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Study of the Influence of Residual Chlorine on Some Parameters of Organoleptic Quality Of Tap Water at Ain Temouchent city (Western Northern Algeria)

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Abstract

Disinfection of water with chlorine plays a leading role in the protection of drinking water against pathogenic microorganisms and consequently the prevention against waterborne diseases. However, this disinfectant can also react with naturally occurring substances in water and which may pose a problem on the aesthetic or health plan.

The objective of this study carried out at Ain Temouchent city was to estimate the influence of residual chlorine on the organoleptic aspects of the drinking water, and that through a monthly sampling carried out on thirteen sampling points from subscribers of this locality during a period of one year.

The determination of chlorine residual level was effected by the DPD method, while the estimate of taste and odor contained in the analyzed waters was based on the capacity of each taster to detect the presence or not of taste or smell.

Our obtained results showed that the concentrations of residual chlorine in drinking water have certainly exceeded the prescribed standards and that was reflected clearly on taste and even smell of the same waters (with a non-compliance rate that corresponds to 53.84% for taste and 46.15% for the smell).

Furthermore the statistical processing of our data with the principal component analysis, allowed us to confirm the existence of highly significant relationships between chlorine used as a disinfectant and the others parameters studied.

This influence of chlorine making this drinking water unpleasant for the drink in some points encourages us to undertake practical actions to better improve the quality of water distributed.

Keywords: Taste, smell, water, Ain Temouchent city, residual chlorine, influence.

INTRODUCTION

Water is one of the most important natural resources for the survival of humanity and the socio-economic development of nations. All water intended for human consumption must be continuously available in sufficient quantity, and should not present a risk to health [1].

For this reason, the drinking water consumers are increasingly concerned about the safety of the water distributed by public water systems[2].

The first concern relates to microbiological contamination [3]. In second place are those associated to chemical contaminants [4]. Aesthetics aspects of water, especially those related to the tastes and smells can represent an important part of the perception relating to the quality of drinking water [5].

The guarantee of this of water safety destined for human consumption involved the disinfection processes (mainly chlorination) which are in mostly implemented at the treatment installations.

However, the chlorination of drinking water is one of the leading causes of complaints related to taste and odor of drinking water [6, 7].

Chlorine is certainly the most reactive used for the disinfection of water in its various forms (bleach, chlorine gas, chlorine dioxide). It is consumed primarily by the organic matter, which offers the formation of chlorinated compounds and that can deteriorate the taste of water (by giving it a medical taste) [8, 9].

The goal of this study is to estimate the influence of residual chlorine used for disinfection on the taste and smell of the tap water collected from Ain Temouchent city over a period of one year.

1. MATERIAL AND METHOD

1.1. Presentation of the study area

Ain Temouchent, city located 72 km SW of Oran, 63 km NW of Sidi Bel Abbes, and 69 km NNE of Tlemcen as illustrated in figure 1 below.

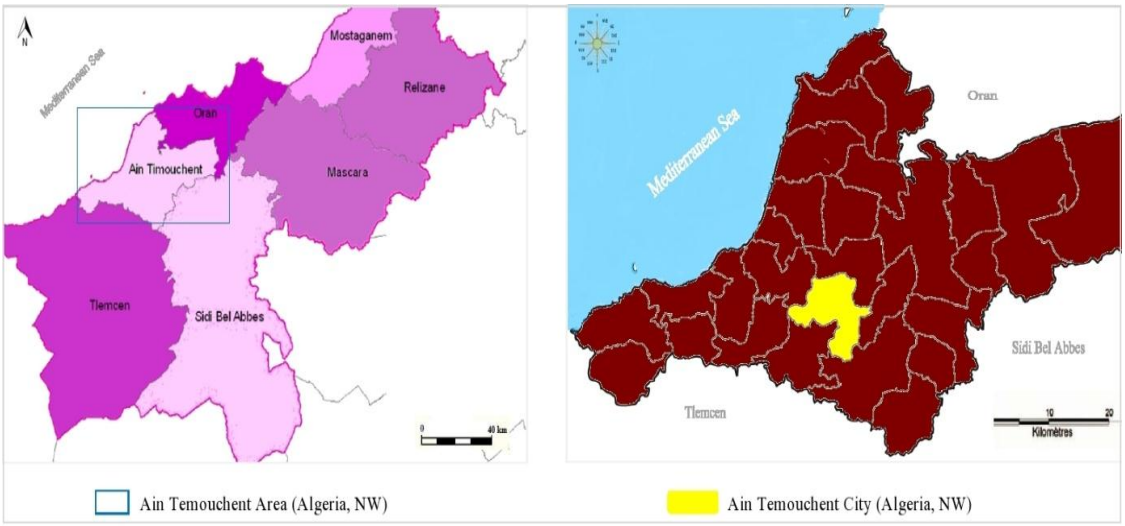

Figure 1: Geographical location of the study area [8].

