# OPTIMIZATION OF TECHNICAL COMPUTING CHLORINE IN A NETWORK OF DRINKING WATER DISTRIBUTION

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**ABSTRACT**

Monitoring activities of the quality of water produced and / or distributed are under the laws and regulations governing the quality of water intended for human consumption: 1) Moroccan law 10/95 on the water. 2) The European Directive on the quality of water intended for drinking. 3) Of Guidelines of the World Health Organization (WHO) for the quality of drinking water. The distribution network of the urban drinking water is often described as a real reactor, where the water and container (driving ...) are the seat of physicochemical and biological interactions. Tap water may have a very remote quality of that resulting from the production plant. Conditions that control the evolution of the water quality in the network are complex and have been subject in recent years of extensive research. Chlorine is used as a means of sterilization. Its absence leads to microbial contamination that can degrade water quality.According to WHO standards, the free chlorine in the water should not be less than 0.25 g / l. [Lenntech.fr].Chlorine reacts with many compounds and so sudden, all of the damage throughout its transit in the network pipes. This deterioration is the result of several physical factors (age of the pipe material, flow, speed, ...) and biological (bacteria, coliform, biofilm ...)Any company working in a drinking water system requires a thorough knowledge of the distribution of the chlorine content in each point of the network, to do this it must mobilize each time a large number of technicians and materials for proceeded levies and sometimes is in accessing able to conduct given the complexity of the network. To overcome the lack of physical medium capable of delivering this information in real time, we present in this chapter the development of a software sensor based on a mathematical model of chlorine degradation in the pipes. This sensor is used to calculate the chlorine levels at each point of a network of optimal way, without resorting to technical and logistical .for this: 1) We Will address first the algorithms of classification "k means" [MacQueen.1967] louse classify all network pipes in classes resemblance base. 2) Then we will install "k" sensors on the entry and "k" sensors on the release of 'k' lines of each "k" classes, such pipes are accessible collection for the calculation of the rate of residual chlorine remaining, the difference in rates between chlorine and early exit of the pipe is the target value that represents the entire population "K".

**Keywords:** classification, disinfection, chlorination, network, graph theory.

## 1. INTRODUCTION

### 1.1 Introduce the problem

The water distribution services must comply with international quality standards adopted by the World Health Organization (WHO), which set the critical values of tolerance related to chemical and biological compounds. Faced with these quality requirements, and prior to mass distribution, the water undergoes special treatment whose main operations are:

- Aeration to remove tastes and odors;
- Filtering to remove algae and suspended particles;
- Sterilization by chlorination and / or ozone treatment to eliminate, in principle, all forms of microbial life.

All these treatments is made, in post distribution, in storage tanks. The evaluation of the quality of the water during its distribution is determined thanks to takings made, as possible, at the level of various knots of the distribution network. This analysis, often outstanding, concerns several parameters as the turbidity, the chemical composition, the content in chlorine, the bacterial population, etc.

The degradation of the rate of the chlorine along the network is numerous she, bound, at first, to the physico-chemical and microbiological quality of the water produced in treatment plant, and then, in the nature of materials put in touch with the water during its transport, that is in the properties of pipes (material, age, diameter, flow rate, etc.).

However, it turns out that the bacterial growth on the walls of the distribution networks is one of the main of germ contamination of the water, which is at the origin of diseases as the typhoid fever, the cholera or the bacillary dysentery (Crittenden, Trussel, Hand, Howe, and. Tchbanoglous, 2005). Indeed, the population of active bacterial constitutes in network 3,6 % against 0,3 % at the exit of the treatment plants is 12 times as important.

### 1.2 Explore importance of the problem

All company working in a water supply distribution system requires a perfect knowledge of the distribution of the content in chlorine in every point of the network, to this end he has to mobilize every hour a significant number of technicians and materials for proceeded to the takings, so sometimes is unable to access a conduct seen the complexity of the network.

For landing in the absence of average physical appearance capable of freeing this real-time information, we present in this chapter the elaboration of a software based on a mathematical model of degradation of chlorine in pipes. This sensor allows calculating the rate of the chlorine in every point of the network in an optimal way, without calling the technicians and the logistics for it:

- we are going to approach first of all the algorithms of the classification "k means" to classify all the conducts of the network in classes has base of resemblance.
- Afterward we are going to install "k" sensors on "k" conducts by "k" classes; these conducts are accessible in taking for the calculation of the rate of the remaining residual chlorine. This rate of the residual chlorine is the same for every conducts of this class.

## 2. MATERIALS AND METHODS

### 2.1 Modeling of the degradation of the chlorine content in the network

The chlorine is a chemical element (symbol Cl) belonging to the group of halogens and the atomic mass of which is 35,457 (santé canada, 2009) reacts with many compounds and thus undergoes, degradation throughout its transit in the conducts of the network. The majority of the models published in the literature consider that the degradation of chlorine follows kinetics for the first order to obtain (Andréanne Simard, 2008). The assessment of the chemical reactions of the chlorine with all the compounds (Wable, 0. N, Dumoutier, 0. N. Duguet, J, P, jarrige, P, A. Gelas, G and Depierre, J. F,1991).presents in the distribution network is written:

$$Cl2 + P \rightarrow Cl + P\text{-}Cl \quad (1)$$

Where: -Cl2 is the concentration of the free chlorine in the water;

- P the compound reacting with the chlorine;
- Cl and P-Cl are products resulting from the reaction.

The reactionrate of the chlorine consumption is written:

$$V = \frac{d(Cl_2)}{dt} = K_{cl_2\,p}(P).\,t \quad (2)$$

Where $K_{cl_2\,p}$ represent the constant kinetics of reaction of chlorine with the reacting products. This speed depends on the temperature, on the nature of products and on the type (chap) of the chlorine (HClO or ClO-). The integration of the equation (2), gives:

$$\ln(Cl_2) = \ln(Cl_2)_0 - k_{Cl_2 p}(P)t \quad (3)$$

The equation (3) can be transformed to obtain (Andréanne Simard, 2008):

$$Cl_2 = (Cl_2)_0 e^{-k_{Cl_2}P(P)t} \quad (4)$$

As the concentration in compounds reacting with the chlorine is generally unknown, we introduce a constant visible kinetics K of the first order (Munavalli, G. R. and. Mohan Kumar, M. S. 2005), named (appointed) constant of degradation. It is expressed by:

$$K = KCL_2P(P)$$

Of this fact we replace $KcL_2P$ (P) by k, the equation (4) becomes:

$$Cl_2 = (Cl_2)_0 e^{-kt_s} \quad (5)$$

Two essential parameters, the factor of degradation K and the residence time ts, appear in this expression. The relation (4) will be used to calculate the decrease of the chlorine in the whole of the conducts of the distribution network compared with a state of well determined functioning.

