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SPECIAL ISSUE: COVID-19
CASE STUDY

Impact of COVID-19 on the qualitative and quantitative aspect of household solid waste

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ABSTRACT

Houshold waste is the residue generated daily by people as a result of consuming goods and services. The qualitative and quantitative aspects depend on the lifestyle and standard of living of citizens. Hence a change in habits, following an economic or health crisis, can influence the production of waste and its composition. The objective of the present work is to assess the impact of lockdown on the generation of trash and on the habits related to the consumption of goods in two communes in Morocco. More specifically, this study would investigate the behavior of citizens with regard to protective equipment against the coronavirus COVID-19. The results of the survey show that there is an influence of lockdown on the items purchased during this period, with an increase in the purchase of disinfectant products and a decrease in the consumption of meat and canned goods. Thus, the results showed that the quantity of organic fractions had decreased in the domestic waste with the appearance of other fractions such as residues of cleaning products. In addition, the survey conducted showed that 87% of respondents mix coronavirus protective equipment with household waste, which may contribute to the spread of the virus. Concerning the quantitative aspect, the weigh-ups showed that the monthly rate of increase of waste production between the months of February and March 2019 and the corresponding period in 2020 have decreased from +11.41% to +3.8% in the city of Khenifra (from 2,572 ton in Mars 2019 to 2,456 ton in the correspondent period in 2020) and from +4.73% to-1.23% in the center of Tighassaline (from 136 ton in Mars 2019 to 123 ton in the correspondent period in 2020).

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INTRODUCTION

The production of Household solid waste (HSW) continues to increase in all countries of the world, with an annual tonnage produced in urban areas estimated at 1.3 million tons in 2012, a figure that could double by the end of 2025 (Hoornweg and Bhada-Tata, 2012). Changes in lifestyle and the changing socio-economic context are determining factors in the qualitative and quantitative aspects of MSW (Hoornweg and Bhada-Tata, 2012; Tahraoui *et al.,* 2012; Youb *et al.,* 2014). Several quantitative and qualitative waste characterization studies have been conducted in Morocco (Elmaguiri *et al.,* 2014; Ouigmane *et al.,* 2017), based on the change in citizens' lifestyle in a socio-economic context specific to each city. Coronavirus pandemic that has been caused by SARS-COV-2, (Gorbalenya *et al.,* 2020; Zhu *et al.,* 2020), the spread of the virus went beyond the local scale in Wuhan, China, where it appeared on November 17, 2019 and spread globally 2 to 3 months after its appearance, (Huang *et al.,* 2020 ; Li *et al.,* 2020; Hassani *et al.,* 2020; WHO, 2020a). The Coronavirus pandemic was declared by the WHO Director General on 30 January 2020 as a "global public health emergency" of international concern. Morocco, like other countries, has been affected by this pandemic; the first case was detected on March 2, 2020. Until 25 April 2020, the number of confirmed cases was 3,889, in addition to 159 deaths and a total of 498 recoveries (MMH, 2020d). Morocco is among the countries that applied the measures of sanitary lockdown early, by issuing decrees and ministerial circulars (Government of Morocco, 2020a., 2020b; MMH, 2020a, 2020b, 2020c ; MMI, 2020b) .On March 13th 2020, the Ministry of National Education and Vocational Training announced the suspension of courses in all schools and universities (MMEVR, 2020). Three days later, the Ministry of the Interior announces the closure of public spaces by launching the sanitary lockdown of citizens (MMI, 2020a). On March 20th 2020, the Moroccan government declared a state of sanitary emergency and obliged the lockdown except in cases of emergency (MMI, 2020b). The implementation of the lockdown of the people and the quarantine of patients can affect the lifestyle and the socio-economic context of the citizens as a result of the panic and psychic effects of the lockdown (Chen *et al.,* 2020; Duan, 2020; Kabaka., 2020; Xiao, 2020). Consequently, waste production may also be affected. For example, the residues of COVID-19 prevention equipment can be considered hazardous waste (*UN, 2020*). The literature shows a lack of evidence regarding the correlation between coronavirus and the impact on the environment and waste management (Klemeš *et al*., 2020; Isaifan, 2020; Nghiem *et al.,* 2020; Wang *et al.,* 2020). This study aims to assess the impact of the COVID-19 pandemic on waste generation in Khenifra city and Tighassaline located in Morocco by comparing waste production in 2019 and 2020, and to study the population's behavior with regard to the management of waste at risk related to the prevention of the spread of the coronavirus and if they properly dispose the residues from coronavirus preventive equipment. The study ghas been carried out in 2020.