1.2. Simpling

The study had taken place over a period of thirteen months where the sampling program has started, the month of November 2012 and ended on November of 2013.

The sampling points were chosen according to the different urban areas of the city (North, South, East, and West) where; thirteen points of water (tap subscriber) were collected from the various selected points.

The table 1 below summarizes the civic address and the geographic coordinates of each selected sampling point.

Table 1: Identification of the sampling points of the drinking water samples

Stations	Adress	Latitude	Longitude
S_1	Akid Othmane city	35.31 ° 51'73" N	1.12 ° 97 '79" W
S_2	1000 housing city	35.30 ° 41'59" N	1.13 ° 94 '28" W
S_3	Boulevard first November 1954	35.28 ° 84 '61"N	1.14 ° 06'79" W
S_4	Baraka city	35.30 ° 21 '19"N	1.13 ° 04'13" W
S_5	Pasteur street	35,29 ° 19'28 " N	1.13 ° 94'99" W
S_6	February 24 street	35.29 ° 68 '47" N	1.14 ° 02'19" W
S_7	Olives city	35.30 ° 67 '27" N	1.14 ° 95'41" W
S_8	411 housing city	35.29 ° 13 '50" N	1.13 ° 11'52 " W
S_9	August 20 street	35.29 ° 70 '42" N	1.14 ° 47'29" W
S_{10}	Castors city	35.30 ° 41 '22" N	1.13 ° 86'89" W
S_{11}	129 housing Tounsi city	35.30 ° 91 '46" N	1.14 ° 13'66" W
S_{12}	The OPGI Complex, road from Oran	35.30 ° 53 '20" N	1.14 ° 28'09" W
S_{13}	City first May	35.29 ° 39 '86" N	1.13 ° 55'19" W

1.3. Determination of the residual chlorine concentrations

The residual chlorine concentrations were determined by using a comparison disc apparatus, LOVIBOND mark, by the DPD method (diethyl-p-phenylenediamine), where the chlorine present in the sample as acid hypochlorous form or hypochlorite ion reacts with the DPD to give a red color which is proportional to the concentration of chlorine.

1.4. Determination of taste intensities

Taste is the term used to describe the sensation in the mouth when absorption of food or liquid. It is evaluated by jury by comparing the sample or its dilutions with a reference water (we had used distilled water as reference water).

The method of sensorial estimation of the water taste is commonly used for a description of flavors and aromas present in samples [10].

It is based on the determination of the taste threshold apparition by panelists after various dilutions with the reference water;

The threshold is determined by the dilution that gives the first appearance of taste or smell.
In order that the water conforms to the standard, it is not necessary to dilute it more than twice at 12 ° C, or three times at 25 ° C [11].

Many more repetitions are necessary to obtain reliable results due to the variability of perceptions of tasters.

Before proceeding to analysis, all samples and reference water must be brought to the same temperature, using a water bath which is able to homogenise them at 25°C.

During this study, the sample and the reference water were deposited to ambient temperature of the room during an hour. This method allowed us to get approximate temperatures.

1.5. Determination of odor intensities

The smell plays the greatest role in the perception of the substances responsible for taste and odor. The response of human tastes and odors is described by two ways: by term (sweet, musty, medical, etc.) and intensity (low, moderate, strong etc.) [12].

To get approximately the scale of the intensities of smells, these steps must to be followed. In conical flasks put 10, 20, 30, 60, 80,100, 120 ml of sample water, and then complete each flask to 120 ml with water odorless; in another, put 120 ml of

water reference. Shake each one 3 or 4 times before feeling order to characterize the type of odor [13].

Classify glasses that have a smell and what does not, and record the threshold. The number of dilution depends to the ability of the operator to detect a small change in smell. For this study the tasting is carried out by a team of three operators.

2. RESULTS AND DISCUSSION

2.1. Study of chlorine residual concentrations of water consumption

The results related to this parameter are reported in figure 2 below.