Several models proposed this method to describe the degradation of the residual chlorine in a system of drinking water distribution (Tzatchkov, V. G. Aldama, A. A., and Arreguin, F. I. 2002).), (Rodriguez, M. J. and Serodes, J. B. 2003), (Biswaz, P., Lu, C. S. and. Clark, R. M 1993), and (Lu,1991).

### 2.2 Residence time

The transit time of the water, the storage tank to the consumer, depends on the demand of the subscribers and consequently on the diet of functioning of the distribution network. Indeed, the low speed of flow and long residence time of the water favor a fast consumption of the chlorine and a microbial growth (Le Chevallier,1990)besides, we distinguish three slices of consumption:

- Hollow phase: characterized by a low demand, and it is generally situated at night;
- Advanced phase: where the demand is very important in the middle of the day;
- Intermediate phase: connect previous both diets and is characterized by an average consumption.

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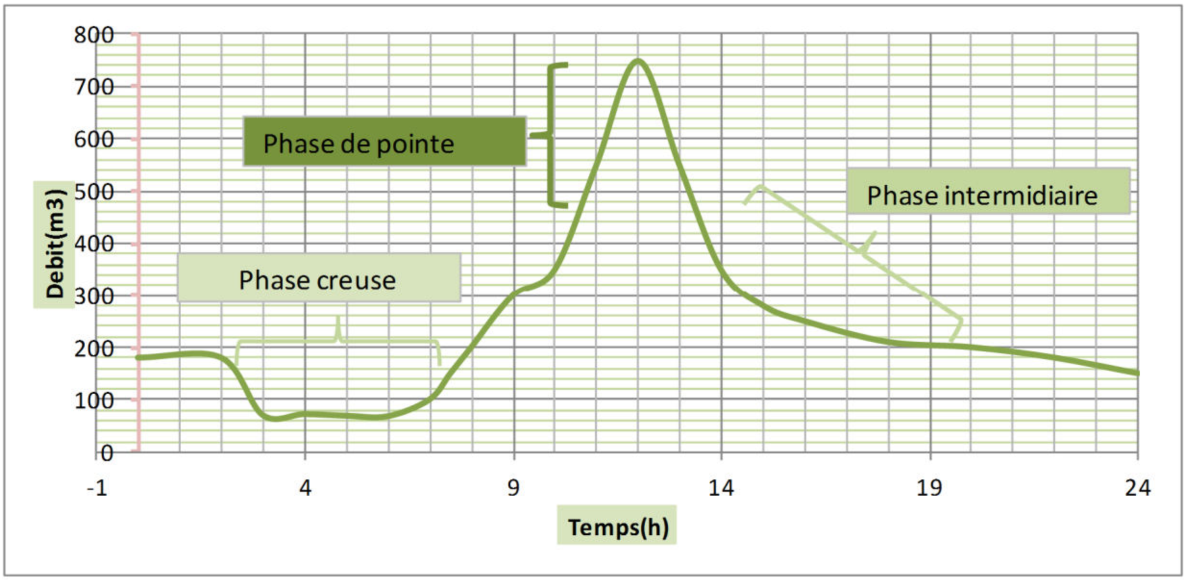


**Figure-1.** Average speed of the consumption of a floo r of the network.

The evolution of the microbiological quality within the network of drinking water interested more of one authors, such as (le chevalier, M. W, 1990); (Le Chevalier, M. W, Cawthon, A. E. and Lee, R. G. ,1988), among these authors several have tents to connect(bind) this degradation has the turbidity or has the temperature but unsuccessfully. Of other one studies look has finds the link between this degradation and the residence time (Kerneis, A., Nakache, F. et Degum, A,1995).The role of the residence time in the network as a mattering factor explaining the difference enters I ' water produced in the entrance of the network and I ' water consumed at the end of network. (Kennedy, M. S., Sarikelle, S. & Suravollop, K,1991).To calculate the residence time of the water within a conduct (driving) it is necessary to determine the age which puts the water between the beginning and the exit(release) of this conduct.

$$\int_0^{t1} E(t)dt \qquad (6)$$

E(t)Represents the distribution of residence times in the conduct equal to 1E(t)d(t) Représente la fraction du débit de sortie de la conduite

$$\int_0^{+\infty} E(t)dt = 1$$

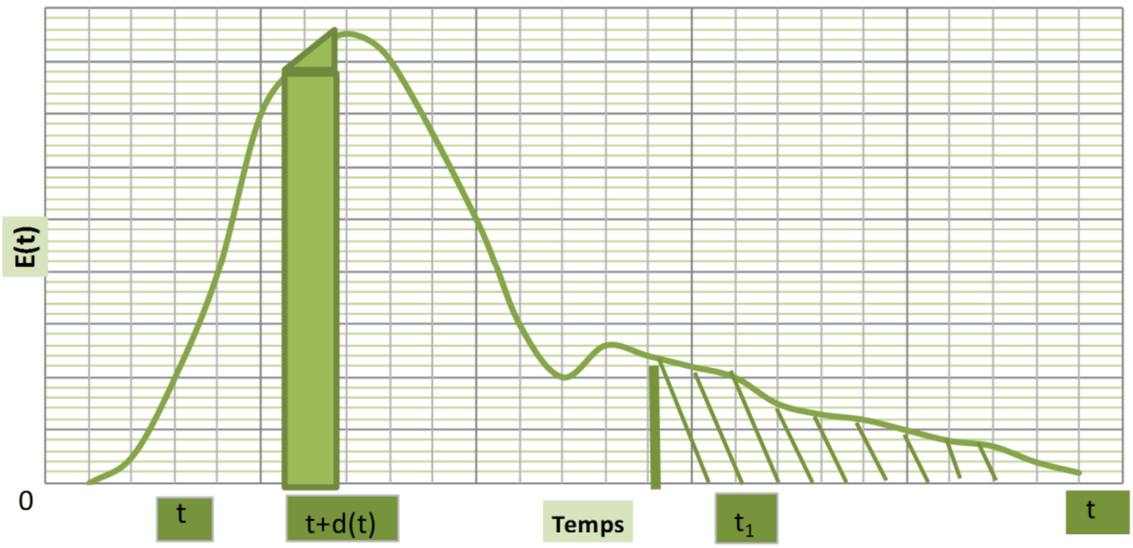


**Figure-2.** Distribution of residence times (E (t) dt is the fraction of the output rate).

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#### 2.2.1Identification of dégradation coefficient

