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Research Article

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Study of the Influence of the Operating Parameters on the Fractions in HOCl and OCl- During the Disinfection Phase

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Abstract

In the first time the introduced chlorine is firstly consumed by nitrogenous organic matters to give some chlorine combined in the form of the chloramines with low power germicide, and secondly the chlorine ad possessed the sought disinfecting properties and establishes the residual free chlorine (hypochlorous acid, hypochlorite).
During this study, we are going to be interested in the study of the variation of the fractions of the sorts of Hocl and Ocl- according to the temperature and to the pH, and also in the evolution of the rate of the residual chlorine according to the temperature during the phase of the disinfection.

Keywords: Hypochlorite chlorinate combined (organized); Chlorinated free residual; Acid hypochlorous; Hypochlorite; pH; Temperature

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INTRODUCTION

In order to be treated in a water treatment plant, the water should be submitted to several stages of basic physicochemical treatment, and whose objective is to make it drinkable in accordance with the standards in force.
Among these steps is chlorination is the action of disinfecting a product, with chlorinated products (bleach, dichlorine, UV). This is the most common addition of chlorine to water to limit the risk of "water-borne diseases" diffused by the drinking water system, despite an increasing supply of alternative disinfectants, hypochlorite, very inexpensive, still has a wide use in the MÉDICAL1 environment and there are no products with so many equal cost benefits.
For public health experts [1] and FAO [2], chlorine presents as a disinfectant the pros and cons, which are:

Advantages
Very low cost of chlorine, and easy handling of industrial formulations.
Persistence considered reasonable in treated drinking water [1], with low environmental impact (compared to other disinfectants).
Activity favourably influenced by temperature (30% increase from 50 to 60°C according to FAO [2].

Easy to use, solubilize in water and rinse with water.
Does not colour [1].

Disadvantages

If some microorganisms such as campylobacters are very easily removed by chlorine or ozone [3], persistence versus chlorine phenomena may appear in some bacteria. Similarly, some encysted forms of some pests are easily resistant to the doses of chlorine that are recommended not to be exceeded for human health (e.g., Giardia and Cryptosporidium, which may be problematic in swimming pools.)

Risks of creating new toxic molecules, undesirable degradation products or toxic synergies of chlorine with molecules already present in the water [5].

Activity of chlorine inhibited by the presence of heavy metal ions, biofilm, or walls in the presence of UV radiation [1]. Odor problems in and around installations [6].

GENERAL INFORMATION ON CHLORINE

Chlorine is a strong oxidizer, widely used for disinfection of drinking water. Chlorine gas (Cl_2) is a water-soluble yellow-green gas that hydrolyzes almost instantaneously in water to form hypochlorous acid (HOCL) according to equilibrium.

Dismutation of Chlorine

$$Cl_{2\,(aq)} + H_2O_{(aq)} \longrightarrow HOCl_{(aq)} + H^{+}_{(aq)} + Cl^{-}_{(aq)} \text{ [7]}$$
$$K_{1.1} = 1.46.10^{-4} \text{ to } 6.05.10^{-4}\ M^2 \text{ from 0 to } 45°C$$

The hydrolysis constant varies significantly with the temperature.
Chlorine can form the trichloride ion (CL_3^{-}) by reaction with the chloride ions according to the equations of [7,8].

Formation of the Trichloride Ion

$Cl_2 + Cl^- \longrightarrow Cl_3^- K_{1.2} = 1.91.10^{-1}$ M to 25°C [8]
Hypochlorous acid is a weak acid in equilibrium with the CLO-hypochlorite ion in the Morris equilibrium [9]:

Dissociation of Hypochlorous Acid

$HOCl_{(aq)} + H_2O_{(aq)} \leftrightarrow OCl^-_{(aq)} + H_3O^+_{(aq)}$
$K_{1.3} = 1.5.10^{-8}$ TO $3.4.10^{-8}$ M (0 TO 40°C)
All of these species (Cl2, Cl3-, HOCl, and CLO-) are commonly referred to as free chlorine as opposed to combined chlorine, total chlorine is the sum of free chlorine and combined chlorine. One can nevertheless cite the minority forms of the free such as the nitrous of chlorine (Cl2O) formed from the hypochlorous acid, as well as the electrophilic entities Cl + and H2ClO +
Intermediates reactions in the halogenations ones [10].
The Figure 2 shows the simplified speciation diagram of chlorine in aqueous medium and summarizes the different possible reactions in pure water.
Total chlorine: Is the combination of free chlorine and combined chlorine.
Free Chlorine: Represents the amount of active chlorine + potential chlorine.

In short

So far we have seen how chlorine decomposes since its injection into the water until the phase of disinfection, we have also known its different forms (total, free, combined, active and potential) and which between it is the most effective.
It remains to be known the area of activity pH and temperature of the active form of chlorine this is the object of our study.