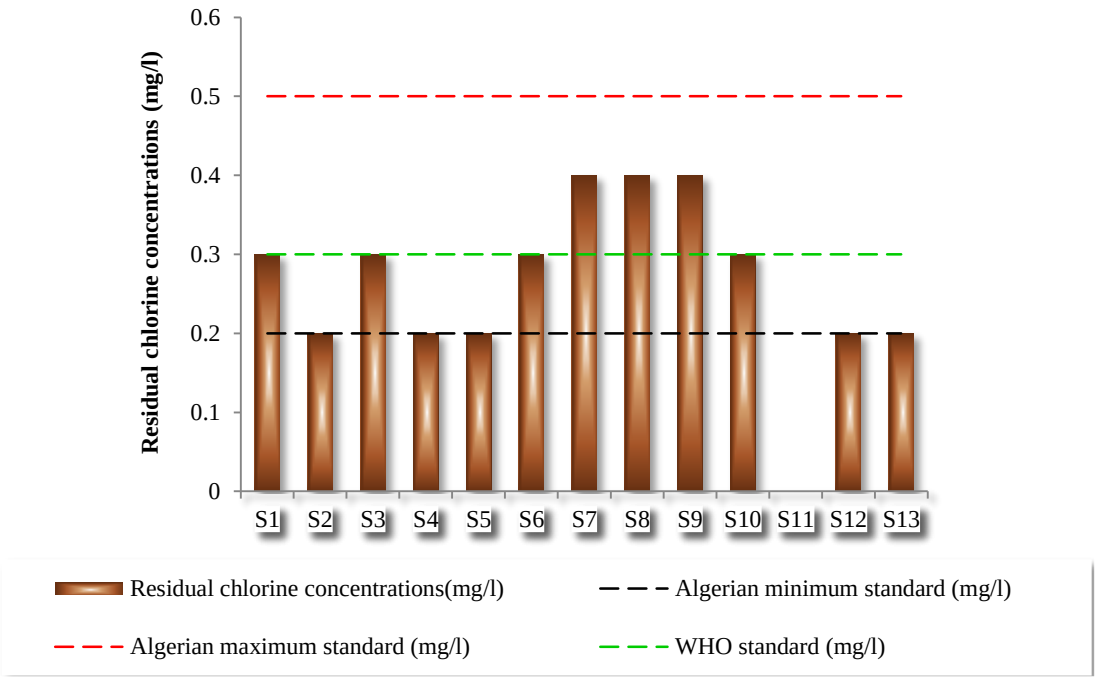

Figure 2: Concentrations of Ain Temouchent city drinking waters on residual chlorine

The results of the level of drinking water collected on residual chlorine, has conducted us to conclude that concentrations of chlorine had been variable from one site to another.

These recorded concentrations are reassuring, but they had really exceeded the required values to maintain the bacteriological quality of the water during transport to the consumer's tap, which, at this point, the residual chlorine level must be included between 0.1 and 0.2 mg / l [14].

On the other hand, if we compare our results with the Algerian standard (Official Journal of the Algerian Republic) relating to this parameter, these levels have exceeded the minimum standard which is set at 0.2 mg/l [15]. However, they were acceptable, according to World health organization because they were situated between the minimum value which is set at 0.3 mg / l and the maximum which is 0.5 mg / l [16].

Moreover, in some sampling points, there was a complete absence of residual chlorine (00 mg / l), in particular at the nearest points to the storage reservoir where, the chlorine content of the water oscillates between 0.8 and 1 mg/l (depending to Water Algeria services). However this absence of residual chlorine recorded is not acceptable according to prescribed standards. More than, it was a certain tendency towards stability of these concentrations and this can be interpreted by the short residence time of water in the supply pipes of drinking water.

2.2. Taste and smell

The experimental study which aims to identify the intensities of the taste and odor of Ain Temouchent city drinking water, allowed us to note in all, 56 dilutions for parameter taste and 75 for the smell.

The results of the sensory analyzes are reported in figure 3 below.

