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DIAGNOSIS OF HAZARDOUS WASTE MANAGEMENT AT THE TECHNICAL UNIVERSITY OF AMBATO

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ABSTRACT

Introduction: In general, university laboratories can be characterized as a polluting source, as they use several chemical substances that are potentially harmful to the environment and human health in the development of their academic activities. Therefore, proper handling of chemical products and management of waste generated are necessary for environmental safety. **Objective:** make a diagnosis respect to the management of hazardous waste at the Technical University of Ambato. **Methods:** it's a quantitative, descriptive and cross-sectional study, in which 41 laboratories generating hazardous waste were selected. A survey was applied based on the current technical regulations of the Ministry of the Environment of Peru, with 3 sections, and the results were analyzed in the SPSS 24.0 program. **Results:** at the laboratories of the university predominates the generation of infectious residues in the School of Health Sciences and construction in the School of Civil and Mechanical Engineering, the number of containers is insufficient for generation demand or does not meet the needs (80.50%), sharps are segregated in rigid containers (75.60%), waste is not disposed of according its class (68.30%), central storage is far from medical and food services (61.00%), no treatment or final disposal is carried out by specialized companies (80.50%). **Conclusions**: the laboratories have an appropriate internal waste management, they have covered containers, the sharps are appropriately segregated, there is a correct middle storage. However, in the external management of hazardous waste, there aren't routes or timetables for transport, no treatment or collect is carried out through an specialized company.

KEYWORDS: hazardous waste, diagnosis, laboratories, waste management, universities, environment.

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INTRODUCTION

The waste generated in teaching and research laboratories of universities can represent one of the main risks to the environment and human health, due to its physical-chemical characteristics and inadequate management, capable of harming sustainable development (1). Today, cities around the world generate more than 1,300 million tons of waste per year, as Uganda produces 28,000 tons of hazardous and common waste per year (2), developed countries such as the USA, Germany and Canada generate a high percentage of hazardous waste solid waste (3). At the university level, for example, in the laboratories in the city of Isfahan, Iran, the amount of waste produced is 2,609 kg per year, 55% in pharmacy, 31% in medicine, 10% in public health, 4% in the faculty of dentistry (4).

In Latin America, Mexico, waste reached a daily production per person of 1.2 kg (5). In Colombia, 25.6 t of hazardous waste are generated annually, being the activity of laboratories, hospitals and medical clinics with the highest generation of waste (73.34%) (6). In Brazil, it is estimated that in the university laboratories biological waste is generated in 62.5%, sharps in 87.5%, chemical and common waste in 100%, organic in 83% and pharmacological in 20.8% (7).

In Ecuador, according to the National Institute of Statistics and Censuses (INEC), each inhabitant of the country generates around 0.58 kg of solid waste per day in urban areas (8). In the city of Guayaquil, a weekly average of 452 kg that were considered non-hazardous waste, while 7.5 kg were labeled as hazardous, and of those, 45% were organic and 12% special (9). In laboratories, there are reference values on waste management in private laboratories in Ambato city, the weekly production of contaminating and infectious waste reaches an average of 1.8 kg in basic laboratories and 3.9 kg in specialized laboratories (10).

According to the Ecuadorian Technical Standard, a waste is any object, material or substance remaining from the consumption of a product, or because of some activity, which may be of an industrial, commercial, domestic, or institutional nature (11). Waste can be classified into two categories: hazardous and non-hazardous waste. Non-hazardous wastes are those which do not represent a risk to human health or the environment (12). They can be sub-classified into biodegradable (those that decompose easily in the ecosystem), recyclable (they do not decompose but can be used as the main material of a new process) and common (generated by everyday activities) (13).