MATERIALS AND METHODS

Study area

The communes of Khenifra and Tighassaline are part of the Province of Khenifra, one of the five provinces in Beni Mellal- Khenifra (B-K) region located in central Morocco. The characteristics of the two communes are presented in Table 1.

The state of spread of COVID-19

Until April 25th 2020, the number of cases infected by the coronavirus in the B-K region was 78, which is relatively low compared to the number of infected patients in other regions of the Kingdom such as Casablanca Settat, Marrakech Safi and Fes Meknes. Thus, the distribution of confirmed cases in the B-K region shows that the province of Khenifra, to which

Table 1: General information on the two communities included in this study (HCP, 2014).

Commune	Khenifra	Tighassaline (Center)
Type of area	Urban	Rural
Number of households	29 281	3 704
Geographical coordinates	X : 475 179 Y : 260 479	X : 490 754 Y : 223 523

the two communes concerned by this study belong, is the least affected with only one imported positive case detected on the 30th of March, 2020 and has recovered on the 13th of April, 2020. This shows that citizens in the study area are complying with the rules of lockdown in addition to the efforts made by the authorities to keep the epidemiological status of the province under control. Fig. 1 shows the distribution of confirmed cases in all regions of Morocco and in the provinces of the B-K region.

Waste management in the study area

Waste management in both municipalities has improved in recent years. The waste collected is placed in the landfill and recovery center that was commissioned in 2017 to receive waste from the province's municipalities (Fig. 2).

