A novel methodology for household waste characterization during the COVID-19 pandemic: case study results

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Received: 23 March 2021 / Accepted: 27 September 2021 / Published online: 2 October 2021
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Abstract

The COVID-19 pandemic has caused a large number of the world's cities to establish quarantines. Much has been said about the environmental impacts of the confinement; however, very little data have been collected related to household waste generation and composition. In this study, the authors propose a novel methodology for the characterization of household waste without having to leave home, by using virtual training and completing forms. The results of the evaluation carried out in late September 2020 in three districts in the Arequipa province, Peru (Districts A, B and C) are presented. A total of 246 people participated in a survey on waste generation and segregation habits, and 44 people participated in the waste characterization study. Taking into account the error of the study, it can only be stated with certainty that waste generation decreased only in District B. The percentage of organic waste declined in Districts A and B, and increased in District C. Composition of hazardous and sanitary wastes increased significantly in all three districts. Each household generated an average of two to four masks and one pair of gloves per week.

Keywords COVID-19 · Household waste · Waste composition · Waste generation

Introduction

The COVID-19 pandemic has severely affected Latin American countries; 54 states in the region have reported COVID-19 cases and deaths [1]. As of May 11, 2021, Latin America has 40% of all reported cases and 47% of total worldwide deaths [2]. Brazil, Argentina and Colombia, in that order, account for the highest number of cases in the region [2].

Starting in the second half of March 2020, most of the countries in the region established quarantines. Some of the quarantines were mandatory, and others either recommended or targeted [3]. These measures of strict confinement were gradually lifted as of September 2020 [4].

In Peru on March 15, 2020, a national state of emergency was declared that began a mandatory national quarantine, a condition that was maintained in all of the country's regions

until July 1 and in the department of Arequipa until September 17 (Fig. 1).

Changes on solid waste management legislation in Peru during the quarantine

In May 2020, two regulations regarding waste management were approved by Congress in Peru, both with implications for waste recycling (Fig. 1). On May 9, 2020 regulations for the resumption of the recycling service and the sanitary protocol for the operation of the recycling service against COVID-19 were approved. On May 11, 2020 a legislative decree that modifies several articles of the Integrated Solid Waste Management Act was published. Among the changes was the mandatory character of source segregation. This implies that both the local and sub national governments were required to implement waste segregation programs and selective collection in all the scope of their jurisdiction.

Changes in waste generation during the pandemic

Throughout the world the variation in waste generation has been diverse. In the US an increase between 20 and 30% was estimated [5] and in Shanghai, household waste decreased in

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Fig. 1 Timeline of start and end of strict quarantine and enactment of legislation on solid waste management

23% [6]. Increases were recorded in the main cities of Latin America. In Quito, household and hospital waste increased by 40% [7]. In Mexico, a government report estimates that medical waste increased by 72% and household waste between 3.5 and 17.5% [8].

With respect to the changes in generation and composition of solid waste in Peru, the increase of hospital waste has been notable; the Ministry of Environment estimates that each person infected with COVID-19 generates 2 kg of bio-contaminated waste per day [9]. There have been some reports about other types of waste during the first months of the quarantine, in April the Rimac river basin (the main source of drinking water in the city of Lima) showed a significant decrease in pollution due to a 90% reduction in the dumping of household and construction waste [10]. The latter may have had a correlation with a lower generation of household waste at the beginning of the quarantine. According to a study carried out in the district of Lima during the month of June 2020 the researchers reported a decrease of 18.69% in household waste per capita [11]. This decrease was also recorded in cities such as Machu Pichu, where the waste generated daily decreased from 10 to 6 tons [12]; however, the generation of bio-contaminated waste such as masks and gloves as well as single-use plastics increased [12]. By mid-year, in July, when confinement restrictions were gradually lifted the National Water Authority reported that the amount of domestic and construction waste increased considerably in natural water sources such as rivers or canals, they also identified large numbers of masks and gloves in these water bodies [13].