Hazardous wastes are those generated by a production process that present any infectious, corrosive, explosive or radioactive characteristics which can harm both: human beings and the ecosystem; also, which generates a mandatory nature of control in its use and exposure. Therefore, special hazardous wastes are those that, without the need to be considered dangerous, produce some type of damage to the environment or health, either due to their difficult degradation or due to the amount of product (14). Infectious waste is those that contain microorganisms with sufficient virulence and concentration to produce a pathology, they can be classified into bio-sanitary or biological, anatomopathological, sharps, and animals (11). The infectious biological waste is those which are generated mostly in the health sectors, like in hospitals, laboratories or research centers, during medical care for humans or animals. They are also characterized by contact with organic matter, blood or body fluids (15). The anatomopathological waste include biopsies, tissues, organs, parts, and body fluids, which are obtained by performing autopsies, surgeries, or sampling for analysis. In the same way, sharps are elements that due to their cutting characteristics can give rise to an accident with a biological risk. The most used in health institutions are scalpel blades, needles, glass ampoules (16).

Chemical waste, in turn, are those that contain substances capable of causing serious damage to human health and even death, in addition to environmental damage, due to their toxicity and dangerousness characteristics, which may be flammable, corrosive, toxic or explosive; among these are drugs, heavy metals present in batteries, thermometers and radiographic films, non-halogenated and halogenated organic solvents, oxidizing substances, among others (17). Radioactive waste, on the other hand, are Radioactive waste, in turn, is those that contain radionuclides, that is, particles that emit energy in the form of ionizing or non-ionizing electromagnetic radiation, whether alpha, beta, gamma or other. Any and all material contaminated with radionuclides is considered radioactive waste, it includes contaminated material and secretions from patients under treatment. Other types of waste from research activities, particularly those from experimental activities, include carcasses or parts of animals that are contaminated or exposed to infectious agents (18). The waste generated by civil construction, metallurgy, automotive, electronic equipment, cement, lime, wood must also be considered (1); in addition to the administrative ones, which are derived from the activities of the, such as: lamps, batteries, ink cartridges, toner, among others; and recyclables that do not decompose easily, so it is better to reuse them as raw material, including paper, plastics, scrap metal, glass, broken equipment parts etc. (19).

Worldwide, the common waste generated corresponds to 80%, 20% hazardous waste, 15% infectious and anatomopathological waste, 3% is chemical and pharmaceuticals, 1% includes cytotoxic and radioactive waste, and sharps, for these reasons waste should be controlled through proper management that allows establishing efficient processes for the prevention, reduction, use, treatment and final disposal of hazardous waste (20,21). According to this, the World Health Organization (WHO) recommends the use of visible posters that indicate the contents of the container which are used for the classification and disposal of waste, in the same way, the use of color coding indicating, yellow for sharps, red for anatomopathological and infectious residues, green for pharmacological or chemical wastes and black for common residues (22).

Regarding to the storage and transport, waste has several management routes, some can be recycled or recovered for a different activity, on the other hand, others can be guided to treatments to minimize risks to human health through physical-chemical, thermal processes, biological, radiation, extreme pressures, before their final disposal (6). In other cases, the waste produced is stored in a designated area within the unit and the storage time is 24 to 48 hours or 24 to 72 hours. The infectious waste is sterilized in autoclaved and disposed of. The common waste is submitted to a recycling process to reduce the amount of it in the landfill (23). Post-storage hazardous waste is collected and transported, using specialized vehicles, from the laboratory to the disposal center. Containers in which there are hazardous waste should be collected as soon as possible to minimize negative impact on the environment and health (24).

The Solid waste collection is a work activity, and according to the International Labor Organization (ILO) that can cause up to 2.2 million deaths from occupational-related illnesses and injuries and 170 million serious injuries (22). For this reason, it is considered one of the jobs with the highest risk in the world, because it exposes employees to both physical and biological or chemical hazards. In relation to this, a study carried out in Ethiopia states that solid waste collectors suffer from different health symptoms such as: respiratory (45.0%), skin (34.2%) and muscular (21.8%). Similarly, a study carried out in Egypt revealed that the most frequently manifested symptoms were respiratory 18.1% and skin 13.8%. A study conducted in India indicated that respiratory problems have a higher incidence (12.99%). Another study carried out in Latin America indicated that 14.3% of collectors have respiratory problems, while 78.8% has musculoskeletal problems (25). In laboratories, in addition to the aforementioned diseases, there are other risks such as exposure to microorganisms such as: Mycobacterium tuberculosis, Brucella, Shigella, Salmonella, Rickettsia, and Neisseria meningitides, human immunodeficiency virus (HIV), virus of the hepatitis B (HBV) and hepatitis C (HCV) (26).