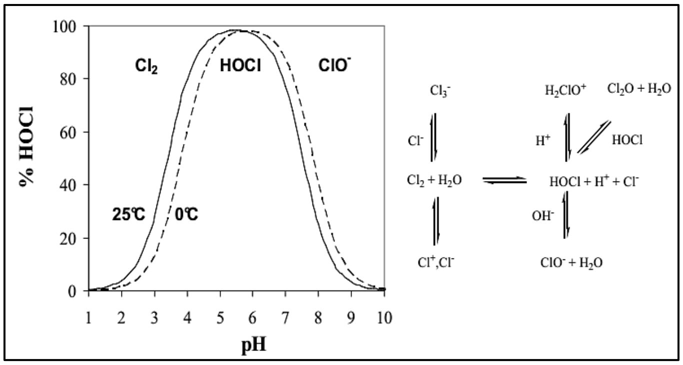

Figure 1: The simplified specification diagram of aqueous middle chlorine

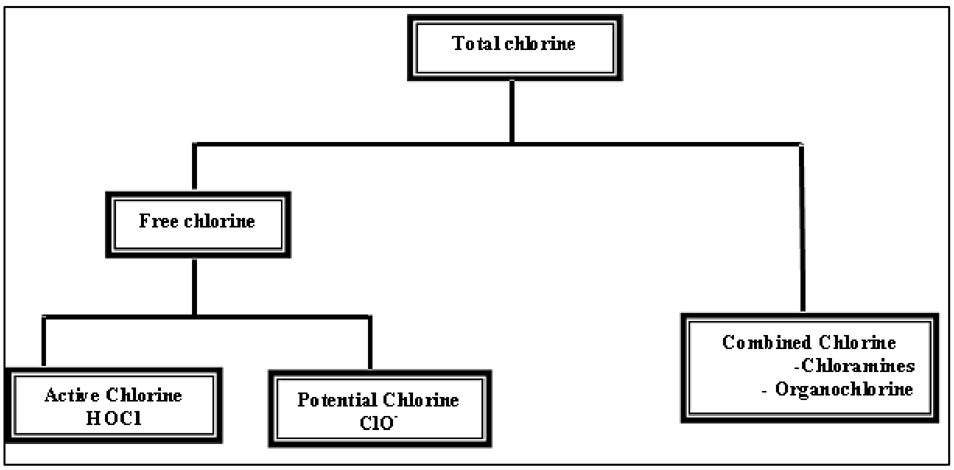

Figure 2: The different forms of residual chlorine

MATERIAL AND METHODS

Sampling

The water samples for the various analyses quoted above were taken during the disinfection phase in the water treatment plant.

The Analysis

The analysis consist of discovering the variation of the percentages in HOCl and OCL-depending on the pH at different temperatures, and this by successively adding the solution of NaOH and sulfuric acid H_2SO_4 with varying doses. The main goal is, therefore to define exactly the field of the active form (HOCL) at these temperatures thus the pH field that must have treated water.

Preparation of the solution of NaOH (0.1 N).

Preparation of the solution of sulphuric acid (0.1 M) diluted from a concentrated solution (18 M).

The pH and temperature of the water are measured using a ph meter type Hach-Model Sension 7 is determined according to the Moroccan standard NM 03-7-001 [11].

The magnetic agitator used of the Stuart type, Stir/cb161.

RESULTS AND DISCUSSION

Effect of pH on Percentages in HOCL and OCL

This study consists of discovering the variation of the percentages in HOCl and OCL^-depending on the pH at ambient temperature 25°C by successively adding the solution of NaOH and sulfuric acid H_2SO_4 with varying doses, in order to know the exact field of the active form (HOCL) at this temperature thus the pH area that must have treated water. The proportion of the two compounds essentially depends on the pH value of the water, as indicated by the figures below:

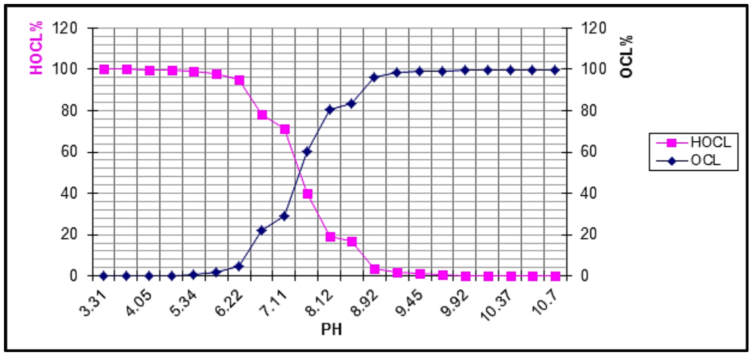

Figure 3: Variation of the percentages of HOCl and OCl- as a function of the pH at the temperature of 25°C

The active form appears with a higher percentage in the acid medium, whereas it is almost invisible in the basic medium. The higher the pH level (water is more alkaline), the lower the chlorination (active form) is effective.
At pH = 7.5 = pKa, [HOCl] and [OCl-] are present with the same percentage of 50%, which corresponds to the characteristics of a buffer solution.
The pH of water treated at room temperature is between 6.5 and 8.5.

