NVEO
Natural Volatiles & Essential Oils

# Solid Waste Management In The District Municipality Of Andahuaylas –Apurimac - Peru

**Wilbert Quispe Prado[1], Doris Esenarro Vargas[2], Susana Irene Davila Fernandez[3] Luis Guillermo Quiroz Bazan [4] , Rogelia Guillen Leon [5] , Samuel Reyna Mandujano[6]**

[1,2,5,6]*National University Federico Villarreal, Lima, Perú*
[2,3]*University Ricaldo Palma, Lima, Perú*
[4]*National University Engineering, Lima, Perú*
[2]*Specialized Institute for Ecosystems and Natural Resources Research (INERN)-UNFV*
[2] *Graduate School- EUPG- UNFV Peru*
*wquispe@unfv.edu.pe desenarro@unfv.edu.pe, susana.davila@urp.edu.pe luis.quiroz.b@uni.edu.pe rguillen@unfv.edu.pe,sreyna@unfv.edu.pe*

***Abstract***
The objective of this research is to carry out a diagnosis and proposal for solid waste management in the José María Arguedas District Municipality, Province of Andahuaylas, Apurímac. A sample size of 83 households was randomly selected. The diagnosis of solid waste generation reports a household average of 2.37 ± 1.33 kg/household/day (representing 83.62% of the solid waste generated), followed by the Restaurants source with an average generation of 2.81 ± 0.89 kg/day. The head with the lowest age was the Boticas with 0.27 ± 0.04 kg/day, showing a significant difference (p-value < 0.05) between the sources of solid waste generation. The characterization of household solid waste comprises 29.24% organic matter, 11.57% wood and foliage, and 27.06% inert matter. In comparison, the other types total 32.13%, organic waste totaled 43.38%, and organic waste 56.62%, with an average density of 116.43 kg/m3, average humidity of 73%, and average per capita production of 0.498 kg/person/day. The formulation of solid waste management proposes strengthening and expanding local waste recycling systems, as well as raising community awareness of the importance of household solid waste collection and management through talks and workshops in educational institutions and neighborhood councils, emphasizing reuse and recycling, which should be proposed and developed by the District Municipality.

**Keywords:** *Solid waste, diagnosis, characterization, management, and handling.*

## 1 . INTRODUCTION

The progressive deterioration of the urban environment in the city due to the incorrect management of municipal solid waste (MSW), which produce a negative environmental impact(Marino, A. et al., 2018). Let's consider the demographic growth occurring in the city and the expansion of the urbanized area. It is appreciated that not all sectors of the town benefit from an adequate waste collection service, which leads many neighbors to coexist near numerous micro dumps generated by themselves. (Alhumid, H et al., 2019)

On the other hand, the handling and management of solid waste is a component of environmental management and is part of the comprehensive program of solid waste management at the national level (PIGARS) of the Ministry of Environment; for this reason, implementing these actions as a policy of the District Municipality of José María Arguedas is

urgent to ensure and prevent environmental pollution and ensure the health of the inhabitants and the environment (Bernstad, A. et al., 2017).

Thus, the present research work aims to obtain information on the generation, composition, density, and characteristics of solid waste in the José María Arguedas District Municipality of the Province of Andahuaylas and, based on this, to develop a proposal for the management and handling of municipal solid waste (Su et al., 2021).

Solid waste is substances, products, or by-products in a stable or semi-solid state, discarded by their generator. A generator is defined as a person who produces solid waste as a result of their activities. They are usually considered to have no economic value and are colloquially known as "garbage." However, it is essential to note that the law also considers within this category semi-solid materials (such as mud, mud, sludge, and slime, among others) and those generated by natural events such as rainfall, landslides, among others (Calabro, P. and Komilis, D., 2019).

According to its origin, waste can be classified into residential, commercial, institutional, construction and demolition, municipal services, treatment plants, industrial and agricultural. Residential waste, in turn, is organized into food waste, paper, cardboard, plastics, textiles, leather, garden waste, wood, glass, aluminum cans, particular waste, and hazardous household waste (Ceribeli, K. and Souza, M., 2019).

In the 1980s, the perspective of sustainable development arose from the United Nations Conference on Environment and Development, which took place in 1992 in Rio de Janeiro, where it was established that all human activity should be developed within a framework of equity, social participation, and environmental preservation (Nižetić et al., 2019).