Finally, the laboratories of Higher Education Institutions (IES) of Ecuador are places with a high risk of contamination, both inside and outside their physical infrastructure, because through waste management, infectious, toxic, reactive, corrosive, flammable and other contaminants will be transported and dispersed to the environment. In these terms, environmental education and the culture of environmental protection go hand in hand with the concept of University Social Responsibility (RSU), making reference to social commitment beyond the strictly academic field, by taking responsibility for the waste generated (21), for this reason the aim of this research was to carry out a diagnosis of hazardous waste management at the Technical University of Ambato (TUA).

METHODS

The research was quantitative, because it raises the resolution of problems through the collection of numerical data (26), descriptive, with the aim of detailing the characteristics of a homogeneous set of phenomena, organizing, summarizing and analyzing the results obtained, and transversal because it had a defined population and period of time (28).

A census-type sampling was used, since the population was the same to the sample, the following inclusion criteria were considered: people in charge of laboratories that generate hazardous waste at the Technical University of Ambato, as a result there were 41 participants. On the other hand, the exclusion criteria used were for the laboratories that do not generate hazardous waste (2). In this way, 41 laboratories were obtained, which were divided into: 13 from the Faculty of Health Sciences (FCS), 10 from the Faculty of Agricultural Sciences (FCA), 9 from the Faculty of Sciences and Engineering in Food and Biotechnology (FCIAB) and 9 from the Faculty of Civil and Mechanical Engineering (FICM).

For gathering the information about the management of hazardous waste at the laboratory level, a survey was applied based on the current technical regulations of the Ministry of the Environment of Peru, through a digital form made up of 56 questions, with responses of if it complies, does not comply, unknow and not applicable. The survey was divided into 4 sections: basic and administrative knowledge, steps of waste management, risks of waste management, and classification of the waste eliminated. The Microsoft Forms platform was used in an online way; it was anonymous and was applied during the month of June/2021. The data obtained in the survey were processed using the statistical software SPSS (Statistical Product and Service Solution) version 24 for Windows, with the production of tables. To perform the analysis and data processing, it was necessary to categorize, synthesize and compare the information, the results of which are presented by means of tables. Pearson's chi-square test was used for statistical analysis of the data since the results obtained are from categorical variables. The selected test makes it possible to assess the independence of unpaired observations on two variables. The significance level adopted was 0.05.

