Quantitative analysis and statistical study of drinking water consumption per m^3: Case of Kenitra region

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Abstract: Like many countries in the world, Morocco is faced with the problem of the development and sustainable management of its water resources. The demand for drinking water is increasing day by day. The objective of this article is to assess the drinking water consumption needs of the Kenitra region by performing a statistical analysis of the sale of drinking water consumed during the three years 2017, 2018, and 2019 by the seven neighborhoods in the city of Kenitra based on the physical-chemical and microbiological water already conducted in a first study using data obtained by the Autonomous Intermunicipal Water, Electricity and Liquid Sanitation Board. We determine the average amount of water consumed by each neighborhood by comparing the amount of drinking water consumed by the population of each neighborhood and its impact on economic development in general, which highlights the average annual consumption of the seven dominant drinking water neighborhoods. The results show that the average quantity of drinking water distributed annually in 2017 is 21,641,231 m^3, thus the quantity of water distributed in 2018 is 21,098,692 m^3 and the quantity of water distributed in 2019 is 24,218,279 m^3.

Keywords - Water consumption, drinking water quality, water distribution, Kenitra, statistical analysis, SPSS.

I. INTRODUCTION

Water is an inevitable necessity of life. Access to sufficient quantity and quality of water is required for the maintenance of health and other human activities. For water used for drinking, including domestic uses such as cooking and personal hygiene, microbial quality of water is of paramount importance. However, everyone recognizes that water is becoming scarce and needs to be used wisely.

Due to multiple factors, such as climate change and population growth, particularly in urban areas, it is expected that in general water stress will increase significantly worldwide by the middle of this century, particularly in Africa [1]. In this context, Morocco is classified as a country with high water scarcity below the "water poverty level", facing possibly extreme water scarcity by 2050. With an index of 4.2 on a 5-point scale, it has been described as "extremely risky" in terms of water availability [2]. As reported by official sources, currently, the limit of the threshold voltage estimated at 1000 m3/inhabitant/year, usually considered a critical threshold, indicates that the emergence of scarcity and the water crisis [3].In addition according to the ''Association Marocaine de prospective'' (A.M.P), population growth and rapid urbanization have created an elastic demand for drinking water and the consumption of drinking water is estimated at 1.21 billion cubic meters, or 11% of the annual supply [4].

The development of water resources must ensure that sufficient water is available in quantity and quality for the benefit of all users by the aspirations of harmonious economic and social development [5]. In general, human and technical factors, primarily the practical utility of water use, must also be considered [6].

In this circumstance, Morocco is committed to an Integrated Water Resources Management (IWRM) approach, under its national Water Sector Development Strategy (2009) and its new Water Law 36-15 (2016) [7] which provides the framework for water resources management and created the necessary strategies such as the National Program for the Prevention of Industrial Pollution (PNPPI), the Green Morocco Plan "Plan Maroc Vert", the National Sanitation Plan, National Wastewater Reuse Plan ", and the" National Household Waste Program "among others [8].

To determine the current and future needs for drinking water, we must determine the needs for the resident population, the needs for public and social facilities without forgetting the needs for individuals and the calculation of drinking water needs relates to the estimate of the workforce to be served, that is to say the population affected by the network and therefore the determination of any water needs. [9]

The objective of this article is to assess the drinking water consumption needs of the Kenitra region by performing a statistical analysis of the data. We chose the average of the results found to express the quantity of water consumed by each site during the years 2017, 2018, and 2019, these statistics will make it possible to analyze the data, in order to comment on or interpret the facts to which these data relate.

II. Methods and Materials

II.1 Study Area

Kenitra is located in the northwest of Morocco near the Atlantic Ocean about forty kilometers north of Rabat, on a bench overlooking a wide meander of the Sebou wadi see Figure 1. This wadi takes its source in the Middle Atlas. Kenitra is the capital of the GHARB

region, a rich agricultural region, watered by the Sebou and its tributaries [10].

In geology, Kenitra is located directly on quaternary marine and continental formations. The meeting of these two structures makes it possible to distinguish three distinct soil formations: dune, continental and alluvial formations. They are broken down as follows: The dune formations extend west to Mehdia, the continental formations are south (Maâmora forest) and east of Kentia. These sandy soils rest on a nearby clay or clay-sandy horizon (50-150 cm),

The alluvial formations of Sebou are formed of fine elements (clay, silt) and meet in the north and northeast of the city.