The information stated above still is anecdotal, since the changes in waste generation and composition during the pandemic have not been systematically collected and the few existing data have not been widely disseminated [14]. Studies related to waste generation during the pandemic have focused on the generation of hospital waste [15, 16], plastic waste [17, 18] or waste throughout the food chain [19]. Those who have addressed the municipal solid waste problem have done so based on current statistics provided by local authorities [20] or in qualitative data supported by surveys and interviews. For example, a study carried out in Iran [21] described the impact of the pandemic on solid

waste management, using qualitative surveys conducted to local specialists and authorities. In that case interviewees preferred to share qualitative information (rather than quantitative information) regarding waste generation, collection and disposal; explaining their appraisal and perception on the changes experienced regarding the municipal solid waste situation. Another study performed in Guyana and Nigeria [22] described the effects of COVID-19 on solid waste collection, based on responses to questionnaires completed online. The study did not establish waste volume changes but rather provided some insights into the waste system disturbances experienced by the respondents since the pandemic started. Regarding research with quantitative data, one example for the region is the study on the changes on waste management in Sao Paulo based on monthly data for the past 10 years [23]. Yet, in Peru, and in many developing countries, statistics on solid waste are not updated [24]. To our knowledge, quantitative studies on changes of household waste generation and composition in developing countries during the pandemic have not been carried out.

Understanding these changes is important to adapt waste management practices in a city; maybe increase or decrease the frequency collection or strengthen local markets for recyclable products. For this reason, a novel methodology is proposed to collect information on waste generation and composition during quarantine without having to leave the house and conduct any field work. A procedure for the collection of solid waste data is suggested, relying on common citizens and college students from environmental related careers and by the use of virtual communication. This methodology makes it possible to collect quantitative data on household waste and to sensitize study participants for proper waste management and recycling. Participants get involved in the study far beyond than just filling out a survey. Being part of the study makes them recognize in a tangible way what type of waste they generate, how to separate it and how to reduce it.

The main objective of the research was to collect data on solid waste that can be used as input for decision-making in waste management. To achieve this objective the data were collected from inhabitants of the Arequipa province, Peru in 2020.

Methodology

Traditionally, data on solid waste characterization are obtained through characterization studies that require fieldwork and economic investment, mainly in personnel. The COVID-19 pandemic made it impossible to carry such fieldwork. The novelty of the methodology presented here lies in the possibility of collecting data on household waste generation and composition without the need to leaving home and with minimal investment.

This methodology is based on virtual means for training, compilation and delivery of information; for this, virtual meetings (Google Meet), forms (Google Forms), and online file hosting services (Google Drive) are, respectively used. A team of between five to ten people can handle the calls, training and processing of large amounts of data. Field work is replaced by the volunteer work of participants in their homes. This methodology is not only useful for gathering quantitative information but also as a means of sensitizing participants. By accompanying the participants in the process of making and installing recycling bins in their homes, they are left with some basic infrastructure to continue this practice after the study have concluded. At the end of the study they have the practical experience of waste separation and the training carried out to the household members.

The study was carried out between September 14 and October 2, 2020; just when strict quarantine conditions were being gradually lifted off in Arequipa. The study was developed with the support of undergraduate students from the Professional School of Sanitary Engineering of the National University of San Agustín, Arequipa. The process consisted of three phases where a total of five training sessions were developed. At the end, the main product collected was the data from household waste generation and composition during 7 days. The final goal of the process was for the participants to segregate their waste in differentiated bins for subsequent weighing. Ultimately, the main product collected was the data on the weights of the waste according to a previous classification provided to the volunteers (Table 4). Using the aforementioned data the generation and composition of household waste for 7 days was obtained.