Effect of Temperature on HOCL and OCL^-

The study consists in determining the temperature at which the active form will be effective, taking the same experiments as before, by varying the temperatures (0°C, 25°C, 60°C, 90°C).
For the Figures 4,5, which represent the HOCl and OCl- fractions as a function of pH for the different temperatures studied: 0°C, 25°C, 6° C, 90°C, it is noted that the temperature has a direct and on the variation of the active form. Indeed, it is observed that as when the temperature increases, the active form (HOCl) decreases while it resists lower temperatures. The Figure 6 is a summary of the Figures 4,5.
The increase in water temperature leads to a decrease in the effectiveness of the disinfectant, which results in a reduction in the active form (% HOCl), resulting in ineffective disinfection. It is therefore advantageous to have water whose temperature does not exceed 25°C.

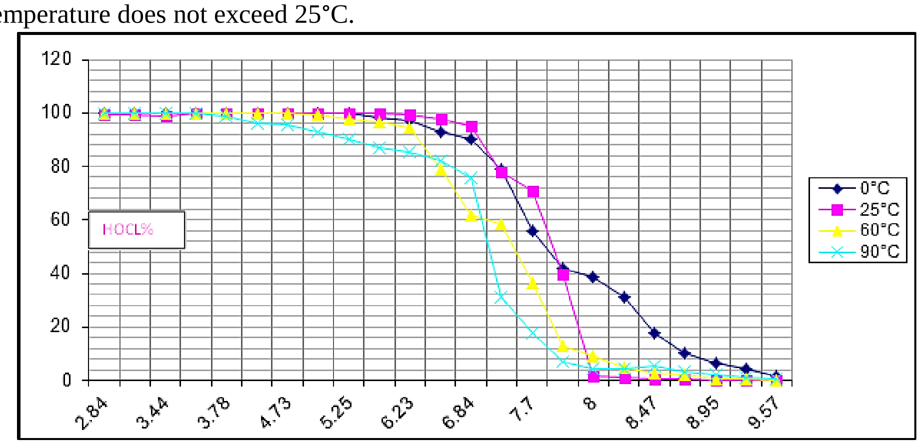

Figure 4: The variation of the HOC1 form as a function of the pH at different temperatures

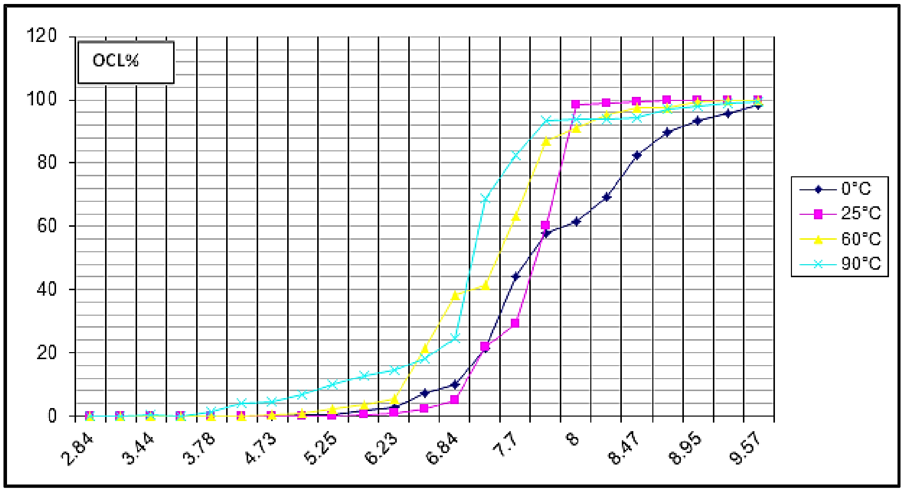

Figure 5: The variation of the OCl- form as a function of the pH at different temperatures