The identification of this parameter, first to determine the concentrations upstream and downstream of the pipe, and then raise the slope of the line represented by the equation (7).

$$\mathrm{Ln}(\mathrm{Cl}_2) = \mathrm{Ln}(\mathrm{Cl}_2)_0 - \mathrm{Kt}_s \quad (7)$$

#### 2.2.1.1. Experimental procedure

On a pipe AB accessible to sampling (cupping, fire hydrants, or load tap tap) of length L and velocity V, the sampling point A (start node) at time t = t0 provides the initial chlorine [Cl2]0

$t_{s=L/V}$

Another swab is levied at the point B (the node arrived) to determine the residual concentration [Cl 2] chlorine after it passes through the pipe.

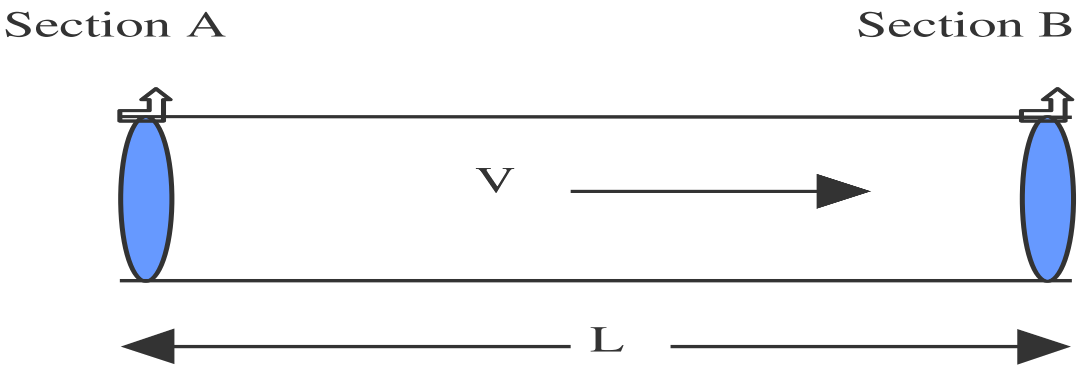


**Figure-3.** Levy on pipe.

Several studies propose methods to count the germs in the water. The daily frequency of measurement of these methods requires to be simple and economical(Gauthier, V., Portal J. M., Yvon J., Rosin C., Block J. C, Lahoussine V., Benabdallah S., Cavard J., Gatel D. and Fass S., 2001).But, this is not possible, in most cases, at the expense of reliability, efficiency and accuracy.

For a better simulation, we decided to assign a coefficient specific to each pipe degradation. However, all pipes are not suitable for measuring this parameter. Thus, we used the automatic classification of lines (machine learning algorithm) based on the characteristics upon which this factor (the nature of the conduct, its diameter and its age commissioning ...).

This leads us first through unsupervised classification, to partition a set of classes in the visible lines in the measurement of the degradation coefficient. In this case, each class will label the average value of this coefficient. Then a supervised classification will allow us to assign to driving, not accessible to measurement, the value of the degradation coefficient corresponding to the label (calculated value) of the class in question

### 2.3 Unsupervised classification algorithms

The principle of unsupervised classification algorithms (MacQueen, J.B.1967)reads optimization in general in terms of a well-defined mathematical criterion. This criterion is intended both to optimize intra-class and inter-class inertia. Is expressed by (Institut de Mathématiques de Luminy):

$$\mathrm{J}(\mathrm{U},\mathrm{V}) = \sum_{\mathrm{I}+1}^{\mathrm{C}} \sum_{\mathrm{x}\in \mathrm{u_i}} \mathrm{p_{ik}} \mathrm{d_A}^2(\mathrm{X_k},\mathrm{V_i}) \quad (8)$$

with: $d_A^2(x_k, V_i) = \|x_k - V_i\|_A^2$ measuring the distance provided by the metric A (positive definite symmetric matrix);

- xk: the pipe characterized by the parameters (age, kind, diameter and coefficient of degradation of the pipe);
- Vi: the center of gravity of class i($1 \le i \le c$);
- $P_{ik}$: the weight of the pipe in the class i xk we made equal to 1, to facilitate any parameters on others.

We can say this optimization process attempts to form from unlabeled pipes, c classes that are as homogeneous and natural potential. "Homogeneous" and "Natural" means that the classes obtained should contain the most similar possible objects, while objects of different classes should be as dissimilar as possible.

The basic partitioning and optimization algorithm is summarized in two phases as follows (Ball and Hall,1967).

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**start** Soit X={$x_1$,…$x_n$} ∊ $R^{np}$ a finite set of n data, not labeled, characterized by t paramètres.
**Initialization step**:
Fix c, 2 ≤ c ≤ n, /* the number of classes */
choose ε > 0, /* the stopping criterion */
Choose metric ||.|| A,
Randomize c initial centers of gravity $V^o = (V^o_1,\ldots,V^o_c)$ $R^{cp}$.
Initialize the number of iterations r à 1.
**Step1 ; iterative sequence**
Build partition $U^r = (u_1^r,\ldots,u_c^r)$ Using the equation:

$$u^r_{ik}(x) = \begin{cases} 1\ldots\ldots Si\ d_A(x_k,V_i) = \min_j d_A(x_k,V_j)\ avec\ j \neq i\ \forall i,k \\ 0\ldots Sinon \end{cases}$$

Adjust the centroids $V^r = (V^r_1,\ldots,V^r_c)$ ∊ $R^{cp}$ par $V^r_i = \sum_{k=1}^{n} u^r_{ik} x_k \Big/ \sum_{k=1}^{n} u^r_{ik}$ .