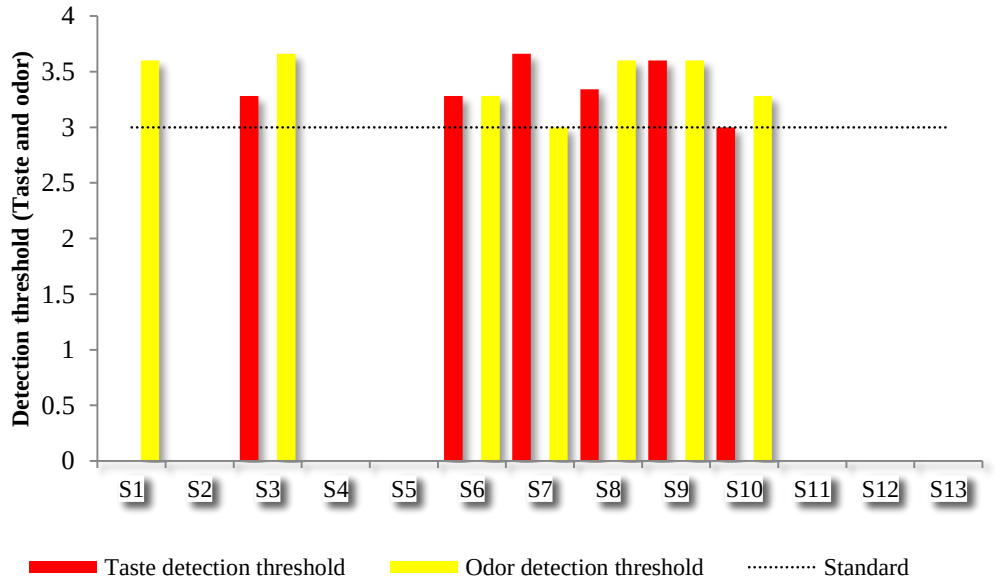

Figure 3: The evolution of the intensity of the taste and odor of drinking water from Ain Temouchent city

The figure 3 which represents the evolution of the intensities of taste and odor of water collected, shows that the results were variable from one site to another, as it confirms that the drinking water in our study area were moderately unpleasant to drink because of the taste detection threshold and odor registered in this city (3.66), and which indicate that these water contain certain tastes and intense odors.

In addition, it appears that the detection thresholds obtained which are comprised between 0 and 3.66, had slightly exceeded the recommended standard which is set at 3 to 25 °C, and with a non-compliance rate that corresponds to 53.84% for taste and 46.15% for the smell.

The identification results tastes of drinking water collected from this locality are reported on figure 4 below.