Table 2 presents the main characteristics of waste

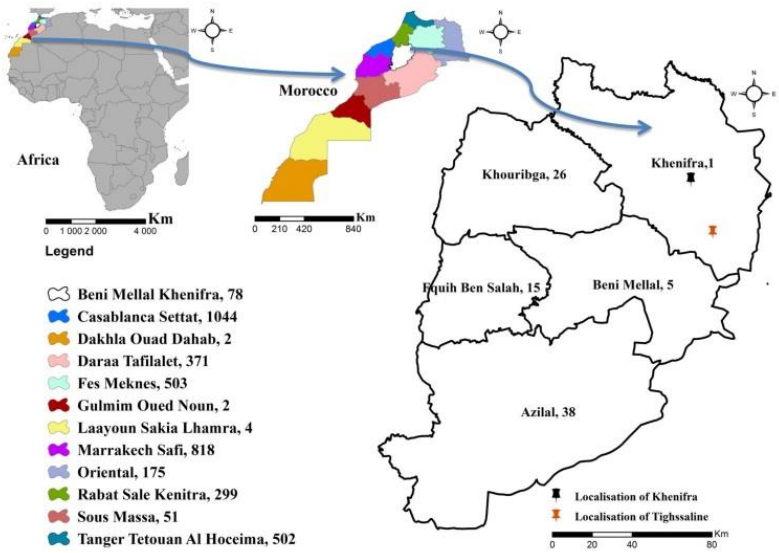

Fig. 1: Propagation status of COVID-19 in the regions of Morocco on 25/04/2020

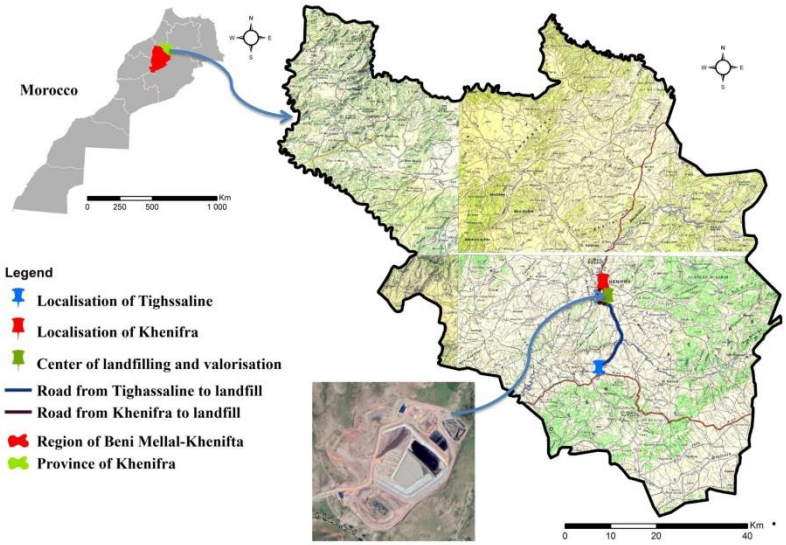

Fig. 2: Localization of the landfill and valorization center of waste in the province of Khenifra

management in the two study areas.

Management of household and similar waste and lockdown

The management of HSW is an essential service to guarantee the cleanliness and hygiene of urban areas. In order to study the impact of Coronavirus on lifestyle and waste management and to assess the degree of awareness of the population on the seriousness of waste at risk of Coronavirus infection, a survey was conducted on a sample of 300 families (240 in Khenifra and 60 in Tighassaline). The number of respondents is small because of the lockdown conditions that prevent us from going out and distributing the cards to a large number of families. The questionnaires are sent by email via the Google Forms platform. The questions and their objectives are shown in Table 3.

Impact of lockdown on waste tonnage

In order to assess the impact of population lockdown on the quantitative aspect of waste in the study area, a comparison was made between two communes with different characteristics. Weighs taken at the weighbridge of the landfill and recovery center for the months of February and March 2019 were compared with those of the same period in 2020. Thus, for each month, the rate of increase was calculated using Eq. 1.

Rate of increase = [(Tonnage of month n - Tonnage of month (n-1))/Tonnage of month n] *100 (1)

Table 2: Data on household waste in the two communities

Community	Khenifra	Tighassaline
Mode of waste management	Delegated management	Direct management
Methods of solid waste collection	From inside the property and community containers	From inside the property
Theoretical tonnage (Ton/day)*	98.12	4.42

*The theoretical tonnage is deduced by multiplying the population by the production ratio (0.76Kg/inhab/day) in urban areas and (0.28 Kg/inhab/day) in rural areas (Ouigmane et al., 2017).

Table 3: Questions dedicated to the citizens of the study area

	Question	Purpose and indication
1	Are you male/ female?	Information on the sex of the respondent
2	How many of you are at home?	Information on the number of people in the house
3	How many times do you shop in lockdown?	To have an idea on the respect of the lockdown
4	What items did you buy more before lockdown?	Have an idea of the lifestyle before lockdown
5	What items do you buy more during lockdown?	To have an idea of the way of life during lockdown
6	How many times do you throw out your trash before lockdown?	To have an idea of the quantitative aspect of the waste before lockdown
7	How many times do you throw out your trash during lockdown?	To have an idea of the quantitative aspect of waste during lockdown
8	Where do you dispose of special waste at COVID-19?	To have an idea of the qualitative aspect of the waste before lockdown
9	Are you aware of the impact of this waste on the spread of the coronavirus?	To have an idea of the qualitative aspect of the waste during lockdown
10	How many masks do you use per day?	Have an idea of the quantitative aspect of the masks used
11	How many pairs of gloves do you use per day?	To have an idea of the quantitative aspect of the gloves used
12	Where do you dispose of special waste at COVID-19?	To have an idea about the conscience of the citizens
13	Are you aware of the impact of this waste on the spread of the coronavirus?	Confirm whether citizens are aware of the seriousness of this waste

RESULTS AND DISCUSSION

Survey results

Lockdown and shopping habits

The results of citizens' habits and lifestyles related to the frequency of shopping and the type of items purchased before and during the sanitary lockdown period are presented in Fig. 3.