**Step 2 ; Stopping criterion Rating**
calculate $E^r = ||V^r - V^{r-1}||^2 = \Sigma\, ||V_i^r - V_i^{r-1}||$.
**Step 3 ; Convergence test**
**If** $E_r$ ≤ ε then Stop
**else** r=r+1, return to step 1
**End if**
**End**

## 2.4. Supervised classification

Supervised classification not accessible conducted to measure the chlorine content was carried out with the classical algorithm of the k nearest neighbors "according Zahid (1999)." Its principle is to calculate the k nearest conducted at the unlabeled sample using a measurement distance dij. This measurement is performed using the Euclidean metric:(dij = || xi –xj ||1/2 ).

Soit X {x1, x2,….., xn}the set of n lines and labeled to be driving to classify. The algorithm form, in a first step, the set E of k nearest neighbors of y in the direction of the distance d used. Then it will affect either the majority class in this set or class whose objects are closest to conduct it (based on the sum of the minimum distances).

```
Start
Read y (Nature, Diamètre, Age)          /* Pipes to classify  */
Read k                                        /* The number of nearest neighbors */
Until i<= n
Calculate d(y,xi)
            If (i<=k) then add xi to the set E for k nearest neighbors.
            else if there is a nearest neighbor xj as xi such that :
                max (d(y,xj) (1≤j≤k), xi ™ E) > d(y,xi) then replacing xi par xi.
            End if
I=i+1
End while
Determining the majority class represented in the set of K Nearest Neighbor.
     If(multiple classes exist) then
       Calculate the sum of the distances from neighbors to each existing class,
         If sums are different then
           Assign it to the class that has the minimum amount,
           Else assign it to the last class that has the minimum amount,
         End if
     Else assign it to the one majority class,
     End if
End
```

Automatic classification has helped to overcome the problem of assessing the degradation coefficient for inaccessible pipes to the identification of this parameter. This constitutes a major step in the successful development of the simulation tool of the chlorine distribution.

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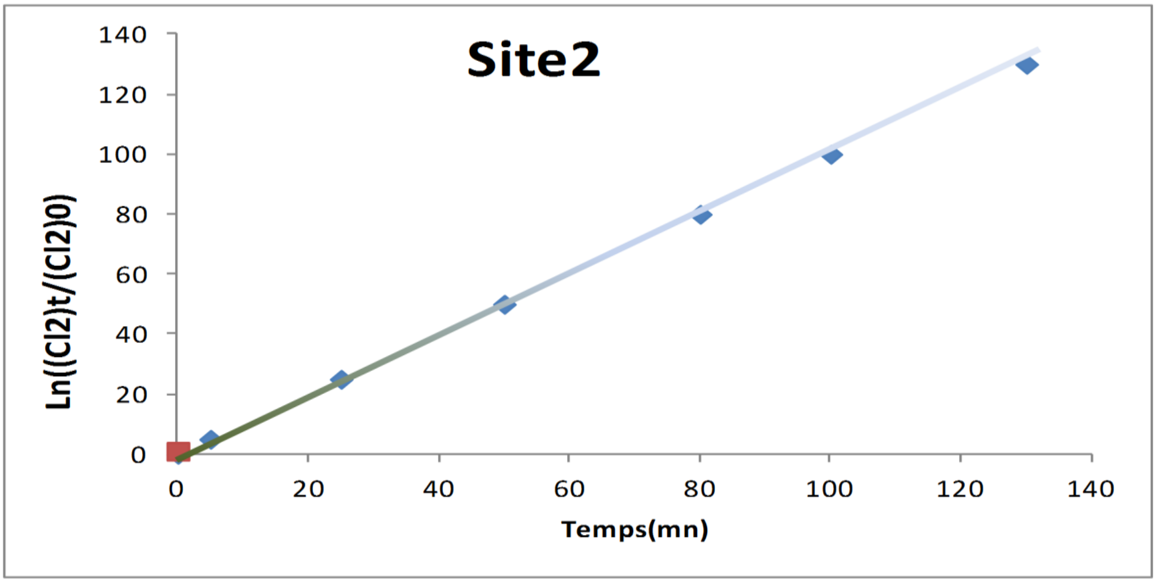
**2.3.2 Determination of the coefficient of degradation**

A measurement campaign for determining the degradation coefficient was conducted on several floors of REDAL. All distribution networks along the lines selected for this purpose; we were able to monitor the level of free chlorine according residence time in these pipelines. Is plotted on the chart (1) the results of the measurement campaign conducted on the stage 61 of the Rabat distribution network.

**Table-1.** Measuring companion on the pressure stage 61.

| Code | Site 1<br>65 et 67 | Site 2<br>41 | Site 3<br>58 | Site 4<br>73 | Site 5<br>38 | Site 6<br>40 |
|---|---|---|---|---|---|---|
| pipe | Rag-22-21 | 10-10A | 21-15 | 22D-23 | 13-8 | 9-11 |
| Diametere (mm) | 500 | 500 | 500 | 400 | 300 | 200 |
| K' ($mn^{-1}$) | 3.63 $e^{-3}$ | 3.50 $e^{-3}$ | 3.66 $e^{-3}$ | 3.70 $e^{-3}$ | 4.28 $e^{-3}$ | 4.64 $e^{-3}$ |



