The Pharmaceutical and Chemical Journal, **2015, 2(4):45-53**

Available online www.tpcj.org

Research Article

ISSN: 2349-7092
CODEN(USA): PCJHBA

Microbial quality of drinking water from traditional tank of rainwater at rural area of Morocco (Safi region)

Aziz F[1], Achtak H[2], Ouahmane L, Bouyatas M[2], El-Fadeli S[3], Farissi M[4], Dahbi A[2]

[1]National Center for Study and Research on Water and Energy, PO Box 511; Cadi Ayyad University, Marrakech, Av. Abdelkrim Elkhattabi, 40000, Morocco.
[2]Department of Biology, Polydisciplinary Faculty of Safi, PO Box 4162, Cadi Ayyad University, Sidi Bouzid, 46000 Safi, Morocco.
[3]Department of Biology, Faculty of Sciences – Semlalia, Cadi Ayyad University, Marrakech, Morocco.
[4]Department of Biology, Polydisciplinary Faculty of Beni Mellal, Sultan My Slimane University.

Abstract In the lack of the dissemination of drinking water networks, rural populations in Morocco tend to use archaic methods by using the nearest resources of waters, namely traditional water tanks directly fed by rainwater used as only sources of water for various uses (consumption, watering etc.) without any quality controlling. Our work is carried out as part of assessing, diagnosing and monitoring the physicochemical and bacteriological water quality of the five traditional tanks, which are exploited by rural populations of Morocco. The physico-chemical analysis has shown that these reservoirs (tanks) studied respect the recommended Moroccan standards, except for orthophosphate and chloride, which contain high levels. In addition, all studied reservoirs show a high bacteriological pollution (145, 5.10^3CFU/100ml) and exceed the standards of water intended for human consumption. These microbial loads may constitute a significant health risk to the consumer.

Keywords Microbial quality, stored rainwater, traditional tank, rural area.

1. Introduction

Water is the first source vital and most important factor in sustainable development of all countries, it considered an inexhaustible resource. However, it begins since little time, to pose serious problems for some regions, including countries in arid and semi-arid like Morocco [1].

Water is essential for life; however it can also be a source of disease. In the world, 1.8 billion people use contaminated water sources with fecal matter [2]. Contaminated water can transmit diseases such as diarrhea, dysentery, and typhoid. The contaminated drinking water caused each year more than 500 000 deaths from diarrhea. By 2025, more than half of the world population will live in areas subject to water stress [2].

In Morocco water resources, already in limited quantity, suffer from several problems that cause deterioration of their quality [3]. Among the factors involved in this degradation are cited population growth, the expansion of agriculture, and the use of uncontrolled septic tanks [4].

Water resources of Morocco suffer from high irregularity in space and time. Currently, the use of 91-94% of resources mobilized for agriculture and only 6-9% for drinking water and industry, the long episodes of drought combined with increased requirements water generate imbalances in both quantity and quality, in most aquifers [5].

Freshwater resources are limited and tend to become scarce [6], capture, storage and reuse of rainwater are an important alternative and help solve the problems of water scarcity [3, 7-9].

The collection and recovery of rainwater in traditional tanks for reuse in domestic use is a well-established and relatively oldest in Morocco, especially in rural and remote areas. The traditional reservoirs are a symbolic system of the rural population [9].

Our work aims to assess the physicochemical and bacteriological water quality of five traditional storage tanks of rainwater used by the rural population of the Safi region as the only source of supply of drinking water.

2. Materials and Methods

2.1. Overview of study area

This study was conducted in the douar Jamaat Shaim located at forty km east of the regional capital Safi (Figure1). The region is characterized by a semi-arid to arid climate; rainfall does not exceed an average of 400 mm / year.

The sanitation state of the study site is critical, the lack of a sewerage system forcing residents digging "pits", in which are discharged wastewater and fecal discharges. These pits are unfortunately poorly constructed or completely non-existent and the evacuation are then performed directly in the natural environment.

The poor socio-economic status of the local people prevents them from digging wells. Consequently, water stored in the traditional way is their only source of water. This water is used for all purposes, including personal consumption and watering of livestock, without any prior treatment.