According to the results of the survey, it was found that lockdown may have changed the habits of citizens; the frequency of shopping during lockdown has decreased. Before lockdown 56% of the respondents shoped twice a week while during lockdown the frequency decreased to 34.5%. On the other hand, the percentage of citizens who shoped once a week increased from 30% before lockdown to 54.8% during lockdown in order to comply with lockdown rules as far as possible. Concerning the type of items purchased, the survey shows that there is an impact of lockdown on the type of items in the study area. There was a slight increase in the consumption of fruits and vegetables and a drop in the consumption of meat products. This can be explained by the intention of citizens to strengthen their immune system through the intake of fibre and vitamins contained in vegetables (Béliveau *et al.,* 2007; Daniel *et al.,* 2015; Hardy *et al.,* 2011; Kritas *et*

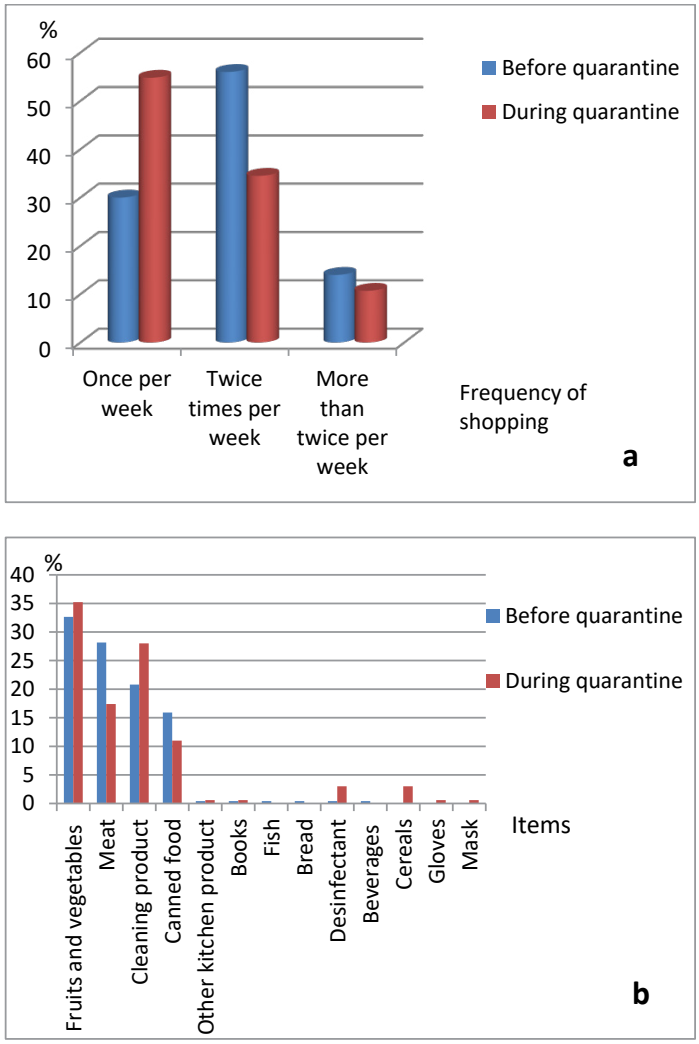

Fig. 3: a) Frequency of shopping before and during lockdown; b) Distribution of items purchased before and during lockdown

al., 2020; Maggini *et al.*, 2018; Negishi *et al.*, 2013; Surh *et al.*, 2003; Veeranki *et al.*, 2015; Wootton-beard *et al.*, 2011). Several studies have shown the importance of following a more suitable diet (Plant diet) to boost the immune system and to better fight against Coronavirus (BDA, 2020; Calder *et al.*, 2020; Gasmi *et al.*, 2020; Jayawardena *et al.*, 2020; WHO, 2020b). Moreover, significant change was seen for hygiene-related items such as disinfectants and cleaning products whose consumption percentages increased during the lockdown period due to the panic caused by the rapid spread of Coronavirus. The effects of the COVID-19 pandemic are not limited to physical health but may have psychological impacts on individuals (Duan, 2020; Xiao, 2020). Social distancing, lockdown, discontinuation of studies and use of masks and gloves impose psychological effect in the general public by generating anxiety, fear and stress public (Chen *et al.*, 2020; Jiao *et al.*, 2020; Yang *et al.*, 2020). Certain behaviors have occurred during lockdown such as wearing gloves and masks to protect against the Coronavirus. As a result, the appearance of these residues is clearly visible in the families' trash cans.