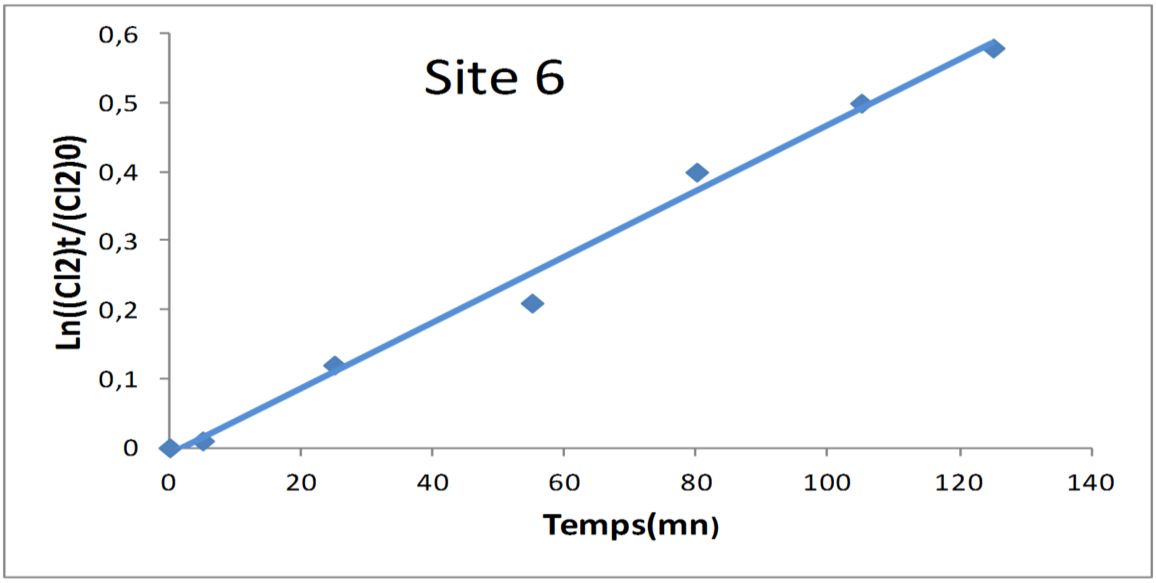




**Figure-4.** Identification of degradation coefficients (Floor 61).

The value of the coefficient K intimately depends on several parameters related to the intrinsic properties of the pipe and the overall network operating condition. The distribution system is comprised of a heterogeneous set of pipes. Each of them is characterized in part by static parameters such as the nature of its material, its diameter and its length, and secondly by dynamic parameters such as its commissioning age and the flow velocity water in the pipe.

## 3. RESULTS AND DISCUSSIONS

With a measurement campaign conducted in collaboration with technical teams from the control water distribution in the wilaya of Rabat (Redal), we were able to collect the necessary information for the development of the results of this work. Before presenting the results, we first present the network covered by the study.

### 3.1. Overview of the network of the wilaya

The distribution network of drinking water REDAL is divided into several pressure stages.

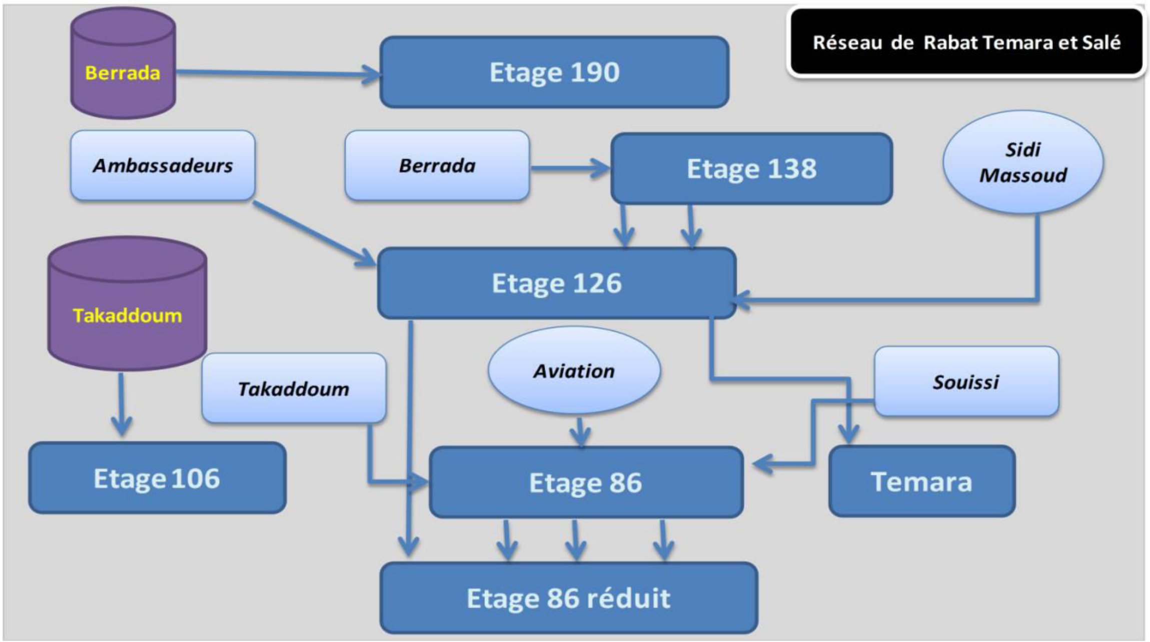



**Figure-5.** Rabat configuration of the network.

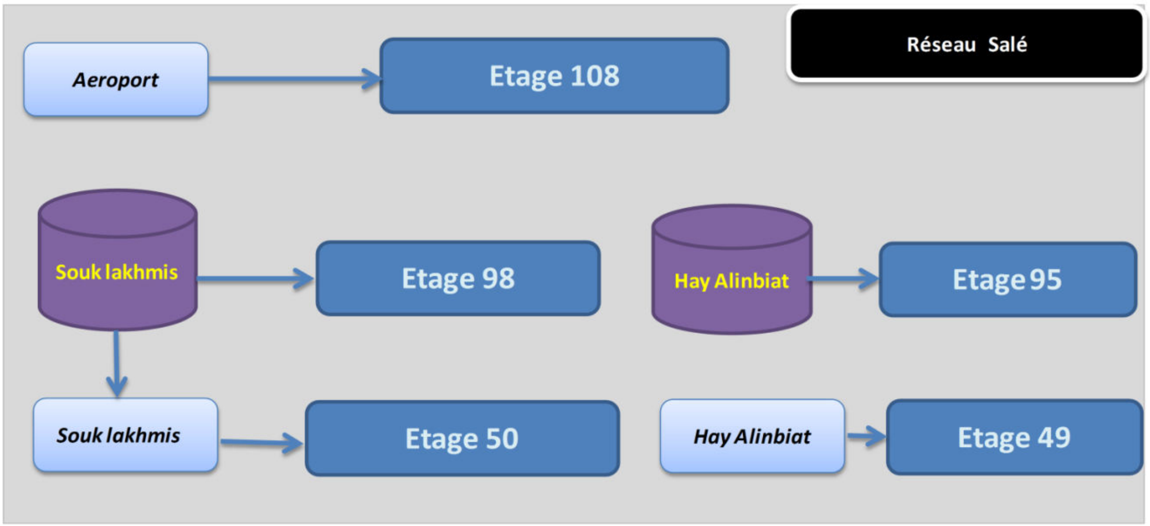



**Figure-6.** Salé configuration of the network.

All studies performed on all floors only to larger diameter pipes or equal to 150 mm.