The world produces some 10 billion tons of solid waste per year, and not even half of this amount is collected and treated. This mainly generates the increase of CO2 and CH4 in the atmosphere, which in turn causes an increase in the planet's temperature, leading to global warming (Organization for Economic Cooperation and Development).

Opportunities for sustainable development accompany the problem of integrated management of household solid waste. This is explained not only by the savings in environmental liabilities and health expenses but also by the economic and social advantages produced by the recovery of commercial materials, the generation of new sources of employment, and the increase in governance (Gwenzi, 2021).

## 2. METHODOLOGY

The study area includes the urban zone of the José María Arguedas district, province of Andahuaylas, department of Apurímac, which is located at 3600 m.a.s.l.


**Figure 1.** Geopolitical map of the district of José María Arguedas.

The location corresponds to 3600 masl, latitude 130 44l 02" south and longitude 730 21l 02" west. The Unit of analysis is the domestic solid waste generated in the homes of the inhabitants of the locality. (Collivignarelli, M. et al., 2021)

Sample selection techniques, Household samples will be selected randomly, taking into account the cadastral zoning of the district. (Hantoko, D. et al., 2021)

**Data Collection Techniques**

It will be carried out through surveys and direct observation in situ at the time of diagnosis and review of secondary information. (Liu, L. et al., 2018)

The quartet method for solid waste characterization was used to characterize the solid waste generated in the José María Arguedas District; utilizing this method, the waste composition, per capita production, and density was determined.

Solid waste generation, generated from different sources such as homes, stores, educational institutions, plazas, and other human activities.

**Direct observation**

Through this method, it was possible to document what was observed during the collection process, recording information such as the location of critical points, type of solid waste storage tanks, management, collection routes, collection schedule, reliable waste treatment, and types of solid waste. (Luo, C. et al., 2021)

**MINAM Methodology**

The reference guide used to prepare the eco-efficient solid waste management plan was the one established by MINAM in the "Fulfillment of the goal," indicating the procedures to carry out the project. (Mazumder, P. et al., 2018)

The density was calculated in the office using the following formula:

$$D = \frac{W}{V} = \frac{w}{N\left(\frac{d}{2}\right)^2 (H - h)}$$

D: Density of solid waste

W: Weight of solid waste

V: Volume of solid waste

d: Cylinder diameter

H: Total height of the cylinder

h: Clear height of solid waste

N: Constant (3.1416)

**Moisture determination**

It is an essential characteristic for the processes to which the garbage can be subjected. It is generally determined in the following way: Take a representative sample, 1 to 2 kg, heat it at 80ºC for 24 hours, weigh it and express it on a dry or wet basis.

**3. RESULTS**

**Table 1.**

Results of average solid waste generation per day.