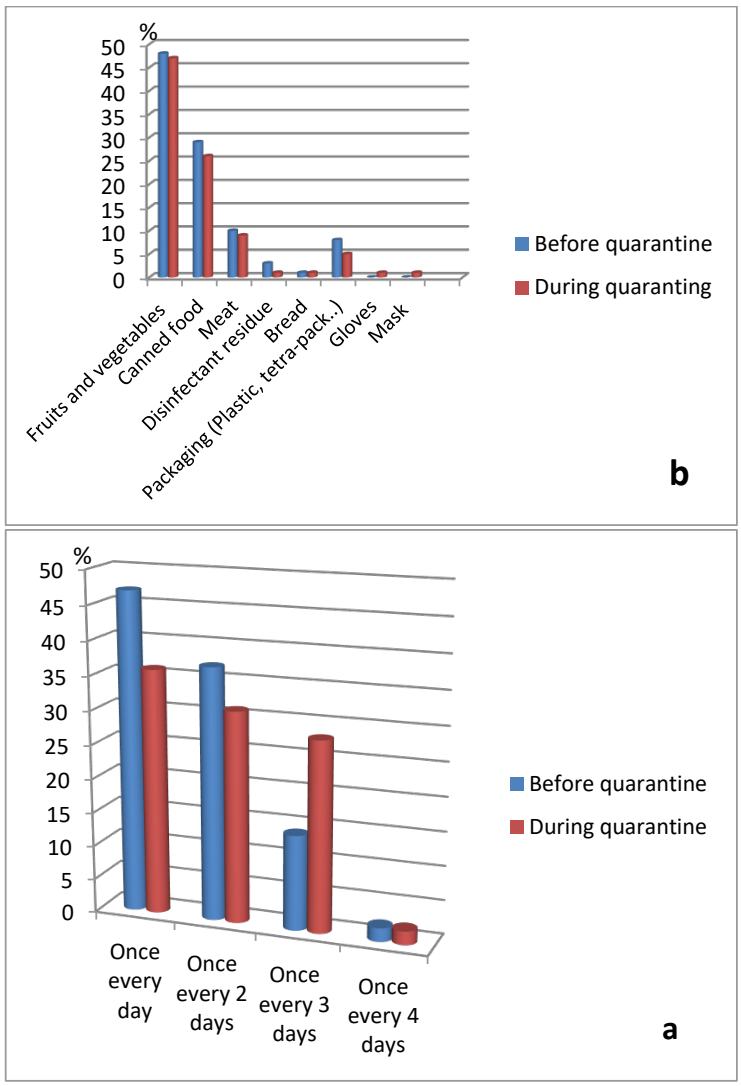

Fig. 4: a) Waste bin discharge frequency before and during lockdown; b) Waste quality aspects before and during lockdown

Qulaity of waste and bin discharge frequency

The results of the impact of lockdown on the frequency of removal from the bin and on the qualitative aspect of the waste are presented in Fig. 4.

From the results shown in Fig. 4a, the impact of lockdown on the frequency of littering can be seen, which is influenced by changes in people's living conditions and lifestyles (Özeler *et al.,* 2006). The percentage of respondents throwing their waste once a day decreased from 47% before lockdown to 35.7% during lockdown. On the other hand, the percentage of citizens who litter once every three days is 38.1% during lockdown compared to 14% before lockdown. This change in garbage disposal habits may be related to minimization in waste generation or to the fear of going out every day during lockdown to empty the garbage (Li *et al.,* 2020). As shown in Fig. 4b, respondents noticed that there are qualitative changes in their waste. Thus, other wastes have appeared in the bin during the lockdown period and in particular personal protective equipment (masks and gloves), which residues are considered as medical and pharmaceutical wastes that must be managed in a rigorous manner (WHO, 2020c., 2020d., 2020e; Sohrabi *et al.,* 2020). In addition, there is a slight decrease in organic fractions and residues of canned food which may be related to the high consumption of legumes (peas, beans, lentils ...) in meals since; these foods do not generate waste which contributes to the decrease in putrescible fractions. In the other part, it can be seen that waste from cleaning products has increased during lockdown due to the intense use of these products to ensure hygiene and cleanliness of the human body and the house.