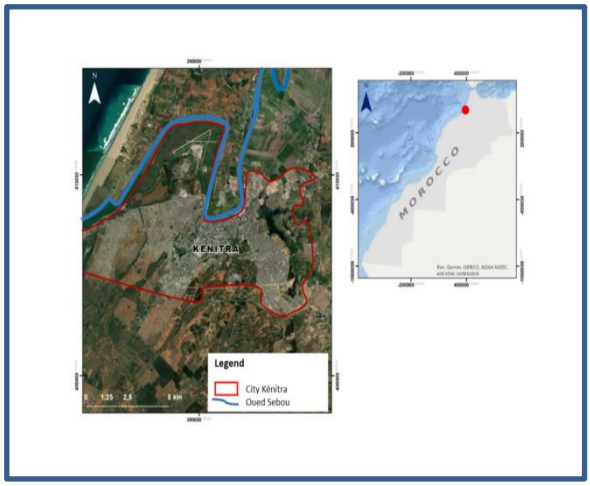

Figure 1. Map of the geographical location of the town of Kenitra.

II.2 Collected Data

This is the data collected from the statistical analysis of drinking water consumption from 2017 to 2019 collected from the ARK as part of this study.

The RAK was created by Order No. 517-21 of the Ministry of the Interior approving the deliberation of the Municipal Council of the city of Kenitra dated December 28, 1970 concerning the creation of an Autonomous Water and Electricity Distribution Company of Kenitra (RAK). Moreover, it is a Public Establishment of an Industrial and Commercial nature (EPIC), endowed with civil personality and financial autonomy. It is under the joint supervision of the Ministry of the Interior and the Ministry of Economy and Finance[11]. The Water and Sanitation Operations Division is concerned with the management of the distribution of drinking water as well as the monitoring of the state of the two networks (Drinking water network; sewage networks) on the one hand, and on the follow-up of the demographic increase to meet the needs of the population of Kenitra, on the other hand. The network of the city of Kenitra is divided into seven major districts of distribution as follows: Centrale, Medina, Ouled Oujih, Saknia, Elwafae, Mehdia, Molay Bousselhame.

II.3 Statistical Tool

All data collected from the Kenitra City Drinking Water Supply Department of our study were entered into an Excel file and analyzed with the SPSS version 25 software and treated for variance by the ANOVA test. After the normality study and homogeneity of variances with a significant difference for p-values of 0.05.

III. RESULTS AND DISCUSSION

To assess the evolution of consumption, we have gathered the data relating to the population and distribution of drinking water in Table 1.

Table 1 Population and Distribution of drinking water in Kenitra region from 2017 to 2019.

YEARS	POPULATIONS	Distributed Drinking water in m^3 /year
2017	454,000	21,641,231
2018	463,000	21,098,692

2019	471,000	24,218,279

This table shows the population in the number of inhabitants for each year from 2017 to 2019 and the annual distribution of drinking water in m3. It allows us to see how the population and distribution of drinking water in Kenitra region evolved during this period.

We also carried out analyses of the statistical data, we chose the average of the results found to express the quantity of water consumed by each site; according to Figure 2, during the years 2017, 2018, and 2019, we find that the average amount of water consumed by neighborhoods is different. We observe that the central district consumes a very high amount that approximates 606339.4848m^3, so Ouled Oujeh is the second district in consumption with 505267.9394 m3 compared to the other districts. The Saknia district has a consumption of 392899.8485 m^3, Medina has 321518.9697m^3, El wafae 300169.6364m^3 and Mehdia has consumed 221596.7576 m^3. Finally, Moulay Bousselham indicates 35894.4545 m^3 and is the lowest area in terms of water consumption.