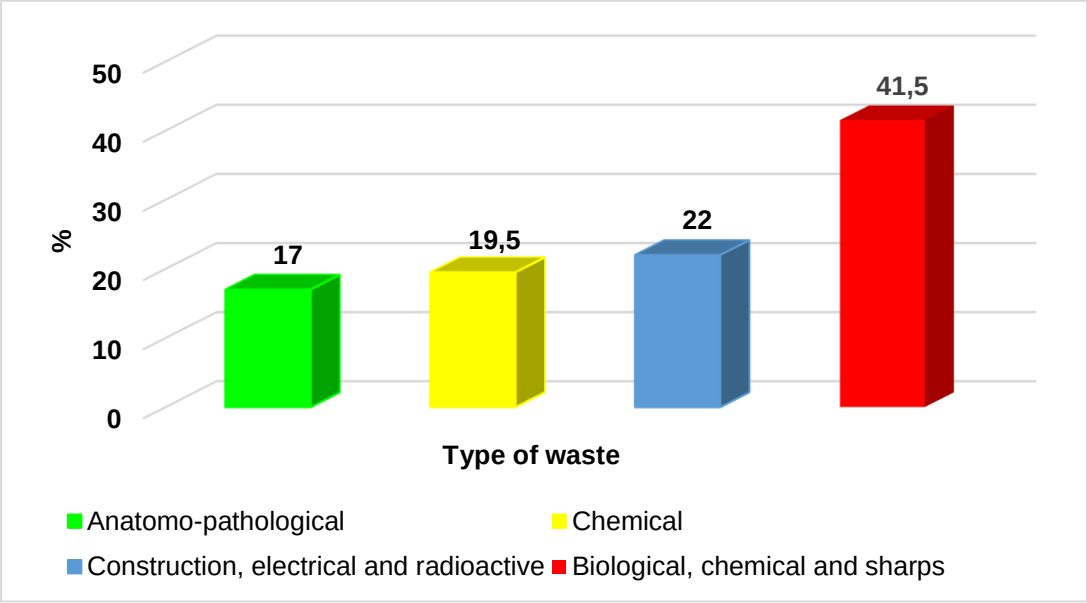
About the Bioethical aspects, authorization was requested from the Technical University of Ambato previous to the application of the collection instrument, specifically from the Deans of the Faculties that had laboratories in which the inclusion criteria were included.

RESULTS AND DISCUSSION

The Technical University of Ambato has four teaching and research units, with a total of 41 waste generating laboratories, distributed as follows: Faculty of Health Sciences (13 units, 31.7%), Faculty of Agricultural Sciences (10 units, 24.3%), Faculty of Food Science and Engineering and Biotechnology (9 units, 22%) and Faculty of Civil and Mechanical Engineering (9 units, 22%).

The types of waste, which predominated in 8 laboratories (61.5%) of the Faculty of Health Science are biological, chemical and sharps; chemical waste in 6 laboratories (66.7%) of the Faculty of Science and Engineering in Food and Biotechnology; the biological, chemical and sharps in 6 laboratories (60.0%) of the Faculty of Agricultural Sciences; and those of construction, electrical and radioactive in 9 laboratories (100.0%) of the Faculty of Civil and Mechanical Engineering. Figure 1 shows the main waste generated at the ATU, according to the frequency of occurrences obtained in the applied diagnosis.

FIGURE 1 - Main types of waste generated at ATU (2021)



Source: Survey applied to people in charge of 41 laboratories of the Technical University of Ambato

Concerning to the steps related to the internal management of hazardous waste, in the packaging step it is highlighted that in 40 laboratories (97.6%) the containers have lids, but the number of containers is not according to the needs in 33 laboratories (80.5%). In the segregation step, in 32 laboratories (79.0%) sharps are segregated in rigid containers, however in 28 laboratories (68.3%) the waste is not disposed according to its class, and neither the special waste is stored in security containers. In the intermediate storage step in 18 laboratories (58.6%) there is a restricted and marked infrastructure, however

the area is not clean and disinfected in 15 laboratories (36.6%). The complete results regarding the internal waste management steps at ATU are shown in table 1.

TABLE 1 - Steps of the internal waste management of the research laboratories of the faculties of technical university of Ambato (2021)