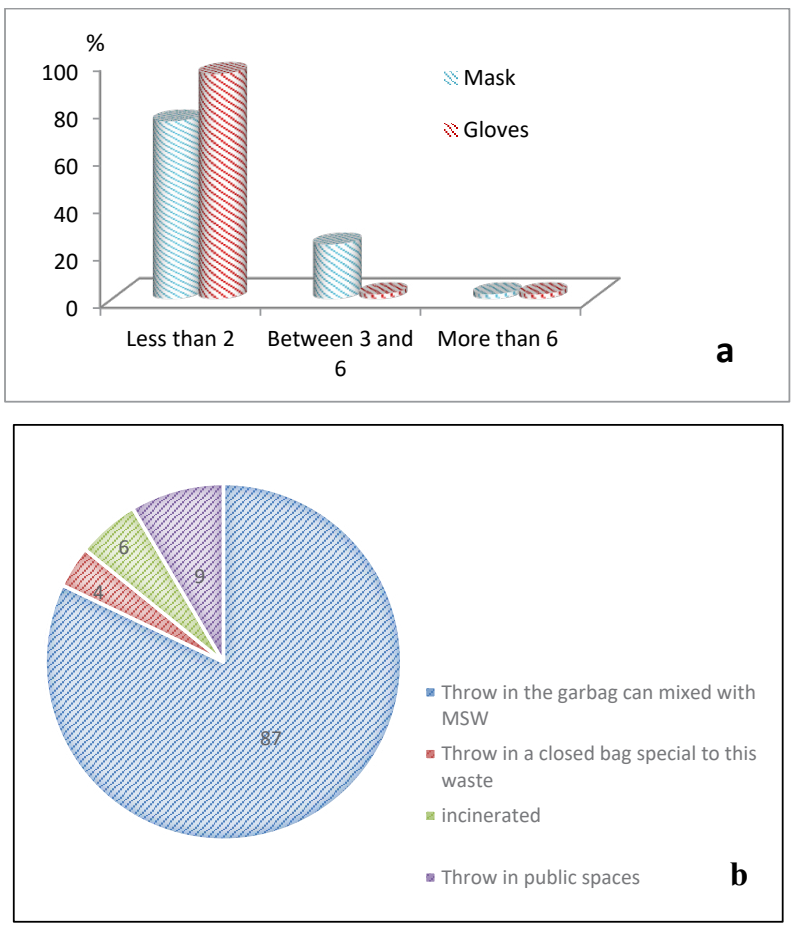

Fig. 5: a) Number of gloves and masks used by respondents; b) Disposal method of COVID-19 prevention equipment

Personal protective equipment

Respondents' responses regarding special waste related to coronavirus prevention are shown in Fig. 5.

Fig. 5a shows that large percentage of respondents use less than two masks and two gloves per day. This quantity remains low and depends on several factors such as the frequency of leaving the house, the presence of the masks and gloves in pharmacies and commercial premises, and the awareness of citizens of the need to use the masks and their changing with each use. The results of the survey of citizens' behaviors with regard to masks and gloves used (Fig. 5b) show that 87% of the respondents dispose of this waste by mixing it with household waste in a single bin. This can contaminate other waste (Blenkharn, 2018; Ghung et al., 2019). According to the Moroccan law 28-00 on waste management, it is forbidden to mix medical waste with household waste (KM, 2015). Most seriously, 9% of respondents dispose used masks in public spaces, which expose the population to the risk of infection (Hellewell *et al.,* 2020). Household waste becomes hazardous if it is mixed with medical waste in any quantity. Consequently, HSW can contribute to the transmission of diseases such as medical and pharmaceutical waste (Ansari *et al.,* 2019; Graikos *et al.,* 2010; Gupta *et al.,* 2006; Marinković *et al.,* 2008; Taghipour *et al.,* 2014; Windfeld *et al.,* 2015; Zamparas *et al.,* 2019). Moreover, 6% of respondents incinerate gloves and masks to eliminate the risk of infection and 4% put these wastes in special bags separated from other garbage. The management of this waste under the conditions of art is essential, as it can be transformed into a source of contamination and can play the role of virus transmission instead of a preventive role (Park *et al.,* 2015). For example, waste collection workers and sweepers are most vulnerable to exposure to contamination by these wastes. It is therefore worthwhile to properly manage these residues, which are considered hazardous waste.