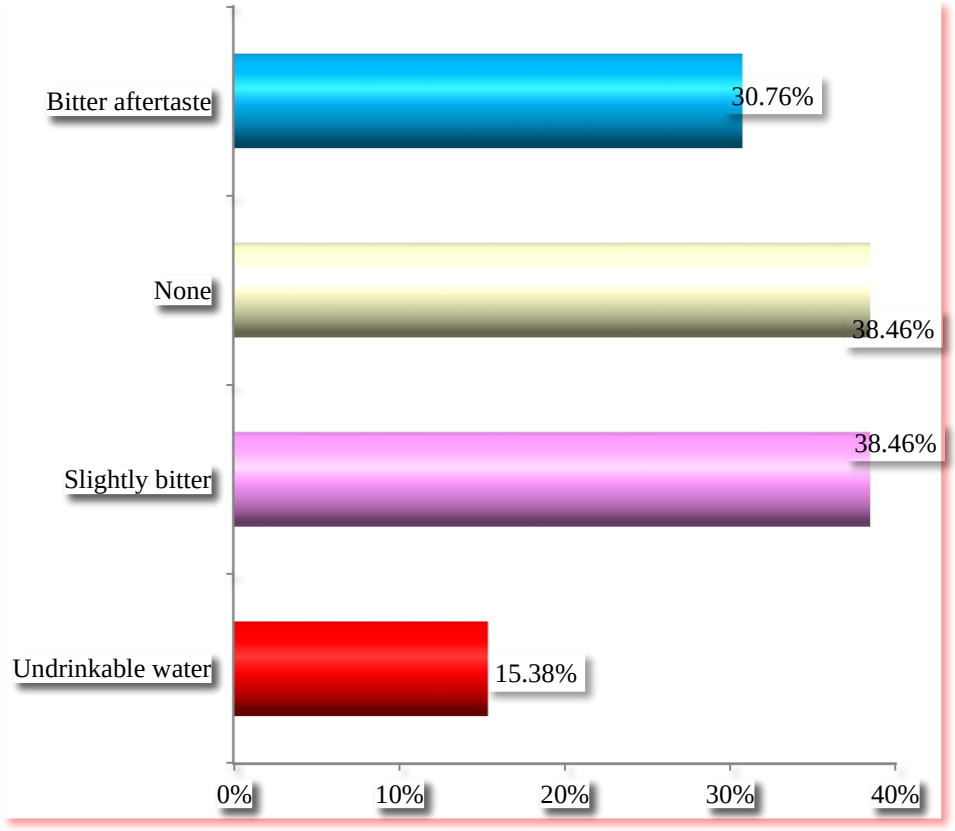

Figure 4: Nature taste of the drinking water of Ain Temouchent city

If we examinate this figure, it appears that at Ain Temouchent city, the three operators have come to detect aslightly bitter taste unpleasant in some samples (38.46%).

The nature of the odors of these samples had varied between that of bleach, earth, and rust. However in some other, no taste and no odor was detected (odorless water).

The estimates of the three tasters regarding odors of the drinking water collected are reported in figure 5 below.

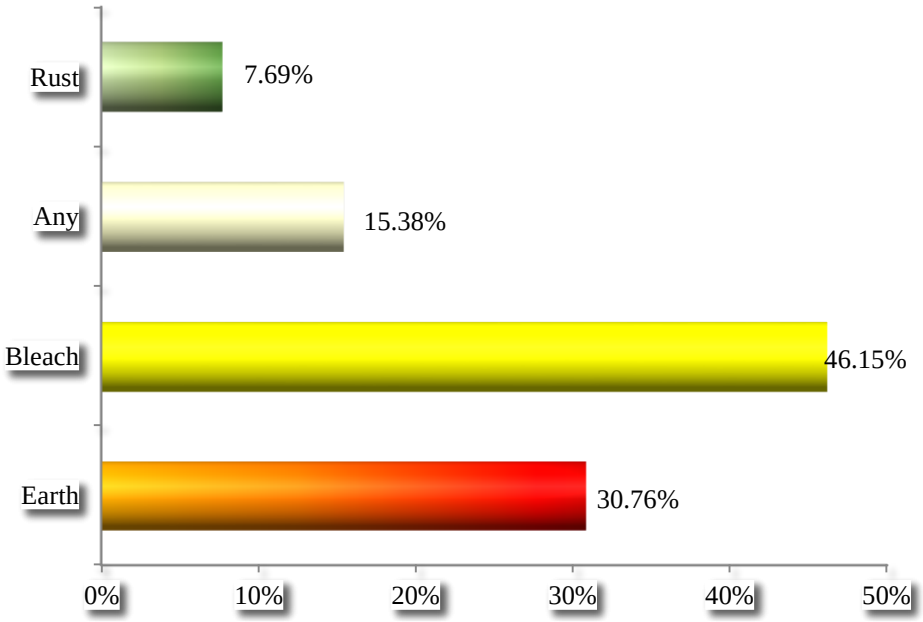

Figure 5: Nature of the smell of tap water of Ain Temouchent city

Given these results, it seems that our water supplied had presented a bad organoleptic quality due to the higher non-compliance rate recorded at this city (53.84% for taste and 46.15% for the smell) and is due in particular to the use of chlorine as a disinfectant for drinking water.

The taste of chlorine (sodium hypochlorite) may come from the process of disinfection during water treatment and to a lesser degree from chlorination before distribution.

In the presence of organic matter, chlorine combines with it to eliminate undesirable elements. This reaction gives birth to by-products responsible for the appearance of taste and odor of bleach.

In addition, tasters have held that these analyzes waters were unpleasant either with an aftertaste of earth. The sensation of water with an earthy taste like that found in this study means the presence of soil or clay which could be due to a failure in the water clarification step. Also, organic compounds synthesized by microorganisms in particular actinomycetes, cyanobacteria and algae are also responsible for tastes of earth and mildew due to geosmine and 2-methylisoborneol [17].

Also the rust smell detected during this study may be due to the presence of iron which can accumulate and block the pipes or plumbing fittings and consequently lead to the presence of rust flakes in water.

2.3. Statistical processing

For this drinking water, the influence of residual chlorine on the taste intensity was highly significant and this had been proving by the statistical test (Test for equality expectations: two observations with different variances) where the:

Statistics $t = -2.79 < t$ critical value (unilateral) = 2.17 which allows us to confirm the presence of a significant relationship between the two parameters.

The main results of this statistical test are mentioned on the table 2 below.