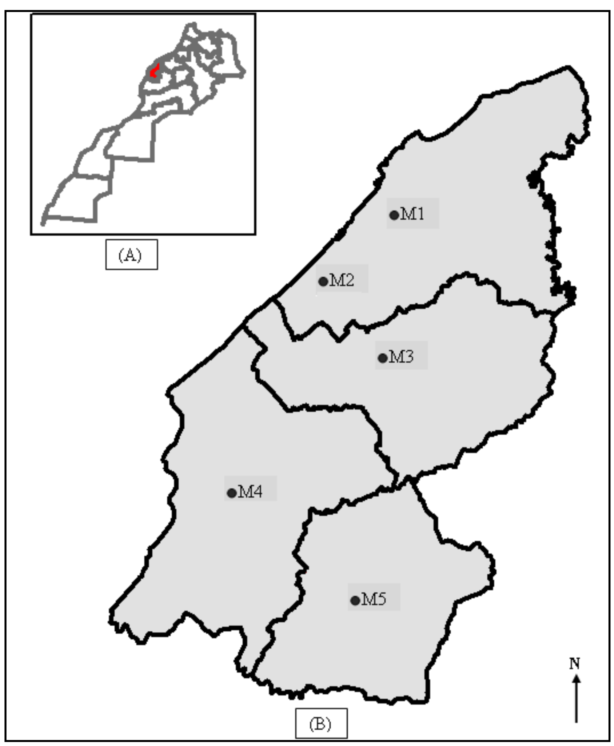

Figure 1: (A) Map of Safi region situation; (B) location of sampling sites (M : matfia)

