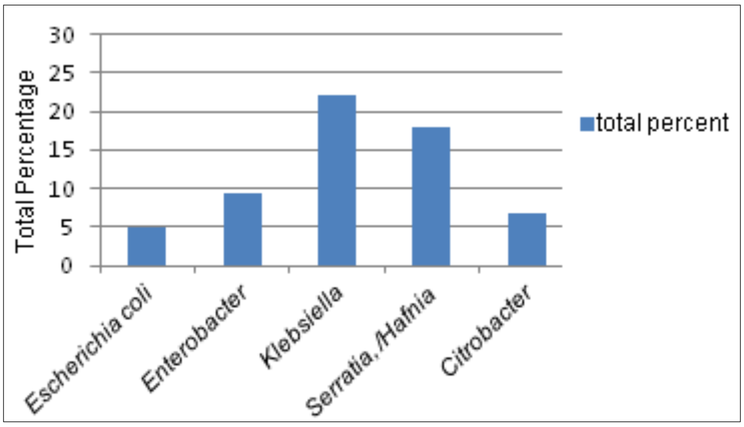

Figure 2. Percentage of Total coliform count isolated from secondary treated wastewater sample

3.2 Effect of 5ppm and 7.5ppm of Chlorine Disinfection on Total Coliform Count Removal

Experiments were carried out for 5 and 7.5 ppm of chlorine dose, and for contact time of 5, 10, 15, and 20 minutes. The samples were collected at regular time interval of 5 minutes and were used for the calculation of different types of bacteria and total coliform count (Poswal et al., 2010)

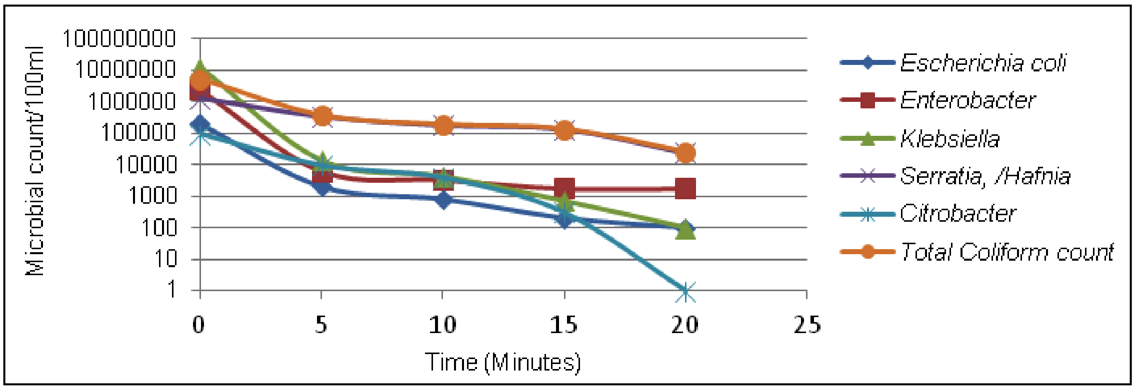

Figure 3. Total Coliform count (per 100ml) removal profile for chlorine dose of 5 ppm (Poswal et al., 2010)

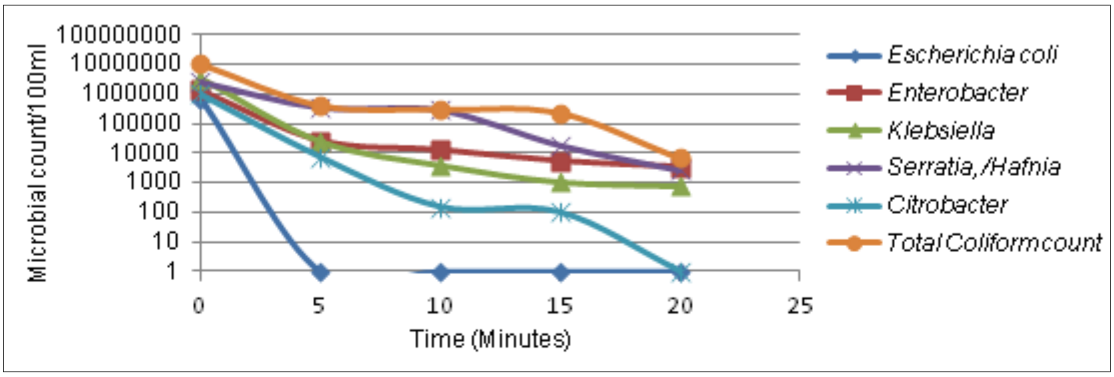

Figure 4. Total Coliform count (per 100ml) removal profile for chlorine dose of 7.5 ppm (Poswal et al., 2010)

From these curves it is observed that there is a 2-log reduction within the first 5 minutes of contact and thereafter for the next 10 minutes, there is negligible effect in coliform removal. Between 15-20 minutes period, there is a further 1-log reduction. This may be due to the free forms of chlorine in the beginning, which later get converted to combined forms which are less effective and require larger contact period (White, 1999).

3.3 Effect of step dose of Chlorine Disinfection on Total Coliform Count Removal

A very initial dose of 5ppm of chlorine was used in the step dose manner like at the zero minute 2.5 ppm chlorine to the sample and again after 5 minute 2.5 ppm chlorine was added and disinfection was allowed for 20 min. Results showed that the same coliform reduction occurs as with single dose of 7.5 ppm of chlorine. And clear data is under progress.

Table 1. Comparative Reduction of Total Coliform at 5, 7.5 and Step Dose 5ppm (2.5+2.5).

Dose	Secondary Wastewater Treated Sample containing Total coliform count.	Total coliform count After 20 min. Chlorination.
5 ppm	$53x10^5$	26000
7.5 ppm	$51x10^5$	7000
5 ppm (2.5+2.5) step dose	$52x10^5$	7500

From the above table we can conclude that applying chlorine in step doses is very beneficial in the disinfection process and reducing the use of excessive chlorine dose, as there is not much difference in Total Coliform reduction after disinfecting water sample by 7.5 ppm and step dosing 5ppm (2.5+2.5) of chlorine.

4. CONCLUSION

In the above study an attempt has been made to administer chlorine doses in steps so as to derive the maximum benefit of free forms. The results have shown a good potential for reducing the overall chlorine dose for the same level of coliform removal, which will be further carried out. HPLC will be used for tracking chlorine species for further research in order to explain the results of these studies (Michael et al.,1998). The design of a hybrid system can help to optimize the overall cost of disinfection so studies on UV or other disinfection methods on those species, which do not respond to chlorination, will be carried out.

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