Study area and participants

The territory of Peru, is divided into 26 units: 25 regions and the Province of Lima. The regions are subdivided into provinces and the provinces are composed of districts. The Arequipa region is located on the southern coast of the country and with a population of 1,382,730, it is the fourth

most populated department [25]. According to the Ministry of Health as of May 12, 2021, the Arequipa region presents a total of 76,480 cases (ranking as the second region with the highest number of cases after Lima, the capital city) and with a mortality of 3.44% (slightly lower than the national average) [26].

The study was carried out in the Arequipa province (Fig. 2.) with the participation of inhabitants of the districts of Cerro Colorado (District A), Paucarpata (District B) and Jose Luis Bustamante (District C). These districts are located to the north, south and southeast, respectively of the Arequipa district, capital of the region of the same name. Districts A, B and C have a population of 157,856; 131,516 and 79,173, respectively [27].

The number of participants in the survey was seven times that of the waste characterization study (Table 1). Most of the characterization data comes from the students who participated in the study. Not all the people initially enrolled were able to complete the 7-day study. Some did not finish the required training, have an appropriate scale for weighing the waste or provide enough information during the 7 days.

Conducting surveys in the first phase of the study is useful to collect preliminary information from the population. However, given the small proportion of people who complete the survey and carry out the characterization study, additional effort is needed to study other incentive methods to motivate participants to complete the 7-day sampling process.

Phase 1 of the study

Phase 1 consisted of the call for participants, registration and awareness-raising talks. The call was made through social networks. To enroll in the process, participants filled out an online form with their personal details and completed a survey with closed ended and open-ended questions. The questionnaire collected data on their waste generation and storage habits and, segregation habits and use of reusable bags.

Two training sessions were held with the registered persons, on waste segregation and characterization. The objective of these first sessions was to differentiate between types of waste; organic, recyclable, non-usable and hazardous.

For the waste characterization portion of the study, participants were instructed to consider as “organic” vegetable and fruit peelings, fruits and vegetables, weeds, leftover food stews, dressings and bone residues. Papers, notebooks or magazines sheets, newspaper, cardboard, bottles or glass containers, tetra pack, cans, plastic (polypropylene, PET—polyethylene terephthalate—bottles and high-density polyethylene) and polyvinyl chloride were classified as recyclable waste. Non-usable waste was categorized as dangerous, sanitary (i.e., used toilet paper, sanitary napkins, diapers,

Fig. 2 Development of the waste characterization study by participants at their homes; **a** containers for waste segregation, **b** training for family members, **c** weighing of the waste and **d** storage of used oil and ecobrick in preparation

Table 1 Number of participants in the survey and the waste characterization study

District	Number of participants	
	Survey	Waste characterization study
A	105	17
B	85	15
C	57	12
Total	246	44

bandages, etc.), inert and others. Disposable masks and gloves were included as hazardous waste. Finally, inert and others waste included hair, textiles, rubber, polystyrene, dirt, dust, kitchen paper towels, etc.

Participants were taught to make “ecobricks” with clean plastic bags and clean packaging material. Ecobricks consist of PET bottles filled with clean and dried: candy and food wrappers, aluminium foil, medicine blisters, receipts paper, drinking straws, plastic bags etc. These ecobricks can be used as building materials for small constructions. To

prevent the disposal of used cooking oil in the drain, participants were asked to store the oil in PET bottles.

Participants were trained to explain the information to their relatives at home and to make their waste containers to store the materials that were segregated, so they could carry out the study during a week without any inconvenience (Fig. 3).

Phase 2 of study

In Phase 2 of the study, participants began to collect information on the amount of waste generated in their homes during the first 4 days. For this phase, they used an online form and a Word template where, in addition to the record of weights, they up-loaded photographs of the work carried out (Fig. 3). The Word files were posted on a Drive. At the end of this phase, one more training session on composting and home gardens was delivered.

Phase 3 of study

In Phase 3, two last training sessions were imparted, one on the problem of plastic pollution and the other on

Fig. 3 Geographic location of the study area; **a** South America, **b** Peru and **c** Arequipa

eco-efficiency. Finally, participants made the final data entry, corresponding to the amount of household waste generated during the last 3 days. This way, data on waste composition and weights for 7 days were collected.