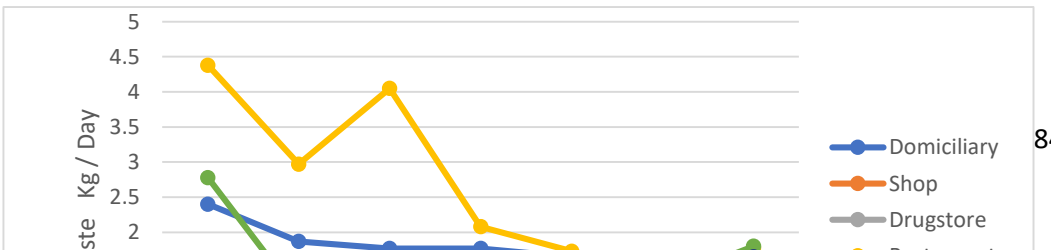
| Source | | Solid Waste Generation (kg)eneración de Residuos Sólidos (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Day one** | **Day two** | **Day three** | **Day four** | **Day five** | **Day six** | **Day seven** | **Total, average** |
| Domiciliary | % | 18.80 | 14.61 | 13.86 | 13.89 | 12.90 | 12.73 | 13.22 | 100 |
| | Average | 2.40 | 1.87 | 1.77 | 1.77 | 1.65 | 1.62 | 1.69 | 2.37 |
| | Dev. Its T. | 1.53 | 1.64 | 1.40 | 1.43 | 1.20 | 1.13 | 1.01 | 1.33 |
| | Maximum | 8.75 | | | | | | | |
| | Minimum | 0.00 | | | | | | | |
| Shop | % | 14.30 | 12.41 | 13.14 | 11.67 | 17.56 | 14.51 | 16.40 | 100.0 |
| | Average | 0.80 | 0.69 | 0.74 | 0.65 | 0.98 | 0.81 | 0.92 | 0.80 |
| | Dev. Its T. | 0.53 | 0.50 | 0.54 | 0.54 | 0.66 | 1.04 | 0.73 | 0.30 |
| | Maximum | 3.65 | | | | | | | |
| | Minimum | 0.00 | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Drugstore | % | 7.89 | 6.58 | 17.11 | 3.95 | 28.95 | 3.95 | 31.58 | 100.0 |
| | Average | 0.15 | 0.13 | 0.33 | 0.08 | 0.55 | 0.08 | 0.60 | 0.27 |
| | Dev. Its T. | 0.21 | 0.11 | 0.11 | 0.11 | 0.42 | 0.11 | 0.07 | 0.04 |
| | Maximum | 0.85 | | | | | | | |
| | Minimum | 0.00 | | | | | | | |
| Restaurant | % | 23.95 | 16.21 | 22.13 | 11.38 | 9.47 | 7.10 | 9.74 | 100.0 |
| | Average | 4.38 | 2.97 | 4.05 | 2.08 | 1.73 | 1.30 | 1.78 | 2.81 |
| | Dev. Its T. | 1.04 | 0.95 | 0.26 | 0.64 | 0.29 | 1.18 | 1.71 | 0.89 |
| | Maximum | 5.15 | | | | | | | |
| | Minimum | 0.00 | | | | | | | |
| Internet | % | 22.31 | 10.77 | 3.08 | 20.77 | 6.15 | 16.15 | 20.77 | 100.0 |
| | Average | 0.73 | 0.35 | 0.10 | 0.68 | 0.20 | 0.53 | 0.68 | 0.46 |
| | Dev. Its T. | 0.53 | 0.28 | 0.14 | 0.25 | 0.28 | 0.25 | 0.25 | 0.10 |
| | Maximum | 1.10 | | | | | | | |
| | Minimum | 0.00 | | | | | | | |
| Motocenter | % | 26.59 | 10.30 | 13.77 | 12.69 | 6.95 | 12.46 | 17.25 | 100.0 |
| | Average | 2.78 | 1.08 | 1.44 | 1.33 | 0.73 | 1.30 | 1.80 | 1.49 |
| | Dev. Its T. | 2.56 | 0.93 | 1.55 | 1.62 | 0.39 | 0.57 | 0.49 | 0.72 |
| | Maximum | 5.05 | | | | | | | |
| | Minimum | 0 | | | | | | | |
| Fuel Station | % | 8.04 | 8.04 | 5.36 | 25.89 | 15.18 | 8.04 | 29.46 | 8.04 |
| | Average | 0.45 | 0.45 | 0.30 | 1.45 | 0.85 | 0.45 | 1.65 | 0.80 |
| | Dev. Its T. | 1.65 | | | | | | | |
| | Maximum | 0.30 | | | | | | | |

Table 1 shows that the maximum amount of waste generated at the household source is 8.75 kg. The average amount of waste generated on day 1 (Monday) is 2.40 ± 1.53 kg (18.80%), followed by day 2 (Tuesday) with 1.87 ± 1.64 kg (14.61%), and the rest of the days are similar in terms of the amount of solid waste generated at the stores and grocery stores. 61%), and that the rest of the days is identical in terms of the amount of collection, the solid waste generated in the stores and/or grocery stores, it is observed that from day 5 to day seven there is an increase in generation, although this is slight. However, the maximum value generated is 3.65 kg/day. (Naughton, C., 2020) The maximum amount of solid waste generated by the restaurants in the area was 5.15 kg. It was similar on days 2, 4, 5, 6, and 7, with the most significant amounts on days 1 and 3, with 4.38 ± 1.04 kg and 4.05 ± 0.26 kg, respectively. Table 1 also shows that the internet sites generate solid waste, although in smaller quantities, with a maximum value of 1.10 kg. The most significant amount generated on day 1 (Monday) was 0.73 ± 0.53 kg.

**Figure 2.**

Variation in the generation of solid waste by source.