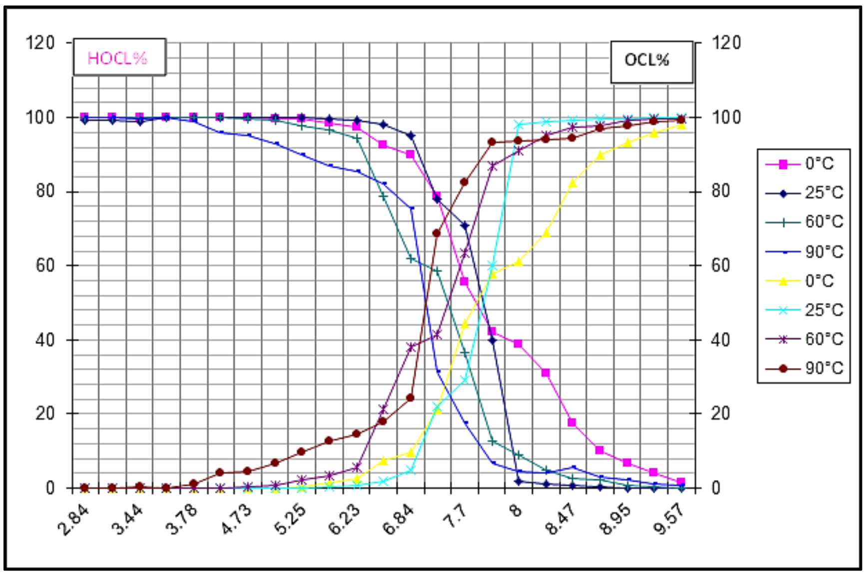

Figure 6: The variation of HOCl and OCl- as a function of the pH at different temperatures

Development of the Residual Chlorine Rate by Temperature

The residual chlorine consists of the sum of active chlorine (HOCl) and potential chlorine (OCl-). This free residual chlorine has a bactericidal effect to treat small possible contamination of water. For water to be considered potable, it should not be less than 0.5 mg / l (filtered water). However, chlorine residual levels should not exceed 1 mg / l in drinking water treated water. The disinfected water is taken at each temperature (0°C, 25°C, 60°C, 90°C.), poured into the bowl, the DPD1 tablet is then added, stirred and compared using the chlorine comparator. The results obtained are as follows. The analysis in Figure 7 confirms the remarks we have made in previous experiments. Indeed, it is found that the residual chlorine decreases with the increase of the temperature this is due to the decrease of the percentage in HOCl.

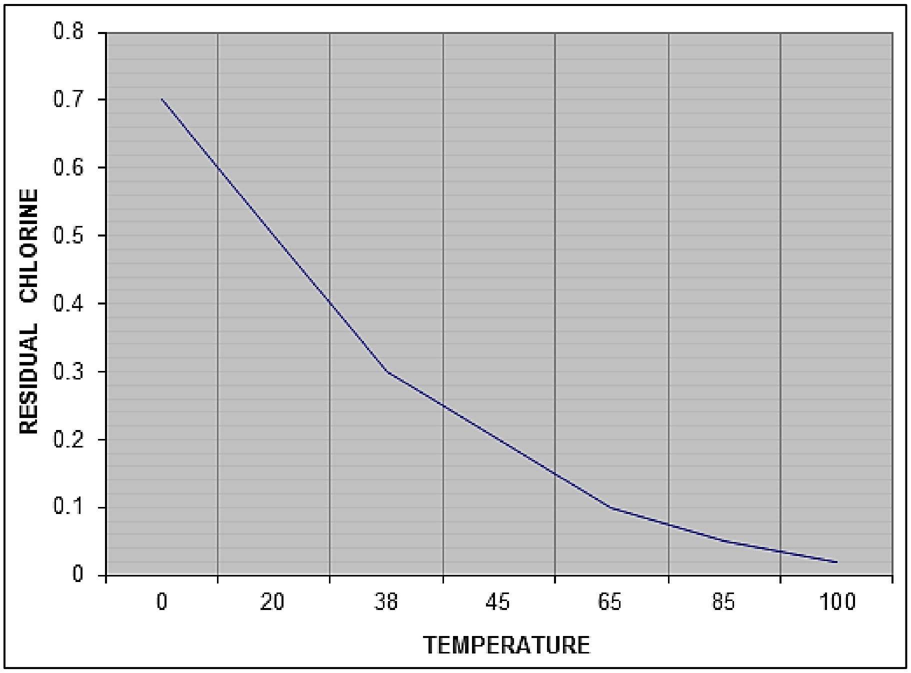

Figure 7: Variation of residual chlorine (mg/l) as a function of temperature (°C)

CONCLUSION

The results obtained show that effective disinfection requires a pH close to neutrality and a temperature not exceeding 25°C. For this reason, the Moroccan standard has set a pH interval of the order of 6.5 to 8.5 so that the active form% HOCl is as predominant as possible and therefore have the possibility of inhibiting the multiplication of pathogens. The study of the residual chlorine variation as a function of temperature confirmed our experimental results. Thus an increase in temperature and pH leads to a decrease in the fraction of the active form (% HOCl).

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