### 3.2 Contestation

The classification results have allowed us to partition the set of identified conducted in n classes (Table-2). The label for each of them is defined by the average of the coefficients of deterioration of its components.

**Table-2.** Results of the classification lines.

| Class | Area | Pip | | Diamèter | Nature | Age | Coef. measured | Label |
|---|---|---|---|---|---|---|---|---|
| | | Code | The nodes | mm | | years | $mn^{-1}$ | $mn^{-1}$ |
| 1 | Etage 138 | 16 | 13-9A | 1100 | 1 | 5< a<10 | 1.24 $e^{-3}$ | 1.44 $e^{-3}$ |
| | Etage 138 | 7 | 6-6C | 1000 | 1 | 5< a<10 | 1.52 $e^{-3}$ | |
| | Témara Bas | 1 | R2.5m-2 | 800 | 1 | 5< a<10 | 1.56 $e^{-3}$ | |
| 2 | Etage 86 | 114 | 66-62 | 800 | 1 | 5< a<10 | 1.75 $e^{-3}$ | 1.80 $e^{-3}$ |
| | Salé Bas | 24 | R30m-2N | 700 | 1 | 5< a<10 | 1.79 $e^{-3}$ | |
| | Salé Bas | 87 | 6C-6D | 600 | 1 | a<5 | 1.86 $e^{-3}$ | |
| 3 | Etage 86 R | 23 | RIB2-40 | 600 | 1 | 5< a<10 | 2.00 $e^{-3}$ | 2.16 $e^{-3}$ |
| | Etage 86 | 81 | 52A-42 | 500 | 1 | a<5 | 2.22 $e^{-3}$ | |
| | Salé Haut | 6 | 4-61 | 400 | 1 | a<5 | 2.26 $e^{-3}$ | |
| 4 | Salé Bas | 51 | 6C-2H | 500 | 1 | 5< a<10 | 2.48 $e^{-3}$ | 2.59 $e^{-3}$ |
| | Etage 86 R | 87 | 58-71 | 600 | 1 | a>10 | 2.55 $e^{-3}$ | |
| | Témara Bas | 2 | 2-20 | 400 | 1 | 5< a<10 | 2.74 $e^{-3}$ | |
| 5 | Salé Haut | 35 | 6C-17 | 400 | 1 | 5< a<10 | 3.15 $e^{-3}$ | 3.11 $e^{-3}$ |
| | Etage 86 | 131 | 60-59A | 400 | 1 | 5< a<10 | 3.00 $e^{-3}$ | |
| | Etage 86 | 40 | 19-19A | 300 | 1 | a<5 | 3.18 $e^{-3}$ | |
| 6 | Etage 61 | 58 | 21-15 | 500 | 1 | a>10 | 3.70 $e^{-3}$ | 3.77 $e^{-3}$ |
| | Etage 61 | 73 | 22D-23 | 400 | 3 | a>10 | 3.66 $e^{-3}$ | |
| | Etage 86 R | 25 | 49-40C | 400 | 3 | a>10 | 3.95 $e^{-3}$ | |
| 7 | Etage 86 R | 30 | 42-33A | 250 | 3 | a>10 | 4.52 $e^{-3}$ | 4.48 $e^{-3}$ |
| | Etage 86 R | 72 | 60-60A | 150 | 1 | a>10 | 4.28 $e^{-3}$ | |
| | Etage 86 R | 5 | 32-35 | 350 | 4 | a>10 | 4.64 $e^{-3}$ | |

To accomplish its tasks, the tool uses data on the one hand the geometry of the studied network, such as information relating to the nodes (name, code, history) and pipes (code starting node, destination node, length, diameter, coefficient of chlorine degradation in driving). And secondly, the data representing the hydraulic state like flow distribution at the nodes, the water temperature (summer or winter season) and the water flow rate in each pipe. The tool also uses two essential parameters to the simulation of the distribution of chlorine in the networks which are: the reference, the value of the chlorine content in the injection point (tanks, wells and pipes with a chlorine booster station) and the minimum threshold (0.1mg/l) chlorine below which a node is declared deficit. Based on these data, the decision support tool developed chlorine distribution anywhere on the network and selects and displays the data of each pipe or selected node.

In this work, we limit ourselves to the presentation of results for two-stage characteristics of the wilaya network. Thus, we have deliberately chosen a floor on the outskirts of Rabat, the Témara and another in the center of the city in this case the 86-floor reduces fueling neighborhoods of Akkari, Yacoub el Mansour and Hay el Fath

**3.3 Floor 86 reduced**

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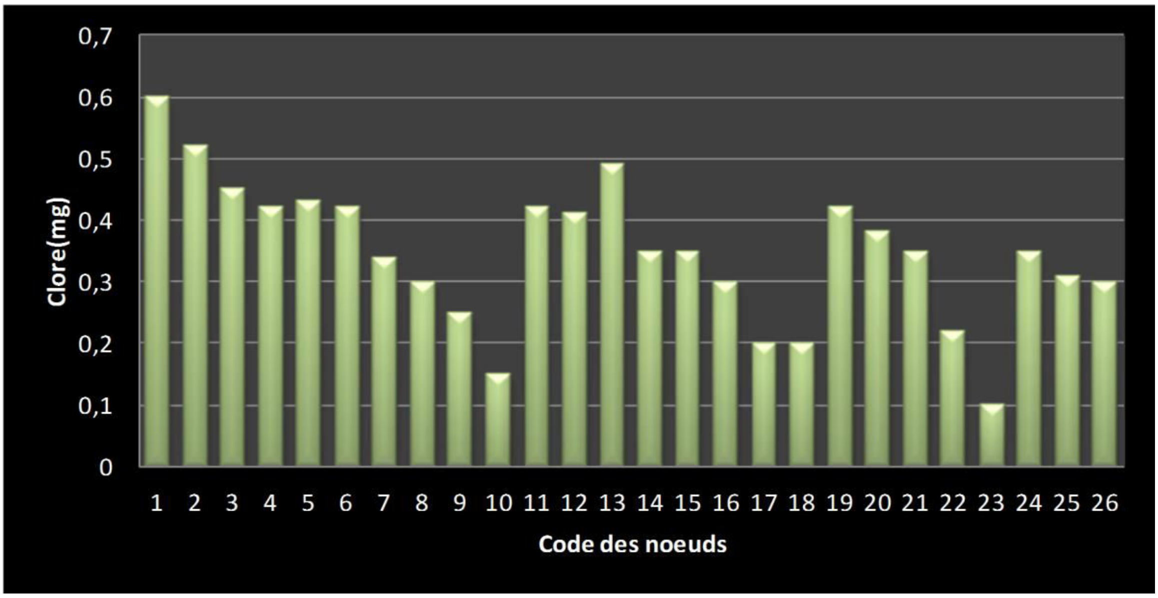


**Figure-7.** Chlorine distribution: Floor-86 reduced.

This floor has the distinction of being supported only by coming transfer lines, as shown in (Figure-7), stages 86 and 126. It consists of 141 pipes (diameter> = 150mm) forming 105 knots.