Impact of lockdown on waste tonnage

The results of the tonnage comparison are shown in Figs. 6 and 7.

Regarding the year 2019 (Fig. 6), it can be seen that the tonnage of waste increases in both municipalities from February to March, with a higher rate of increase in the city of Khenifra (11.41%) compared to that of the center of Tighassaline. This monthly increase is due to the effect of the season, as waste tends to increase towards the summer season (Guadalupe *et al.,* 2009). In 2020 (Fig. 7), it is noted that the rate of evolution of waste production in the city of Khenifra has decreased (From 11.41% to +3.8%). Concerning the center of Tighassaline, the tonnage decreased from February to March (-1.23%). The results show that there is an impact of the lockdown that has been in place in Morocco since the 16th of 2020. The tonnage anomalies confirm the results of the surveys which showed a change in the way of life of the population. Indeed, the production of waste is largely linked to the economic level (Cheng *et al.,*

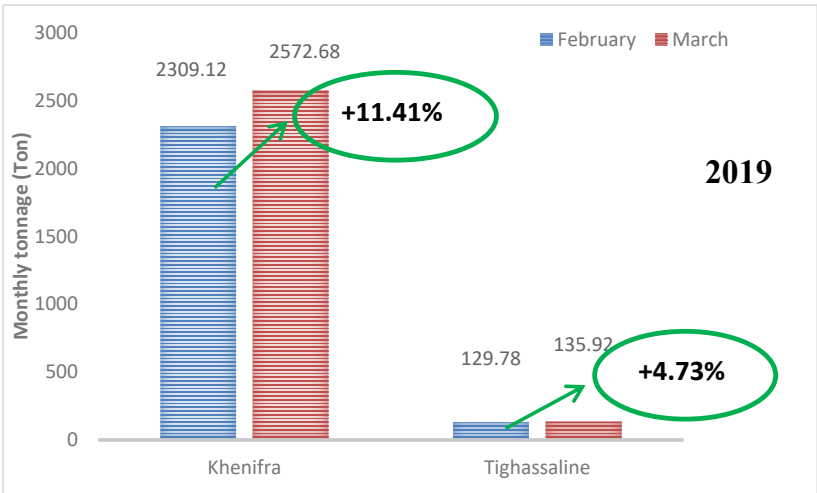

Fig. 6: Evolution of tonnage between February and March 2019 in Khenifra and Tighassaline

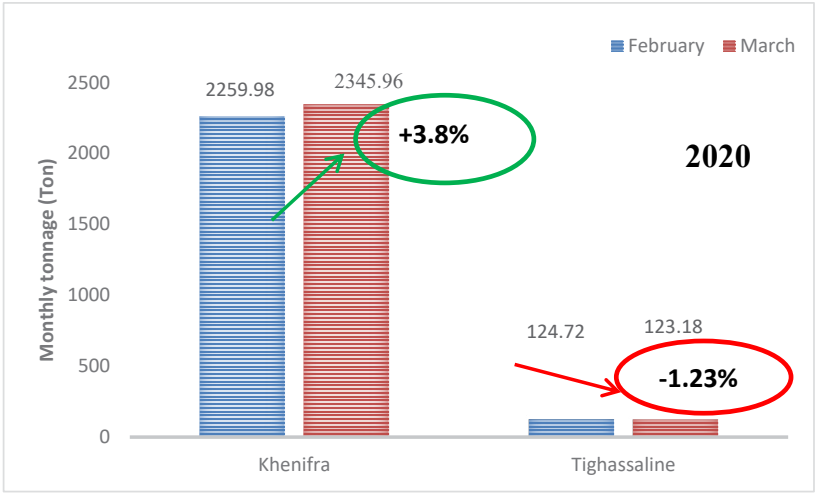

Fig. 7: Evolution of tonnage between February and March 2020 in Khenifra and Tighassaline