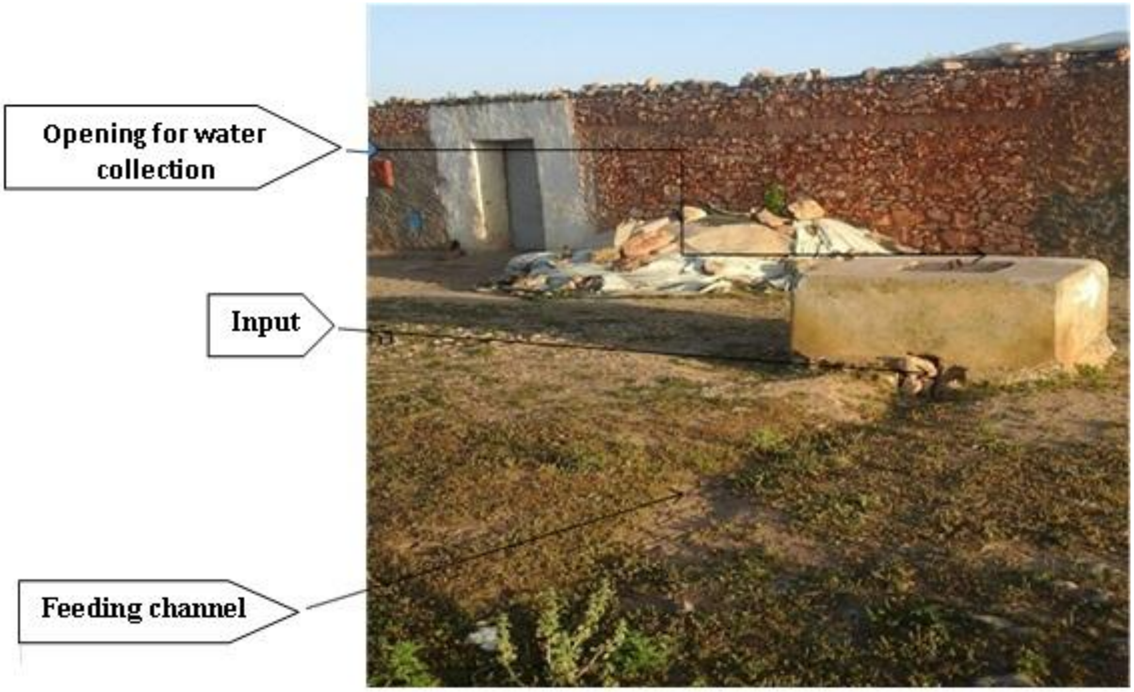

Figure 2: Detail of matfia and its components

The traditional storage method uses reservoirs known locally as "***matfia***". The *matfia* is a type of cistern, buried in the ground to a level of three-quarters of its total height. A *matfia* may be tubular in shape, 4–9 min depth and 2–4 min diameter, or rectangular in shape, 6–10 m in length, 3–5m in width and 2–4 m in depth. These reservoirs are supplied by rainwater in a collected area (Figure 2).

2.2. Methodology

2.2.1. Sampling

Water samples were collected from five traditional reservoirs, which stored water intended for human use. Sampling was according the French standard methods [10] and Rodier [11]. The study reservoirs were chosen according to four main characteristics: urbanization, intensity of usage and accessibility.

The water samples were collected using plastic bottles for chemical assays, and in sterile glass bottles for bacteriological studies.

All samples were transported to the laboratory in the dark in a cooler at a temperature of 4 °C.

2.2.2. Parameters analyzed and methods used

Physicochemical parameters

The temperature, pH and electrical conductivity were measured in situ for water samples using a multiparameter probe type WTW LF 92. The mineral nutrients (nitrite, sulphate, chloride and orthophosphate) data were measured in the laboratory by spectrometry or volumetry according to French standard methods [10] and Rodier [11].

Microbiological analysis

The methods were quantitative for the indicator organisms of fecal contamination and qualitative for pathogens [12]. Membrane filtration was used to enumerate aerobic mesophilic flora total (AMFT), fecal coliforms (FC) and total coliforms (TC), *Escherichia coli* (EC), fecal streptococci (FS) and Salomnella.

The culture media used were as follows:

• Lactose TTC agar with Tergitol, for coliform counts (FC and TC), and soybean casein digest agar for *E. coli* [12].

• Slanetz and Bartley medium for enumeration of FS [12].

• CHROMagar was used to isolate Salmonella. Each isolated bacterium was subsequently identified according to biochemical criteria.

3. Results and Discussions

3.1. Physicochemical parameters

The physicochemical parameters of the reservoir water samples are shown in Table 1. It seems that there is a high concentration of the major elements in the stored water, especially for calcium and magnesium, which reached maximum concentrations of 15 and 231 mg/l respectively. This may be related to the calcareous materials used in the construction of the reservoirs and to the geological propriety of the studied area, which is dominated by limestone and dolomite outcrops.

However, this increase in concentration of minerals does not exceed the safe limits for human consumption according to Moroccan Standards [13]. But, it was shown that chloride and orthophosphate exceed these standards. Indeed, the chloride levels are quite large (varied from 1063 to 2127 mg/l), and are higher than the consumption guideline value that is 750 mg/l. In addition, phosphate levels are quite large and exceed standards (0.3 mg/l), which, the values are ranged between 0.4 and 3.43 mg/l, that could be explained by agricultural activities conducted around this *matfia*.

Table 1: Average of physicochemical parameters for the water of the five studied *matfia* (M).

	T°	**pH**	**CE**	**SO_4^{2-}**	**NO_2^-**	**HPO_4^{2-}**	**Cl^-**	**Ca^{2+}**	**Mg^{2+}**
M1	21.2	7.97	296	0.4	0.035	0.68	1418	12.3	225.9
M2	16.4	7.86	423	0.35	0.295	0.41	1772	15.1	221.5
M3	17	7.79	518	0.3	0.024	1.09	1063	14.2	209.1
M4	12.1	7.87	400	0.39	0.005	2.09	2127	12.5	231.4
M5	13.3	7.9	333	0.49	0.006	3.44	1635	13.6	211.7
Standard	Acceptable	6.5-8.5	2700	400	0.5	0.3	750	-	-

3.2. Bacteriological results

The bacteriological test results showed the presence of a quite large organism's number that exceed the Moroccan standards of water feeding which would then mean that this water is not clean drinking.