The variation in solid waste generation can be seen, clearly showing that the amount of waste generated by restaurants is more significant, followed by the household source, than by motorcycle centers. (Ogechukwu, A., 2020) In contrast, the heads of stores and groceries, faucets, internet, and drugstores show similar generations and variations, although the lowest is drugstores.(Radwan, N. et al., 2021)

**Figure 3.**

Total generation of solid waste by sources

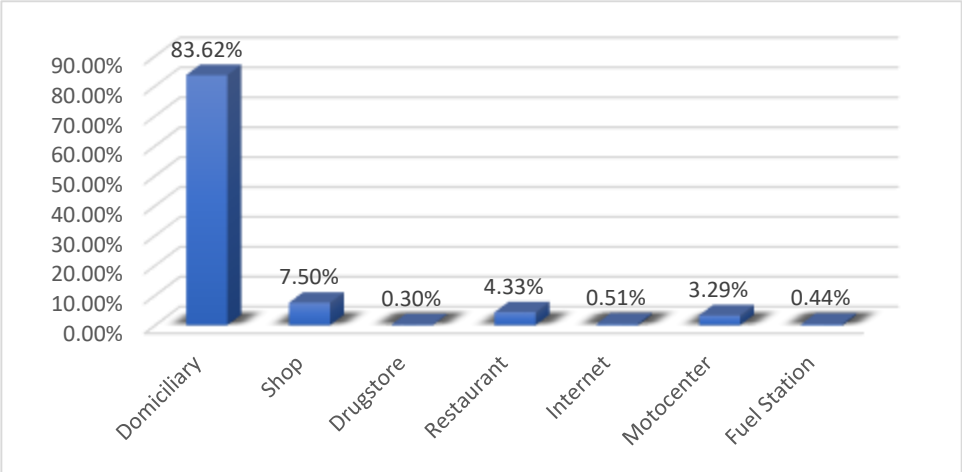
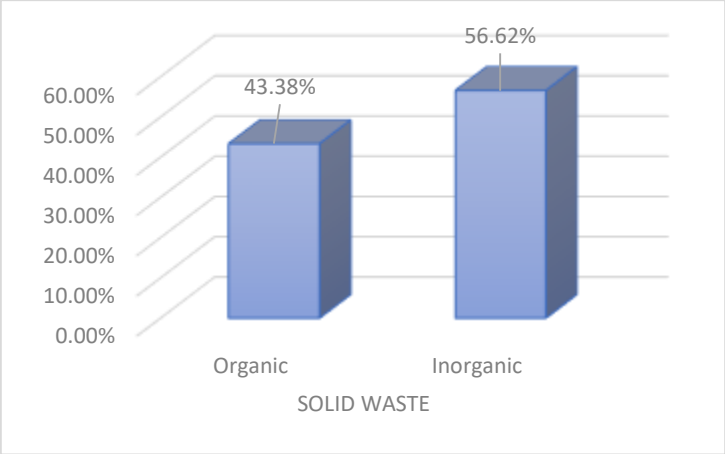



Figure 2 shows that the household source contributes 83.62%, almost all of it; another source, although in smaller quantities, is generated by stores and/or groceries; another source that generates considerable amounts is restaurants, which represent 4.33%, while the generation of the other sources is minimal. (Ramirez, C. and Gonzalez, E., 2019)

**Figure 3.**

Household composition of organic and inorganic solid wastes




Organic waste consists of Organic Matter, Wood, Foliage, Paper, and Cardboard, which represent 43.38% which is relatively less than the inorganic waste, which amounts to 56.62% and is made up of Glass, PET Plastic, Hard Plastic, Bags, Tetrapak, Tecnopor, and similar, Metal, Fabrics, Textiles, Rubber, Leather, Rubber, Rubber, Batteries, Remains of medicines, Sanitary Waste, Inert Waste, Wrapping, Cans, WEEE and Bones.

**Table 2.**

Moisture content of household solid waste

| DAY 1 | DAY 2 | DAY 3 | DAY 4 | DAY 5 | DAY 6 | DAY 7 | AVERAGE |
|---|---|---|---|---|---|---|---|
| 75% | 71% | 70% | 70% | 73% | 78% | 72% | 73% |

Table 2 shows that, on average, this value is 73%, while the maximum value was 78% and the minimum value was 70%. (Quispe, W. et al., 2020)

**Hypothesis test**

**Table 2.**

Analysis of variance of RRSS generation in the sources.

| Source | GL | SC Adjusted | MC Adjusted | F Value | p-value |
|---|---|---|---|---|---|
| Factor | 6.00 | 43.68 | 7.28 | 10.48 | 0.00 |
| Error | 49.00 | 34.02 | 0.69 | | |
| Total | 55.00 | 77.70 | | | |

Table 3 shows the results of the ANOVA test, showing that p-value = 0.00 (Annex 02), which indicates that the null hypothesis is rejected, i.e., there is a significant difference in the generation of solid waste by source.