In the three phases of the study, all participants received close monitoring and constant guiding. Any doubts they might have during the entire week of study were answered.

Data processing

Once the first three phases were completed, the information was processed according to two groups, (1) responses from the questionnaire and (2) data on waste generation and composition.

With the second group of data, waste generation per capita (GPC) and composition were calculated. The statistical parameters of the waste characterization data were found according to the formula for calculating the sample size (Eq. 1):

$$n = \frac{Z_{1-\alpha/2}^2 N \sigma^2}{(N-1)E^2 + Z_{1-\alpha/2}^2 \sigma^2}, \quad (1)$$

where n is the sample size, $Z_{1-\alpha/2}^2$ the confidence level, N the population size, σ the standard deviation and E the allowable error. Sample data were then validated using the significance test for the mean of a normal population.

To calculate the composition, the percentage of each type of waste was found taking into account the data of the total weight and the weight of each type of waste (Eq. 2). Participants segregated their waste according to nine types (Table 4).

$$\text{Waste percentage (\%)} = \frac{P_i}{W_t} \times 100, \quad (2)$$

where P_i is the weight of each component and W_t the total weight of the waste. The weight of each component was determined by adding the weights recorded by all participants during the 7 days of study. In this way, nine different P_i

were obtained, one for each type of residue. The total weight of the residue, W_t , is the total sum of all the weights recorded by the participants during the 7 days of study.

Results and discussions

Waste generation habits

In the area of study, the most common method of setting waste out onto the street, for the collection truck to collect, is in plastic bags (55%, 80% and 61% in District A, B and C, respectively). Other materials used are sacks (18%) and plastic buckets (13%).

Paper bags and cardboard boxes are used in less quantity (7%). Both in the study area and much part of the country, waste collection is carried out house to house, some families take out their waste at the times indicated by the municipality, others do so when they hear the collection truck approaching, and there are even some that take out their waste regardless of the established schedule. Waste collectors pick up the bags one by one and place them on the truck; there are no bins in the street or automated side or front loader garbage trucks. In this system the use of plastic bags is the most practical for users and collectors.

Regarding the frequency in which waste is collected, these vary between daily and more than every 5 days. In District A the distribution was more uniform; 26% every 2 days, 24% every 3 days, 25% every 4 days, and 26% more than every 5 days. In Districts B and C the highest frequency of responses was every 2 days (35% and 42%) and the lowest frequency of responses was daily with 15% and 7%. In many districts the deficiencies in the collection system prevent the municipality from complying with the established frequencies, this might be the reason that in the same district responses regarding the collection frequency have been so varied.

Waste collection in the districts was mostly performed in the morning, between 4 am and noon (60%, 86% and 47% in Districts A, B and C respectively). In this question, one of the response options was “I do not have the collection service”, this alternative was used to estimate service coverage. In Districts A, B and C the collection coverage was 96%, 98% and 95%, respectively. These data differ from those reported in the Comprehensive Solid Waste Plan of the Arequipa province [28], which indicates that in District C the collection coverage is 100%. In the case of Districts A and B, local governments have reported a collection coverage of 75% in both districts [28], this difference may be because participants live in the urban area of the district where the collection percentage is higher.

On the perception of the municipality's waste collection service 52% consider the service regular. In District A, 33%

perceived it as good, in Districts B and C only 19% consider it good.

Participants were asked for their suggestions or comments on the collection service, the main concern (by 49% of the participants) was the need for a waste segregation program. It should be noted that local authorities of the three districts evaluated have reported having segregation programs since 2018; however, they have very limited coverage (6% in District A, 1% in District B and 12% in District C) [29]. Other relevant suggestions were the petition to increase the frequency of collection (16%), and establish and meet a waste collection schedule (17%). Four people demanded greater coverage of the service, three people the installation of containers in strategic places in the neighborhood, three people improve efficiency in the service, two people better treatment from the collection personnel, one person asked for improvement of the trucks used in the collection service, one person to apply fines for taking out the waste outside the established hours and one person to provide better personal protective equipment to the waste collectors.