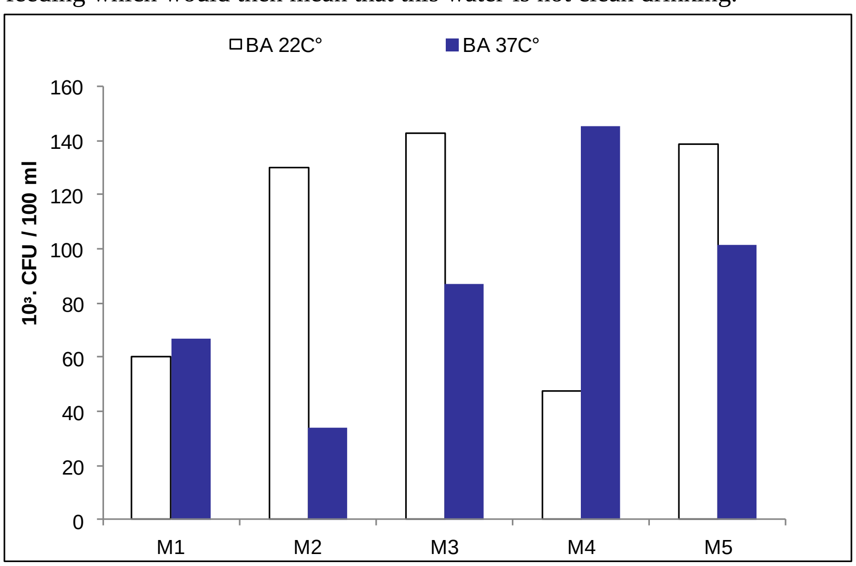

Figure 3: Number of colony-forming units/100 ml in the studied matfia (M) (BA22 °C: Aerobic bacteria at 22 °C; BA37 °C: and Aerobic bacteria at 37 °C).

3.2.1. Total mesophilic flora

Aerobic mesophilic flora total (FMAT) is a general indicator of the degree of the pollution of the water used to assess the total number of CFU (colony forming unit). The range counts (in CFU/100 ml) from the studied reservoir water samples were vary from 47, 5.10^3 to 143.10^3 and 34.10^3 to $145,5.10^3$, respectively for Aerobic bacteria at 22 °C and Aerobic bacteria at 37 °C (Figure 3). These values were exceeding the limit fixed by the standards, which are 20 and 100 UFC/100ml respectively for Aerobic bacteria at 22 °C and 37 °C.

3.2.2. Total coliforms, fecal coliforms and *Escherichia coli* (*E. coli*)

Coliforms and *E. coli* are considered as indicators of microbial water quality because they can be indirectly associated with fecal pollution. It has been used to determine the general quality of drinking water worldwide [14-15]. The *E. coli* in particular has been found to be the most specific indicator of fecal contamination in drinking-water [15]. Its presence indicates contamination of water with fecal waste that may contain other harmful or disease causing organisms, including bacteria, viruses, or parasites [14]. Because the risks of disease outbreaks correlate with the incidence of fecal contamination, fecal bacteria are used as indicators of fecal contamination and hence, the possible presence of disease-causing organisms [16].

In all surveyed reservoirs (Figure 4), the waters are loaded with these germs, who's the values fluctuate between 15 to 50.10^2; 3 to 20.10^2 and 0,5 to 10.10^2 CFU/100ml, respectively for Total coliforms, fecal coliforms and *E. coli*, which make sure that this water is not safe to drink as above the limit of standards.

The correlation between coliform and *E. coli* counts was positive and significant ($r = 0.83$, $p < 0.05$). Total coliform counts were significantly ($p < 0.05$) higher than those of *E. coli*. The general trend in the number of CFU of *E. coli* increase as those of total coliforms increased also, while densities of *E. coli* were lower than those of coliform for all the water sources.

The number of total coliform and *E. coli* counts found in unprotected water sources suggest though not conclusively that poor source water protection and poor sanitation conditions and practices are potential reasons for the high presence of microbiological contaminants.