2020). The pandemic caused a local economic crisis. The main works are blocked in the study area. With the exception of state officials and food vendors, all other employees and informal workers (coffee boys, craftsmen, masons, drivers) are out of work, which has caused panic among their families. As a result, eating and living habits in general are being changed with an economy in consumption, which has directly influenced the generation of household waste. In addition to eating habits, the cessation of restaurants, cafes, dairy creamer affects considerably the tonnage during the period of lockdown. The effect of lockdown on the production of garbage has a positive impact on the environment following the minimization of waste burial (Minimization of leachate, biogas). In the other part, the delegate of the landfill and recovery center is influenced by the fall in tonnage, since it is paid per ton of waste buried. In addition, the qualitative aspect of the waste during the lockdown period constitutes a harmful impact on human health because the waste is mixed with the coronavirus protection equipment.

CONCLUSION

The present work has been carried out to assess the impact of coronavirus COVID-19 on the qualitative and quantitative aspect of household waste. The study area is represented by Khenifra and Tighassaline cities which are both part of the Province of Khenifra, one of the five provinces of the Beni Mellal- Khenifra (B-K) region located in central Morocco. The results were compared during February and March 2019 in Khenifra and Tighassaline and their respective duration in 2020. The results were obtained from a survey that was conducted by intervieweing the residents of those municipalities. Several aspects of the possible impact of COVID-19 on the Household solid waste were investigated. These include the impact on the habits and lifestyles related to the frequency of shopping and the type of items purchased before and during the sanitary lockdown period, the frequency of waste removal from the bins, the management of sanitary waste due to the risk of contamination and the reflection on the tonnage of waste produced during the lockdown period. The study showed that COVID-19 lockdown has significant influence on the consumption habits of the citizens in the study area. The frequency of shopping and the purchase of some items such as canned food and meat decreased, which influenced the qualitative and quantitative aspect of waste. The quantity of garbage decreased when comparing the weigh-ins for the years 2019 and 2020 as a result of the change in the standard of living caused by the coronavirus-induced panic and diet. Thus, the study showed that citizens do not properly manage the residues of protective equipment; they are mixed with household waste, which poses a risk for collection workers. This is a very sensitive period, so the following suggestions should be taken into consideration in order to minimize the impact of infectious waste on

human health: 1) Placeing the bin in a safe place and ensure that it is washed after each emptying; 2) Put the preventive equipment in a special, uniform bag before throwing it in the bin to protect the garbage collectors and ragpickers; 3) The waste collection company or the municipality should distribute plastic bags to homes for special waste; 4) The virus can be transmitted largely by garbage collectors. Therefore, the municipal officials must organize training and provide personal protection kits (gloves, mask, alcohol gel, coveralls). The communal hygiene office must ensure permanent disinfection and decontamination operations of the equipment and waste collection points.

AUTHOR CONTRIBUTIONS

O. Ouhsine performed the literature review, analyzed and interpreted the data and prepared the manuscript text. A. Ouigmane performed the conception and design of the study, manuscript preparation and manuscript edition. E. Layati helped in the literature review, and in the statistical analysis of the collected data, B. Aba compiled the data and participated in the manuscript preparation. R. Isaifan helped in English review and participation in the manuscript preparation. M. Berkani helped in the literature review, and in the statistical analysis of the collected data.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

ABBREVIATIONS

%	Percentage
BDA	British Dietetic Association
B-K	Beni Mellal- Khenifra
COVID-19	Coronavirus disease 2019
Eq.	Equation
Fig.	Figure
Kg/inhab/day	Kilogram per inhabitant per day
KM	Kingdom of Morocco
HSW	Household solid waste
UN	United Nations
WHO	World Health Organization

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