Table 2: Results of the statistical test

	Variable 1: Residual Chlorine (mg / l)	Variable 2: Taste threshold
Observations	13	13
Statistics t	- 2.79	
T critical value (unilateral)	2.17	

The same thing for the odor detection threshold parameter because the:

Statistics $t = -3.36 < t$ critical value (unilateral) = 2.17 (Table 3) which enables us to confirm the presence of a significant relationship between the contents of waters residual chlorine and odor detection threshold.

Table 3: Results of the statistical test

	Variable 1: Residual Chlorine (mg / l)	Variable 2: Odor Threshold
Observations	13	13
Statistics t	- 3.36	
T critical value (unilateral)	2.17	

To better demonstrate the nature of the relationship existed between these parameters, we had used XLSTAT 2016 software to establish a data processing by Principal Components Analysis (PCA), which we had used three variables: the residual chlorine, the taste detection threshold and those of the smell.

This statistical processing was given as a result a correlation circle which is shown in figure 6 below.

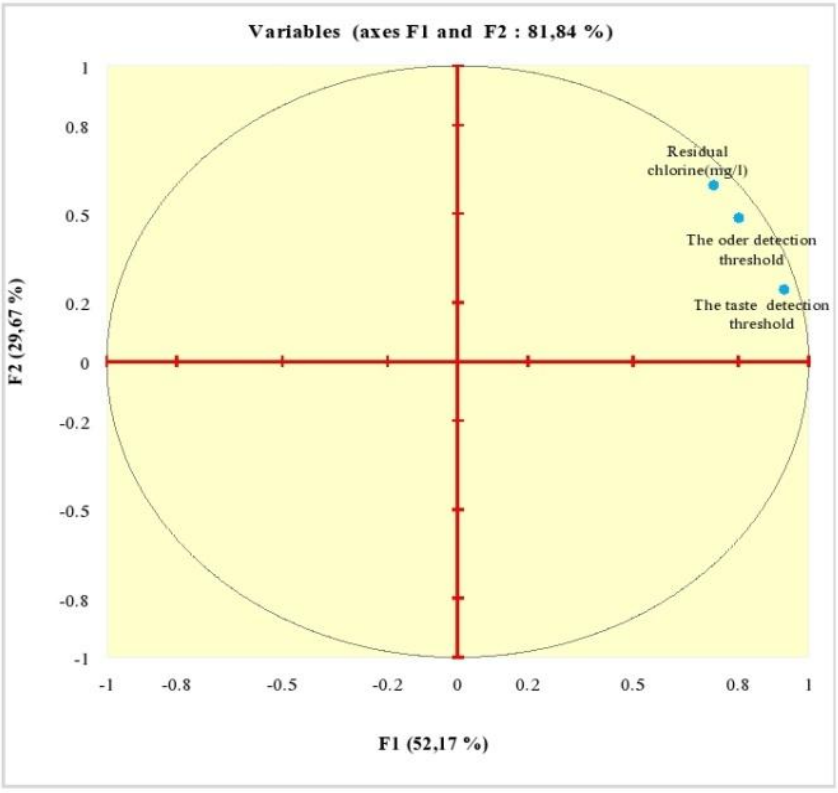

Figure 6: Circle of correlation between variables

We have clearly seen on the correlation circle which represented 81.84% of information, that the residual chlorine is positively and strongly correlated with taste detection threshold and the odor , where the values are positively and strongly correlated with the F1 axis which alone explains 52,17% of the variability.

Similarly, the axis F2 which explains 29.67% of the variability brings together the taste detection threshold and the smell and residual chlorine which they are positively correlated.

CONCLUSION

Even though tastes and odors, according to the World Health Organization, have no effect on the health of the consumer, of course, they are considered as indicators of quality, because their degradation may indicate pollution or malfunction of the treatment or distribution installations.

During this study, the three operators had been unsatisfied with the tap water, where the main tastes and odors identified were related to chlorine (46.15%).

On the basis of our results obtained through this study, we can say that chlorination at this city is badly practiced because the chlorine levels used are not adjusted to the quality of water, in addition, the chlorine dosage had not been done on the basis of laboratory chlorine demand tests.

Than we had observed that free chlorine concentrations were highly variable ranging from zero values (0 mg/l) to the other of the order of 0, 4 mg/l.

The various domestic water samples collected and, after organoleptic test had conferred a slight bitter taste which makes them unpleasant to their use as a beverage. This salty taste probably comes from some salts such as sodium chloride (NaCl) used during treatment.