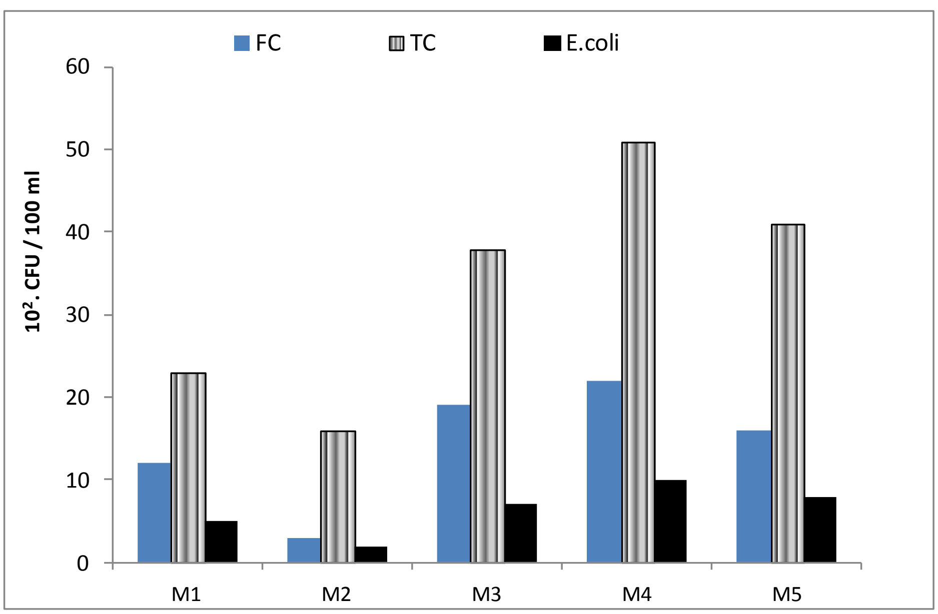

Figure 4: Bacterial load on colony-forming units/100 ml, in water of the studied matfia (M) (FC: fecal coliforms;TC: total coliform; E.coli: Escherichia coli).

3.2.3. Fecal streptococci

These germs were related to the coliform and considered as an indicator of pollution. The count of streptococci shows that all prospected reservoirs are contaminated and very loaded with values around 11. 10^2 CFU/ 100 ml (exceed the standard limit).

3.2.4. Fecal coliforms: fecal streptococci ratio

Fecal coliforms: fecal streptococci (FC/FS) ratio has been used as an indicator to differentiate fecal pollutions of human from animal with little success. According this ratio in this study it appeared that water contamination is fecal origin at human dominance in all surveyed reservoirs, since it is always less than 1.

Table 2: FC/FS Calculated ratio in studied *matfia*

	M1	**M2**	**M3**	**M4**	**M5**
FC/FS	0,04	0,25	0,94	0,15	0,28

3.2.5. *Salmonella*

The pathogenically test results showed the presence of *salmonella sp.* in all studied water reservoirs. These results provide insight into the potential health risks found in water of reservoirs. Contamination of water by pathogenic bacteria was potentially attached to livestock and human faeces that created a diffuse source of fecal contamination to water sources.

Generally, the results of this study reveal that average bacterial density in drinking water from *matfia* was relatively high. The presence of *E. coli* in water suggests enteric pathogens and fecal pollution and has been reported to be the causative agent of diarrhoea, urinary tract infection, and haemolytic uraemia syndrome in similar studies elsewhere.

In some cases there was a decrease in the numbers of total coliforms and *E. coli*. This was linked to the protection of the water sources consumer using the sources. According on these results, it is necessary to know the link between water quality, environmental quality, sanitation and public health. These remarks imply the need for focused contribution on source water protection and sanitation practices as this could enhance the water quality at source.

Problems related with access to safe sources of drinking water are not unique to Safi region alone as they have been highlighted already in the literature. Inadequate drinking water supplies, poor sanitation and none protection of water sources are especially highlighted as severe for most rural communities in developing countries that depend on raw water for drinking.

Comparing the results of this study with a similar study conducted in the villages of Assif El Mal [17], sanitation was found to be a serious problem compromising the quality of domestic water as well as contributing to outbreak of water-borne diseases.