Waste segregation, recycling and minimization habits

Less than half of the participants had previous training or experience in waste segregation (45%, 36% and 30% for Districts A, B and C respectively). Despite this, a higher percentage of participants (48%) knew what an ecobrick is.

In Districts A, B and C the percentage of people who do not segregate their waste is; respectively, 40%, 55% and 39%. Only one person, from District A, said they did not segregate due to the quarantine. A group separates waste into three types; organic, recyclable and non-usable (26%, 25% and 21% in Districts A, B and C, respectively). A higher percentage separates their waste into two types, recyclable and the rest (32%, 18% and 40% in Districts A, B and C, respectively).

In relation to the employment of organic waste, this has two main uses, animal feed (29%, 39% and 26% in Districts A, B and C, respectively) and production of organic fertilizer (41%, 35% and 24% in Districts A, B and C, respectively). Part of the participants stated that they did not reuse their organic waste (30%, 25% and 50% in Districts A, B and C, respectively).

Destination given to used cooking oil was also consulted, 68% said they did not separate or accumulate it. In District A 50% store it in bottles and kept it at home, because they do not know where they could deliver it for recycling. In District B and C, 53% and 50% reuse it either as part of the dog food, in the kitchen, as an energy source or to make homemade candles and soaps. About 20% of the participants, despite storing the used oil, once the container is full, they throw it away together with their

Table 2 Statistical parameters of the characterization study

District	Sample size	Confidence coefficient	Error (%)	Standard deviation	GPC (kg/cap/day)
A	17	1.96	30	0.227	0.359
B	15	1.96	26	0.179	0.354
C	12	1.96	28	0.211	0.427

Table 3 Comparison between GPC from 2019 and this study

District	GPC (kg/cap/day)		
	2020 ^a	2019 ^b	Change (%)
A	0.359	0.38	– 6
B	0.354	0.57	– 38
C	0.427	0.45	– 5

^aThis study^bSigersol, 2019

common waste. Only two people in District A and one person in District B claimed to deliver the stored oil to an organization for recycling.

Regarding the use of reusable bags for shopping, these are either always used (27%, 33% and 46% in Districts A, B and C, respectively), on many occasions (44%, 34% and 33% in Districts A, B and C, respectively) or sometimes (22%, 29% and 16% in Districts A, B and C, respectively). Districts A, B and C; 27%, 33% and 46% respectively, indicated that they never use reusable bags to do their shopping.

Generation per capita (GPC)

The data in Table 2 show the statistical parameters used in the characterization study.

Table 3 compares the GPC reported by each district in 2019 and those obtained in the present study.

The GPC reported by each district in 2019 comes from solid waste characterization studies. The main differences between the district data and the data from this study are: the number of samples, the error and the field work. In this study, during the data collection phase, an important difference is the variability in weighing the waste due to the use of different scales by each participant. Despite this, these data are useful as exploratory information and as indicators of the changes that have occurred. Data processing follows the same methodology in both cases.

The data in Table 3 show that in the three districts the GPC was lower during the quarantine than in previous years. However, only in the case of district B this decrease is greater than the error of the study. Therefore, for district B, it can be stated with certainty that, between March and July 2020, the GPC of household waste decreased. This decline in the generation of household waste may be due to a lower purchasing power of families during the pandemic [14, 30]. In districts A and C it can be affirmed that the COVID-19 pandemic, between March and July 2020, has not had a notable impact on the household waste generation.