Although chlorination can help to reduce the taste and smell due to the reaction of chlorine with organic material, it can also produce very pronounced taste and odor of chlorine due to the presence of the disinfectant.

Faced to this situation, our contribution consists in assigning a continuous measurement of the residual chlorine content at the exit of the disinfection treatment installation, or the contact tank disinfectant. In addition, the residual free chlorine must be registered with a minimum rate of 15 minutes.

Also, training and specialization of tasting panels at approved laboratories can help to improve the quality of drinking water as they allow the detection of a problem of taste and smell with a good insurance before the waters are served to subscribers because consumer perception against the tap water remains a domain to explore, and even

some links have been established between the organoleptic quality of tap water and a refusal to a consumer to drink tap water.

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REFERENCES

[1] Aminata, K., Boubacar, S., Francis, R., Alfred, S., Straore and D.Dayéri, 2013, Optimisation de l'efficacité des graines de *moringa oleifera* dans le traitement des eaux de consommation en Afrique sub-saharienne : cas des eaux du Burkina Faso, Journal of Water Science, 3 (26), 209-220

[2] Proulx, F., M. Rodriguez et J.B. Serodes, 2010, Les goùts et les odeurs dans l'eau potable: revue des composes responsables et des techniques de mesure, Revue des Sciences de l'Eau, 3(23), 303-323

[3] Levallois, P., J. Grondin and S. Gingras, 1999, Evaluation of consumer attitudes on taste and tap water alternatives in Quebec, Water Science and Technology, 6 (40) ,135-139

[4] Khiari, D., S. Barrett, R. Chinn , A. Bruchet, P. Piriou et L. Matia , 2002, Distribution Generated Taste-and-Odor Phenomena, American Water Works Association Research Foundation and American Water Works Association, Denver

[5] Doria, M.F., N. Pidgeon et P. Hunter, 2005, Perception of tap water risks and quality: a structural equation model approach, Water Sciences Technology, 8 (52), 143-149

[6] Suffet, 1. H., Corado, A., Chou, D., S. Butterworth, and M. J. Mcguire, 1996, A WW A taste and odor survey, Journal American Water Works Association, 4(88), 168-180

[7] Welté, B. and A.Montiel, 1999 , Study of the possible origins of chlorinous taste and odour episodes in a distribution network, Water Science and Technology, 6 (40) , 257-263

[8] Hansson, R. C., Henderson, M. J., Jack, P. and R. D. Taylor, 1987, Iodoform taste complaints in chloramination, Water Research, 10 (21), 1265-1271

[9] Cancho, B., Fabrellas, C., Diaz, A., Ventura, F. and M. T. Galceran, 2001, Determination of the odor threshold concentrations of iodinated trihalomethanes in drinking water, Journal of Agricultural and Food Chemistry, 4 (49) , 1881-1884

[10] Office National des Statistiques, 2012,Premier Recensement Economique (2011), Résultats Préliminaires de la première phase, Alger

[11] Bartels, J .H.M. Burlingame, G .A. et I .H. Suffet, 1986, Flavor profile analysis: taste and odor control for the future, Journal American Water Works Association, 3(78), 50-55

[12] Lechevallier, M. W., C. D. Lowry and G. Lee, 1990, Disinfecting biofilms in a model distribution system, Journal American Water Works Association, 7(82), 87- 99

[13] Dietrich, A., Hoehn, M., R. C. Burlingame and G.Gittelman, 2004, Practical Tasteand-Odor Methods for Routine Operations. Decision Tree, American Water Works Association Research foundation, Denver

[14] Rodier, J., C. Bazin, J.P.Broutin, P. Chambon, H. Champsaur and L. Rodi, 2005, L'analyse de l'eau, eaux naturelles, eaux résiduaires, eau de mer, chimie, physico-chimie, microbiologie, biologie, interprétation des résultats, Dunod Ed, Paris , France

[15] Baziz, N., 2008, Study on the quality of drinking water and potential risks to health if the city of Batna, Magister memory, Batna Univ., Algeria

[16] Journal officiel de la République algérienne, 2000, Les normes de potabilité d'une eau de consommation. Journal officiel de la République algérienne.

[17] Ozbek, O.P., 2011, Consumers detect odd odors, tastes in water despite government guidelines, scientist says, PhysOrg. Com

[18] World Health Organization, 2011, Guidelines for drinking water quality, 4th Ed