Contamination of water was also potentially tied to livestock and human feces that created a diffuse source of fecal contamination to water sources, poor hygiene and sanitation practices that include laundry activities close to water sources by households; and water sources being very near or down slope of latrines. This implied the risk of contamination was very high.

These conclusions prove the need to come up with source water protection strategies and policies for rural communities where water supply and treatment is not available. Public conscience of protecting water resources as well as monitoring its quality and human health effects are also important and recommended. An integrated approach taken account policies, plans and activities that minimize contamination of the drinking water sources could be the departure step for Safi region.

3.3. Principal component analysis

This analysis allows establishing the relationship between physical, chemical and bacteriological parameters to determine the water quality of the studied *matfia* M1, M2, M3, M4 and M5.

The Eigen values of the two axes F1 and F2 and their contribution to the total inertia are shown in Table 3(a). This table generates a first typological approach for the different variables according to their affinities and their grouping on the first two principal components from their contributions. These determine 75.14 % of the total information at a rate of 45.86 and 29.28 of inertia respectively for the factorial axes 1 and 2. The coordinates of the variables on the same axes are shown in Table 3(b). Thus, the projection of these variables on the plan of the two main components (1 × 2), presented on the graph (Figure 5) shows the affinities of the variables from each axis. This figure shows that all the variables examined are defined very clearly positive in relation to axis 1. In contrast, nitrite is negative. A correlation is clearly distinct between Gram- negative bacteria on one hand and between mineral ions on the other hand. In general, the analysis of the correlation matrix between variables shows that all variables studied are strongly interrelated.

Table 3(a): Inertia ratio of the first two axes

Axes	Contribution to the total inertia (%)	Cumulative contribution (%)
F1	45.86	45.86
F2	29.28	75.14

Table 3(b): Correlations of variables with axes

	Principal component analysis	
	Axis 1	**Axis 2**
Fecal coliform	1,5	1,2
Total coliform	1,2	1,5
E. Coli	1,5	0,8
Fecal streptococci	1,5	-0,8
AB22°	0,5	1
AB37°	0,9	0,8
T°	0,4	1,5
pH	0,4	-1,8
EC	0,5	-1,2
Sulphate	1,7	-0,9
Nitrite	-0,8	-0,3
Chloride	1,7	-0,5
Calcium	1,4	-0,4
Magnesium	1,4	-0,5

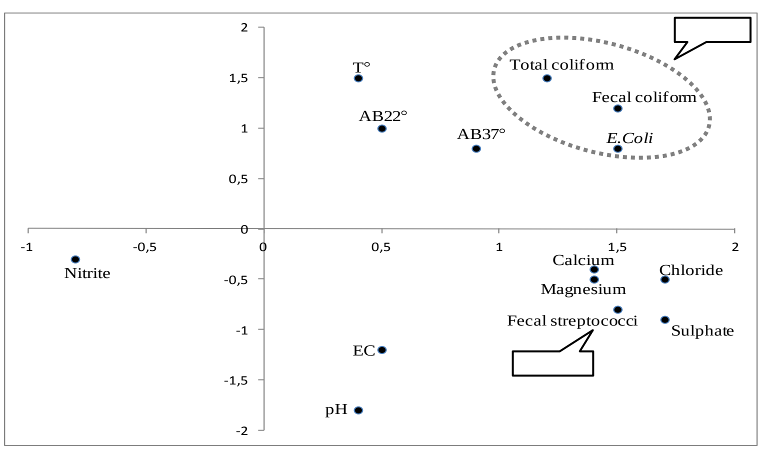

Figure 4: Principal component analysis for the physicochemical and bacteriological parameters for all sampling sites during the two study periods.

Conclusions

The water of *matfia* represents valuable resources for rural population of Safi region. Anthropogenic and domestic activities related to housing make these waters are exposed to various sources of pollution.