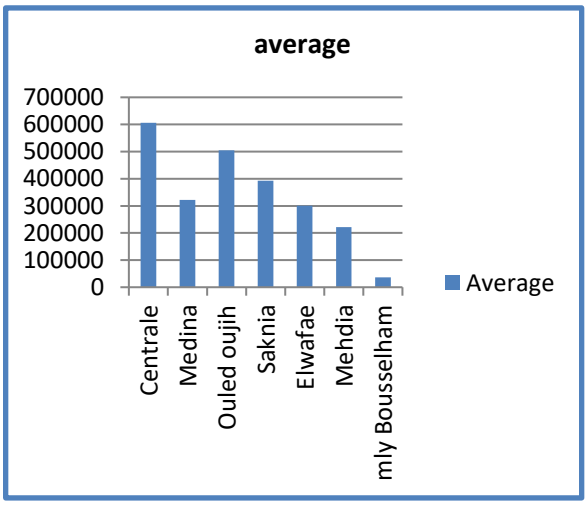

Figure 1 . Average water consumption in m^3 by the district in the years 2017, 2018, and 2019.

On the other hand, Figure 3 represents the average of each site compared to the years 2017, 2018, and 2019. This shows that there is a correlation between the average of all years per site and the average of each site per year. Similarly, it can be said that the largest quantity was consumed by the Central site and followed by the site Ouled oujih, and the small quantity was consumed by Mouly Bousselham.

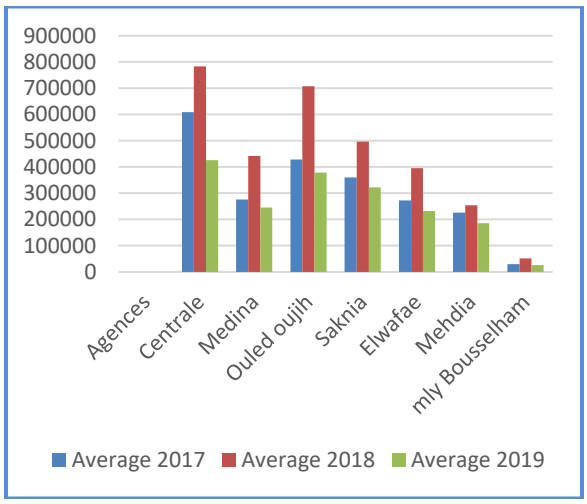

Figure 3. The average water consumption in m^3 of the neighborhoods compared to the years 2017, 2018, and 2019.

According to Figure 4, the results obtained from a statistical analysis indicate that the sum of water consumed at each site in 2017, 2018, and 2019 is on the same trend as the average water consumed. In addition, the power station whose average is larger than the average of ouled oujih (20009203.00 m^3 and 16673842.00 respectively). While the Kenitra-Mouly Bousselham district represents a lower sum (1184517.00 m^3).

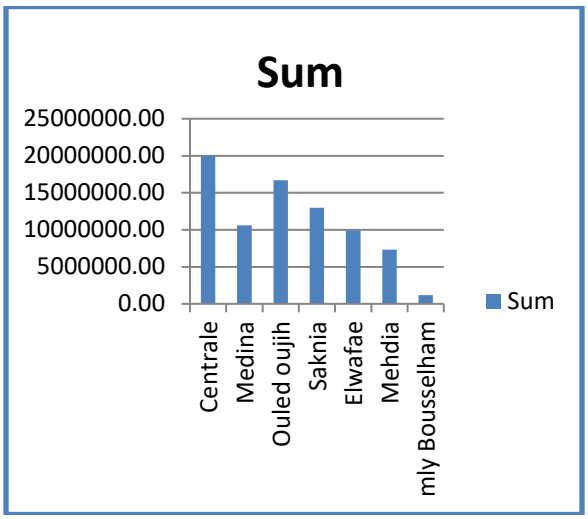

Figure 4. Evolution of the total amount of water consumed in m^3 at each site between 2017, and 2019

Table 2 Analysis of variance of each neighborhood's average water use between the years 2017, 2018, and 2019 by ANOVA.

ANOVA						
		sum of squares	**ddl**	**medium square**	**F**	**Sig.**
Centrale	Intergroup	700583111889,515	2	350291555944,758	,258	,774
	Intragroup	40723024071518,730	30	1357434135717,291		
	Total	41423607183408,240	32			
Medina	Intergroup	246595358842,970	2	123297679421,485	,254	,778
	Intragroup	14583098741296,000	30	486103291376,533		
	Total	14829694100138,969	32			
Oujih	Intergroup	695247872146,606	2	347623936073,303	,200	,820
	Intragroup	52137649681723,266	30	1737921656057,442		
	Total	52832897553869,875	32			
Saknia	Intergroup	186875709465,152	2	93437854732,576	,116	,891
	Intragroup	24211275818047,094	30	807042527268,237		
	Total	24398151527512,246	32			
ElWafae	Intergroup	160417318729,636	2	80208659364,818	,173	,842
	Intragroup	13893792655228,000	30	463126421840,933		
	Total	14054209973957,637	32			
Mehdya	Intergroup	25822029885,515	2	12911014942,758	,037	,963
	Intragroup	10361359829074,547	30	345378660969,152		