## 4. DISCUSSION

Organic waste, made up of organic matter, wood, foliage, paper, and cardboard, represents 43.38%: Organic Matter, Wood, Foliage, Paper, and Cardboard, represent 43.38% which is relatively less than the inorganic waste, which amounts to 56.62% and is made up of Glass, PET Plastic, Hard Plastic, Bags, Tetrapak, Tecnopor, and similar, Metal, Fabrics, Textiles, Rubber, Leather, Rubber, Rubber, Batteries, Medicine waste, Sanitary Waste, Inert Waste, Wrapping, Cans, WEEE and Bones. in the Huánuco region, the physical composition of solid waste varies from an organic solid waste production of 63.63% to an inorganic waste production of 36.37%. At the same time, these values are of the order of 80.68% of organic waste and inorganic waste average weight (paper, cardboard. Glass, among others) with 19.32%. (Quispe, W. et al., 2020)

The moisture contained in the solid waste is converted into a very acidic liquid (organic acid-containing, among other elements: iron, zinc, nickel, copper, and chlorides); this liquid seeps through the garbage and seeps through the soil until it reaches the groundwater contaminating it. (Ogechukwu, A., 2020) Also, the humidity is responsible for the proliferation of vectors such as flies, being high is the higher the humidity. The results of the moisture of the solid waste are presented in Table 2, from it we can see that on average this value is 73%, while the maximum value was 78%. The minimum was 70%, this variation of humidity.

Thus on excellent methanogenesis, a concentration higher than 60% of moisture in the waste is required. The biological degradation of organic matter improves with humidity between 50 and 70% although an optimal value is 55% moisture established to be viable for an incineration process. (Marino, A. et al., 2018)

## 5. CONCLUSIONS

The diagnosis of solid waste generation in the urban center of the José María Arguedas district reports that the average household waste generation is 2.37 ± 1.33 kg/household/day, being this the source with the highest generation representing 83. 62% of the solid waste generated, followed by the source Restaurants whose average daily generation was 2.81 ± 0.89 kg/day, while the source with the lowest generation was the Boticas with 0.27 ± 0.04 kg/day, showing that there is a significant difference (p-value < 0.05) between the sources of solid waste generation.

The characterization of household solid waste shows that it is composed of 29.24% organic matter, 11.57% wood, and foliage, and 27.06% inert matter, while the other types total 32.13%. It was also reported that the total organic waste amounted to 43.38% and organic waste to

56.62%. The average density was 116.43 kg/m3, with an average humidity of 73%, and that the average humidity per capita production was 0.498 kg/person/day.

The formulation of solid waste management proposes strengthening and expanding local waste recycling systems, as well as raising community awareness of the importance of household solid waste collection and management through talks and workshops in educational institutions and neighborhood councils, emphasizing reuse and recycling, which should be proposed and developed by the District Municipality.

**6. REFERENCIAS**

1. Alhumid, H. A. et al. Performance assessment model for municipal solid waste management systems: Development and implementation. Environ. MDPI 6, 2–26 (2019).

2. Bernstad Saraiva, A., Souza, R. G., & Valle, R. A. B. (2017). Comparative lifecycle assessment of alternatives for waste management in Rio de Janeiro – Investigating the influence of an attributional or consequential approach. Waste Management, 68, 701-710. https://doi.org/10.1016/j.wasman.2017.07.002.

3. Calabrò, P. S. & Komilis, D. A standardized inspection methodology to evaluate municipal solid waste collection performance. J. Environ. Manag. 246, 184–191 (2019).