The analysis of the simulation results (Figure-7) shows that 18% of the nodes are in deficit, 4% in a precarious situation (between 0.25 and 0.3 mg/l), 24% in medium range between (0.3 and 0.45 mg/l), the remaining 54% are in a comfortable position because their concentration is above 0.45 mg/l. It is clear that the number of nodes deficit increaseswith the value of the threshold.

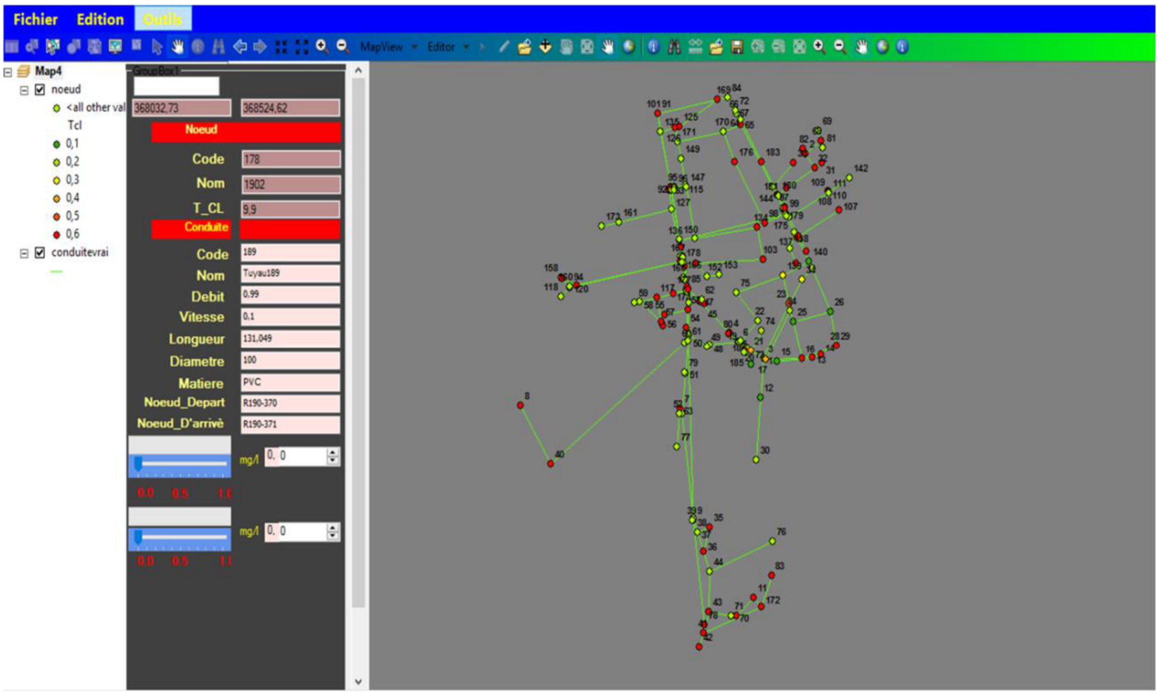


**Figure-8.** Block diagram of the 86-floor reduces.

(Figure-8) shows the GUI simulation where we combined a set of useful information for better use of this tool. The displayed values are relative to the node and the selected line (in white on the graph). Green nodes represent the stage feeding points; their chlorine content corresponds to the desired (Cl rate reservoirs). Those in red indicate deficit nodes whose content is below the minimum threshold.

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### 3.4 Temara low floor

Temara The distribution network consists of two pressure stages. We present only the results of the bottom floor.

This floor has the distinction of being less dense than the center of Rabat. It consists of 26 nodes interconnected with 29 lines. (Figure-9) shows the graphical interface of the simulation tool. Information displayed on the conduct and highlighted node (in white) in the diagram. We also note that the locations of the nodes deficit generally occupy the terminal ends of the network.

Simulation results for a set of 0.6 mg / l and a tolerance of 0.25 mg / l are shown (Figure-10). Indeed, it appears from this simulation that 19% of the nodes are in deficit, and 4% are in a critical area (between 0.3 and 0.25 mg/l).

Taking into account the simulation results of the two-story, we find that 20% of the network is below the international quality standards. Therefore curative measures are required.