Composition

The information presented in Table 4 shows the waste composition for each district. Table 5 compares the results

Table 4 Waste composition in Districts A, B and C

	District A 2020 ^a (%)	District B 2020 ^a (%)	District C 2020 ^a (%)
1. Usable waste			
1.1 Organics	46.99	47.53	55.32
1.1.1 Food scraps and garden waste	34.86	33.90	36.12
1.1.2 Leftover food and stews	12.13	13.63	19.20
1.1.3 Others	–	–	–
1.2 Inorganics	30.16	33.58	26.73
1.2.1 Plastics	11.59	15.37	8.80
1.2.2 Glass, cans, paper and cardboard	14.27	13.92	15.21
1.2.3 Ecobrick	2.93	3.08	1.44
1.2.4 Used oil	1.37	1.22	1.28
2. Non usable waste	22.8	18.46	17.94
2.1 Sanitary	13.30	9.83	12.12
2.2 Hazardous	3.01	3.46	2.13
2.3 Inert	6.53	5.17	3.70
3. Electronic waste	–	0.42	–

Table 5 Comparison of the waste composition between 2020 and 2019

	District A		District B		District C	
	2020 ^a (%)	2019 ^b (%)	2020 ^a (%)	2019 ^b (%)	2020 ^a (%)	2019 ^b (%)
1. Usable waste						
1.1 Organics	46.99	64.95	47.53	56.84	55.32	51.85
1.2 Inorganics	27.24	24.60	30.93	16.31	25.30	22.95
2. Non usable waste						
2.1 Sanitary	13.30	1.77	9.83	8.85	12.12	10.77
2.2 Hazardous	3.01	0.01	3.46	0.22	2.13	0.00
2.3 Inert	9.46	8.67	8.25	17.78	5.13	14.43

^aThis study^bSigersol, 2019

of waste composition in the present study with the information reported in 2019 by each district.

In the three districts studied, the highest percentage of the waste was organic. When comparing the percentages of 2019 and 2020 (Table 5) we can see that in District A and B organic waste decreased, but in District C it increased. From 2019 to 2020 (Table 5) the percentage of inorganic waste augmented in Districts A, B and C. The increase in the use of recyclable waste during quarantine may be due to a rise in the applying of cleaning products and an increase in take out food consumption, as has occurred in other cities [31].

District A reported a low proportion of sanitary and inert waste in comparison to Districts B and C. However it is difficult to attribute this difference to the nature of each district. All three districts are located within the Arequipa Metropolitan Area, with a similar socio economic development and waste management indicators [28]. There was a significant increase in both sanitary and hazardous waste. The former can be explained because during the quarantine there have been more persons in the house during the entire day, who used the household toilet more frequently than before the quarantine. The latter is explained because in the 2019 municipal reports only batteries were considered as hazardous waste, and in this case both masks and gloves were considered as hazardous waste. An increase in hazardous household waste was also reported by Requena et al. [11] and Nzediegwu and Chang [32].

Hazardous waste consisted primarily of masks, gloves and, to a lesser extent, batteries, medicines and fluorescent lights. During the study week, each family generated an average of two to four masks and one pair of gloves. These values are similar to those estimated in other countries, in Italy it is calculated that weekly each person generates four masks and a pair of gloves [33]. Although these wastes are being disposed of as hazardous, they are collected together with common waste by the municipality. Taking into account that the COVID-19 virus can remain viable on plastic surfaces for up to 9 days [34] its collection, transport and

disposal represents a risk for waste collectors and for the spread of the disease [32].

Implications for waste management

The results of this study are indicative of the waste situation in the region of Arequipa. The solid waste management indicators at the national level show great differences between the different regions of the country. Waste generation and composition varies according the mores of each area (such as consumption or eating habits), geographical location (which influences the temperature, humidity, precipitation and altitude), size of the population and level of economic activity (a greater economic movement is related to a greater generation of solid waste [35]). For this reason it is not possible to extrapolate the results obtained up to the national level.