	Total	10387181858960,062	32			
MlyBous selham	Intergroup	4374914598,545	2	2187457299,273	,276	,761
	Intragroup	237772764697,636	30	7925758823,255		
	Total	242147679296,182	32			

Table 2 shows the average of each year at each site, so we note that there is no significance for the three years and the seven sites with the same amount of water consumed.

In this analysis, we observe that there is a correlation between the number of customers and consumption at each site with a correlation factor greater than 0.6. In general, as the number of customers increases, consumption increases.

This table shows that no significant differences were shown between the sites in each neighborhood. This is explained by the fact that all p-values are highly superior to 0.05. For ddl are all equal to 32.

For the nature of the treatment, we studied the normality of the data through the Kolmogorov–Smirnov test. The results showed that the data were normal. This made it possible to use parametric tests (ANOVA) to study the homogeneity of variances.

Analysis of the statistical results of the sale of drinking water to the ARK in the city of kenitra shows that the average quantity of drinking water distributed annually in 2017 is 21,641,231 m^3, thus the quantity of water distributed in 2018 is 21,098,692 m^3 and the quantity of water distributed in 2019 is 24,218,279 m^3. This indicates that the volume of water distributed in the year 2019 is greater than the volumes of water consumed in the years 2017 and 2018 because of several factors: Rapid population growth, environmental degradation, and the effects of climate change. In addition to that, population and urban growth, the development of economic activities, the increase in the rate of household equipment and the frequent practice of hygiene, etc... all mean that the need for drinking water is becoming more and more important. In reality, in this average amount of drinking water supplied to the city's neighborhoods, there is also the share of individuals, commercial activities, industry, administrations, offices and «preferential», A mouths, local passes, fraud, and public drinking fountains.

As a comparison with the city of Kenitra, Casablanca was displayed in 2018 with an average quantity of drinking water distributed daily of 547.428 m^3. This large and growing quantity is due to the current urbanization and permanent development of the first economic and industrial pole of Morocco. The forecast assumes a daily need of 783,000 m^3 in 2030 [12].

For the City of Agadir, it is characterized by average drinking water consumption over the years 2017, 2018, and 2019, 36,707 (10 m3), 37,031 (10 m^3), and 38,962 (10 m^3) [13].

In this regard, and in a context marked by the scarcity of water resources, national needs should reach 16.7 billion cubimeterses by 2030, against 13.7 billion cubimeterses in 2015. The water law needs to be revised for better control. Indeed, the management of requirements has long been neglected in Morocco's water regulations. Efforts are focused on life development; however, population growth and water

demand in key areas such as agriculture make demand management a priority.

In this regard, the Economic, Social, and Environmental Council (EESC) recalled in its "Alert" published in September 2019 that Morocco's demand for water exceeds the number of renewable water resources available each year. Something that makes water security a priority for Morocco today and for the years to come, which is why the EESC sounded the alarm on 26 September 2019 [14].

As a result, it will be time to take urgent awareness measures to influence user behavior. To do this, it is a matter of opting for awareness-raising by implementing communication strategies: Citizens, Local Authorities, and Economic Actors... to attract them more towards the urgent importance of adopting an eco-responsible attitude towards water. This requires breaking the habit of watering public green spaces and different structures and opting for the systematic reuse of treated wastewater.

IV. CONCLUSION

Water is a natural resource at the base of life, and an essential commodity for most of man's economic activities. the results of the statistical study allow us to conclude that the average consumption of drinking water in neighborhoods for each year or in all years is almost the same. However, consumption between the different sites shows a change in the most populated sites. This indicates that the main cause of this variation is the presence of population density, which continues to have a major impact on the environment.

For a more complete and accurate assessment of the volume and management of water in Morocco, it is necessary to establish a long-term plan to ensure the control of the use of drinking water that will determine the spatial variation related to the season.

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