The majority of the water sources from the studied *matfia* in this study were grossly polluted. In fact, bacteriological analysis of this resource used by the rural population of Safi, show the presence of a high load of bacteria (145,5.10^{3}CFU/100ml) and pathogenic germs that is very pronounced and exceeding the guideline value for human consumption according to Moroccan standards. The effects were attributed to poor source water protection, poor sanitation and low level of hygiene practices, and lack of monitoring and healthcare awareness. The potential risk of infection of water consumers calls for prompt intervention to mitigate the potential health impact of water-borne diseases in the community. A proper sanitary survey and implementation of water and sanitation projects in the community is recommended.

References

1. Ana, I., Garrote, L., Flores, F., & Moneo, M. (2007). Challenges to Manage the Risk of Water Scarcity and Climate Change in the Mediterranean. *Water Resources Management.* 21(5):775-788.
2. Bain, R., Ryan, C., Rifat, H., Sophie, B., Kyle, O., Jim, W. et al., (2014). Global assessment of exposure to faecal contamination through drinking water based on a systematic review. *Tropical Medicine & International Health.* 19 (8):917–927.
3. Aziz, F., Farissi, M. (2014). Reuse of Treated Wastewater in Agriculture: Solving Water Deficit Problems in Arid Areas (Review). *Annals of West University of Timişoara, ser. Biology.* XVII (2): 95-110
4. Belghyti, D., El Guamri, Y., Ztit, Gh., L.Ouahid, My., Joti My B., Harchrass, A., Amghar, H., Bouchouata, O., El Kharrim, Kh., Bounouir,a H. (2009). Caractérisation physico-chimique des eaux usées d'abattoir en vue de la mise en œuvre d'un traitement adéquat. Cas de la ville de Kénitra, au Maroc. *Afrique SCIENCE*, 05(2):199 - 216.
5. Agoussine, M., Bouchaou, L. (2004). Les problèmes majeurs de la gestion de l'eau au Maroc. *Sécheresse*, 15(2):187-94
6. Serraj, M. (2013). Secteur de l'eau au maroc et strategie de l'onee, office nationale de l'electricité et de l'eau potable. Pp25.
7. Ghisi, E., Montibeller, A., Schmidt R.W. (2006). Potential for potable water savings by using rainwater: An analysis over 62 cities in southern Brazil. *Building and Environment.* 41(2):204-210.
8. Eroksuz, E., Rahman, A. (2010). Rainwater tanks in multi-unit buildings: A case study for three Australian cities. *Resources, Conservation and Recycling*. 54 (12):1449–1452,
9. Aziz, F., Farissi, M., Khalifa, J., Ouazzani, N. , Mandi, L. (2014). Traditional storage tanks of water: characteristics, popularity and problems. *International Journal of Innovation and Scientific Research, 11*(1):83-95.
10. AFNOR. Recueil de norme française: eau, méthodes d'essai, 2ème édition, Paris. 1997.
11. Rodier, J. et al., L'analyse de l'eau, 9emeéditon. DUNOD (éditeur), Paris, France. (2009), p 1579.
12. Moroccan Standards 2006 Norme Marocaine homologuée Par arrêté du Ministre de l'Industrie, du Commerce et de la Mise à Niveau de l'Economie. Service de Normalisation Industrielle Marocaine (SNIMA).
13. Moroccan Standards 2002 Bulletin officiel NW 5062 du 30 ramadan. 1423 fixant les normes de potabilité à la consommation humaine.
14. Ashbolt, N. J. (2004). Risk analysis of drinking water microbial contamination versus disinfection by-products (DBPs). *Toxicology,* 198(1-3):255-262.
15. JMP. Progress on Drinking Water and Sanitation: Special Focus on Sanitation. UNICEF and UNICEF, New York and WHO, Geneva, 2008.
16. Pam, T., Magajna, B., Lofranco, C., Leung, K.T. (2005). Microbial Indicators of Faecal Contamination In Water: A Current Perspective. *Water, Air, and Soil Pollution,* 166(1-4):139–166

17. Aziz, F., Mandi, L., Boussaid, A., Boraam, F., Ouazzani, N. (2013). Quality and disinfection trials of consumption water in storage reservoirs for rural area in the Marrakech region (Assif El Mal). *Journal of Water and Health*, 11 (1) :146–160.