4. Carlos Tome, Esenarro Vargas Doris, Cordova Miranda and Alcira Irene. (2020). Use of grass bio-waste as a substrate for the cultivation of the edible mushroom Pleurotus akin ostreatus , Solid State Technology Volume: 63 Issue: 1s

5. Carpio, M. and Ruiz, C. and Esenarro, D. and Rodriguez, C. and Garcia, G. and Brena, (2020). Natural coagulant based on mango seeds (Mangifera indica L) in removal of turbidity of domestic wastewaterInternational Journal of Advanced Science and Technology EID: 2-s2.0-85085357305,Part of ISBN: 22076360 20054238, 2020

6. Ceribeli, K. B., & de Souza-Santos, M. L. (2019). Effect of dry-solid content level in feeding slurry of municipal solid waste consumed by FSIG/GT power generation process; a theoretical study. Fuel, 254, 115727. https://doi.org/10.1016/j.fuel.2019.115727.

7. Collivignarelli, M. C. et al. Treatment of high strength wastewater by thermophilic aerobic membrane reactor and possible valorisation of nutrients and organic carbon in its residues. J. Clean. Prod. 280, 124404 (2021).

8. Gwenzi, W. (2021). Leaving no stone unturned in light of the COVID-19 faecal-oral hypothesis? A water, sanitation and hygiene (WASH) perspective targeting low-income countries. Science of The Total Environment, 753, 141751. https://doi.org/10.1016/j.scitotenv.2020.141751

9. Hantoko, D. et al. Challenges and practices on waste management and disposal during COVID-19 pandemic. J. Environ. Manag. 286, 112140 (2021).

10. Liu, L., Chen, H., Jiang, L., Hu, J., Zhan, W., He, Y., Zhu, D., Zhong, Q., & Yang, G. (2018). Water table drawdown reshapes soil physicochemical characteristics in Zoige peatlands. CATENA, 170, 119-128. https://doi.org/10.1016/j.catena.2018.05.025

11. Luo, C., Ju, Y., Giannakis, M., Dong, P. & Wang, A. A novel methodology to select sustainable municipal solid waste management scenarios from three-way decisions perspective. J. Clean. Prod. 280, 124312 (2021).

12. Marino, A. L., Chaves, G. de L. D., & Santos Junior, J. L. dos. (2018). Do Brazilian municipalities have the technical capacity to implement solid waste management at the local level? Journal of Cleaner Production, 188, 378-386. https://doi.org/10.1016/j.jclepro.2018.03.311

13. Mazumder, P., Kalamdhad, A., Chaminda, G. T. & Kumar, M. Coalescence of co-infection and antimicrobial resistance with SARS-CoV-2 infection: The blues of post-COVID-19 world. Case Stud. Chem. Environ. Eng. 3, 100093 (2021).

14. Naughton, C. C. Will the COVID-19 pandemic change waste generation and composition? The need for more real-time waste management data and systems thinking. Resour. Conserv. Recycl. 162, 105050 (2020).

15. Nižetić, S., Djilali, N., Papadopoulos, A., & Rodrigues, J. J. P. C. (2019). Smart technologies for promotion of energy efficiency, utilization of sustainable resources and waste management. Journal of Cleaner Production, 231, 565-591. https://doi.org/10.1016/j.jclepro.2019.04.397

16. Ogechukwu, A. A (2020). Review of solid waste management strategies in Nigeria. J. Environ. Earth Sci. 10, 132–143.

17. Radwan, N., Khan, N.A. & Elmanfaloty, R.A.G. (2021) Optimization of solid waste collection using RSM approach, and strategies delivering sustainable development goals (SDG's) in Jeddah, Saudi Arabia. Sci Rep 11, 16612 (2021). https://doi.org/10.1038/s41598-021-96210-0

18. Ramírez, C., & Gonzalez, E. (2019). Methodological proposal for the inter-institutional management of wastes in health care centers in Uruguay. MethodsX, 6, 71-81. https://doi.org/10.1016/j.mex.2018.11.022

19. Su, G., Ong, H. C., Ibrahim, S., Fattah, I. M. R., Mofijur, M., & Chong, C. T. (2021). Valorisation of medical waste through pyrolysis for a cleaner environment: Progress and challenges. Environmental Pollution, 279, 116934. https://doi.org/10.1016/j.envpol.2021.116934

20. Wilber Quispe, Doris Esenarro, Ciro Rodriguez, Karina Alvarado, Carmen Ruiz, Wilson Alvarez. (2020). Physicochemical quality of honey bee (Apis mellifera) in three bioclimatic zones in Apurimac Perú. International Journal of Advanced Science and Technology, 29(7), 268 - 275.