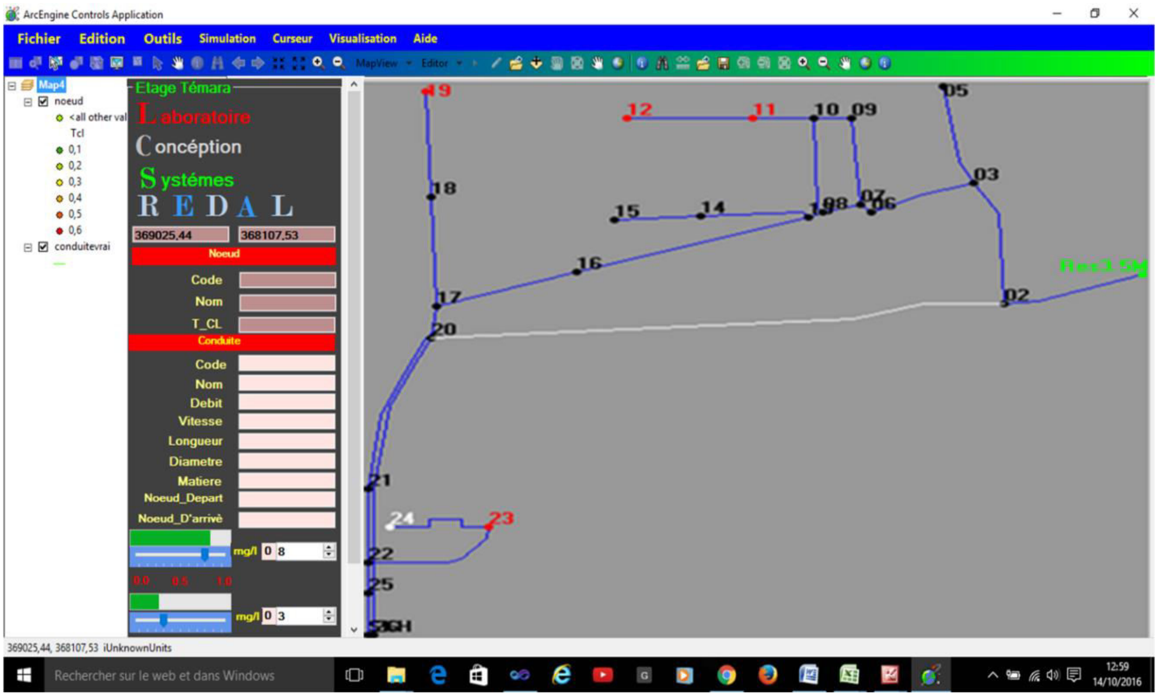


**Figure-9.** Block diagram of the floor Temara.

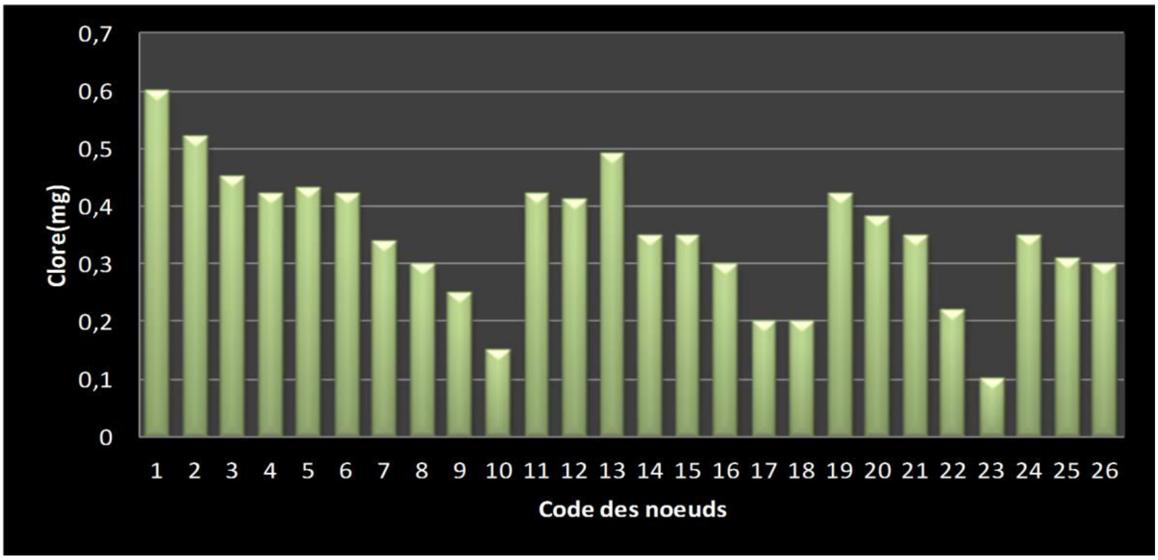


**Figure-10.** Chlorine distribution: Floor Temara.

### 3.5 Evaluation of the method

This work was performed in the laboratory system design and the Faculty of Science in Rabat Morocco, The fundamental objective of this work is the search for an optimal method for calculating the rate of chlorine at any point in the network and solve the problem of inaccessible pipes to the measure.

To evaluate this method, we proceed in accordance with a value judgment by comparison with hydraulic simulation software.

For this reason we have chosen for comparison a very popular software in the water property (EPANET).

- EPANET 2.0

This software provides a quality module that calculates the concentrations of chemicals, water residence time in different parts of the network. It also tracks the origin of the water. Using this quality module requires a prior hydraulic timing. To do this it is required to enter data for all the lines which are:
Feedback coefficient in the mass of water.
Reaction coefficient to the walls.
To calculate:

Flow:
- The flow velocity.
- The pressure drop.
- The friction factor Darcy-Weisbach.
- The mean reaction rate (along the pipe).
- the average quality of the water (along the pipe).

EPANET Suppose that all pipes are full at all times (which is not obvious).

Each formula uses a different roughness coefficient to be determined empirically, hence the problem of choosing the formula.

The Hazen-Williams formula is the head loss formula most used in the United States. It can not be used for liquids other than water and was originally developed only for turbulent flows. The Darcy-Weisbach formula is theoretically the most correct and is the most widely used in Europe. It applies to all flow regimes and all liquids. The Chezy-Manning formula is generally used for flow in open channels and for large diameters. The Darcy-Weisbach formula is selected by default (Manual epannet 2.0).

Each formula uses the following equation to calculate the pressure drop between the n.uds start and end of the pipe:

$h_l = Aq^B$

The advantage of our method is that it is over all these problems choosing the roughness coefficient and optimizes material and human resources by and offers a very simple method to optimize the time and cost at the same time.

## 4. CONCLUSIONS

The study of the laws governing the phenomena of degradation of the quality of water in urban distribution networks has enabled us to develop a mathematical model capable of evaluating the chlorine content in any point of the network of optimal manner. However, the reliability of this simulation tool is the efficient estimation of the constant chlorine degradation kinetics. Moreover, this parameter depends on the physico-chemical and microbiological quality of water distribution and status lines (kind of pipes, commissioning age and diameter). The inability identification of this coefficient for each pipe, we opted for automatic classification of pipes is mainly based on their similarity indices. Thus, we have reduced the complexity of the problem, assigning to each pipe, not accessible to measurement, the best coefficient of degradation to be as close as the actual structure of the network. This allows refining the calculations and also considering small diameter pipes, where the degradation is intense. Thus, we will provide users a reliable and powerful tool. The tool thus designed to offer the user a snapshot of the chlorination system. This one allowed a share cost reduction measures (reagents, samples, travel), and also the identification of critical areas where implementation chlorine concentration is below international health standards. Finally, this simulation tool will be the nucleus of the optimal search for locations of intermediate stations chlorination, the next chapter, in order to continuously maintain a tolerable concentration of chlorine anywhere on the network.

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