The downward trend in the household waste generation in some districts during a quarantine represents an opportunity for local governments. This reduction in the amount of solid waste for collection allows local authorities to address other problems, such as cleaning of critical points where waste is accumulated in the city. Less generation of household waste permits municipalities to have more personnel and vehicles available to collect waste accumulated in the streets. In addition, during the confinement of the population, measures can be taken to prevent the resurgence of critical points such as cleaning, signaling or installation of green and/or gray infrastructure.

In relation to recycling, two situations occurred simultaneously at the beginning of the pandemic. On one side, the increase in the proportion of plastics and on the other the decrease in recycling services. In the first months of the lockdown, recycling activities were suspended. It is important to note here that in Peru a large part of recycling occurs through informal chains. Formal recycling is mainly carried out by associations of recyclers, who sell their products to intermediaries. The COVID-19 quarantine suspended both

formal and informal recycling. However, as of May, formal recycling was reestablished; despite this, it took the waste picker associations several months to comply with the requirements established by the state to restart their activities. At the beginning of the pandemic, it was not possible to store the plastic waste generated for its later use; these had to be collected and disposed in sanitary landfills to observe the biosafety recommendations established by the health authorities. Over the next months, the increase in the generation of plastics could be exploited by both formal and informal recycling chains, the two already re-established as the strict conditions of confinement were lifted.

In countries like Peru, changes in the composition of solid waste that affect recycling will be difficult to measure and benefit until the high informality rate in the sector is reversed.

Regarding household hazardous waste, it is likely that the increase is due to disposable masks, which are mandatory at the national level. Although this waste presents the risk of biocontamination, it is not disposed of as hazardous waste; in most cases it is taken to the sanitary landfill or open dumps for final disposal. Taking into account the increase in this type of waste, it is important that local governments place greater emphasis on raising awareness among the population so that they can properly dispose these residues, and thus prevent the spread of the coronavirus.

Conclusions

In the present study, household solid waste from three districts of the Arequipa province in Peru was characterized. The information was collected using a novel methodology that uses virtual tools and allows obtaining information on waste generation and composition without the need for fieldwork. A total of 44 people participated in the waste characterization and 246 people completed a survey on waste generation and recycling habits. The GPC of household waste decreased in the three districts; 6% in District A, 38% in District B and 5% in District C. It can be conclusively stated that the COVID-19 pandemic caused a reduction in waste generation in District B, between March and July 2020. This reduction can be associated to a decline in economic activities during the quarantine, this leads to a diminution in the purchasing power of the families. In Districts A and C, quarantine had no discernible effect on the household GPC. Regarding waste composition, the highest percentage corresponded to organic waste; results to be expected in developing countries. From 2019 to 2020 in Districts A and B organic waste decreased, and in District C it increased. The percentage of inorganic waste increased in the three districts evaluated. The rise in the proportion of recyclable waste can be related to an increase in the acquisition of

cleaning products, and an increase in take out food consumption, which responds to the recommendations provided to reduce the risk of contagion from COVID-19. Given the presence of masks and gloves as part of hazardous waste, this category showed a significant increase in the three districts. Each family generated an average of two to four masks and one pair of gloves per week. Given the persistence of the virus on plastic surfaces, an inadequate disposal of this type of waste can become a vector of the disease. Although the results presented in this research are influenced by the type and precision of the scales used in the work, minor differences that may have taken place in the segregation of the materials by the participants and the variations in tares and procedures, the results provide an overview of the changes that have occurred. This type of information is especially important in cities where data on solid waste is not available. Furthermore, the importance of this methodology also rests in the training of students and in the education of the participating families in waste management and recycling.

Acknowledgements The authors wish to thank the Professional School of Sanitary Engineering of the National University of San Agustín Arequipa, and their students, for its support in conducting this study.

Author contributions Conceptualization, methodology, investigation: RS; formal analysis, writing—original draft preparation: CR; writing—reviewing and editing: DC.

Declarations

Conflict of interest The authors declare that there is no conflict of interest.

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