STEPS	LABORATORIES OF THE FACULTIES OF THE TECHNICAL UNIVERSITY OF AMBATO									
	COMPLIES		NO COMPLIES		UNKNOW		NOT APPLICABLE		TOTAL	
I. PACKAGING	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**
Number of containers according to needs	8	19.5	33	80.5	-	-	-	-	41	100.0
Containers with lids	40	97.6	1	2.4	-	-	-	-	41	100.0
Containers with colored bags according to the type of waste (common waste: black, biocontaminated: red, special waste: yellow)	29	70.7	12	29.3	-	-	-	-	41	100.0
Rigid sharps containers	32	79.0	9	22.0	-	-	-	-	41	100.0
Use of black bags in administrative areas	38	92.7	3	7.3	-	-	-	-	41	100.0
Use of red bags in toilets	27	65.9	14	34.1	-	-	-	-	41	100.0
II. SEGREGATION										
Disposal of waste according to its class	13	31.7	28	68.3	-	-	-	-	41	100.0
Sharps segregation in rigid containers	31	75.6	10	24.4	-	-	-	-	41	100.0
Removal of bags and containers at 3/4 capacity	29	70.7	12	29.3	-	-	-	-	41	100.0
Treatment of biocontaminated waste in generating source	10	24.4	2	4.9	14	34.1	15	36.6	41	100.0
Elimination of anatomopathological pieces in red bags	8	19.5	-	-	6	14.6	27		41	100.0
Special waste is stored in security containers	5	12.2	23	56.1	5	12.2	8	65.9	41	100.0
								19.5		
III. INTERMEDIATE STORAGE										
Intermediate storage	14	34.1	22	53.7	5	12.2	-	-	41	100.0
The area cleaned and disinfected	13	31.7	15	36.6	13	31.7	-	-	41	100.0
Infrastructure restricted, signposted	18	58.6	6	14.6	11	26.8	-	-	41	100.0

Source: Survey applied to people in charge of 41 laboratories of the Technical University of Ambato

With regarding to the external management of the waste, in the collection step 22 laboratories (53.7%) use bins or cars with necessary wheels, but there are no designated routes for transporting in 28 laboratories (68.3%), in the step central storage, the storage is far from medical and food services in 25 laboratories (61.0%), however in 24 laboratories (58.5%) the waste is not stored according to their class, in specific areas, in the treatment step 16 laboratories (39.0%) have a detailed treatment system in the Hazardous Waste Management Plan, but the same percentage does not perform waste treatment, either at the institution or by external company and 38 laboratories (92.7%) do not receive the mandatory legal documents on the final disposal of waste within the established deadline. Another legal irregularity revealed by the results is the absence of a daily record of managed hazardous waste, which occurs in 23 laboratories (56.1%).

TABLE 2 - Steps of the external waste management of the research laboratories of the faculties of technical university of Ambato (2021)

STEPS	LABORATORIES OF THE FACULTIES OF THE TECHNICAL UNIVERSITY OF AMBATO									
	COMPLIES		NO COMPLIES		UNKNOW		NOT APPLICABLE		TOTAL	
IV. COLLECTION AND TRANSPORTATION	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**
Bins or cars with necessary wheels	22	53.7	19	46.3	-	-	-	-	41	100.0
Established schedules for transportation	18	43.9	20	48.8	3	7.3	-	-	41	100.0
Marked routes for the transport of waste	9	22.0	28	68.3	4	9.7	-	-	41	100.0
Cleaning and disinfection of containers or cars	10	24.4	20	48.8	11	26.8	-	-	41	100.0
The containers or cars do not use for other purposes	10	24.4	28	68.3	3	7.3	-	-	41	100.0

V. CENTRAL STORAGE										
Final or central storage	21	51.2	16	39.0	4	9.8	-	-	41	100.0
Delimited and marked storage	17	41.5	15	36.6	9	21.9	-	-	41	100.0
Storage in easily accessible area	19	46.3	14	34.1	8	19.5	-	-	41	100.0
Internally lined storage	9	22.0	20	48.8	12	29.2	-	-	41	100.0
Storage away from healthcare and food service	25	61.0	9	22.0	7	17.0	-	-	41	100.0
Waste stored according to its class in corresponding areas	17	41.5	24	58.5	-	-	-	-	41	100.0
Biocontaminated waste does not remain more than 48 hours	2	4.9	13	31.7	26	63.4	-	-	41	100.0
VI. TREATMENT										
Treatment by the university or external company	8	19.5	16	39.0	17	41.5	-	-	41	100.0
The treatment system is approved	10	24.4	-	-	31	75.6	-	-	41	100.0
Detailed treatment system in the hazardous waste management plan	16	39.0	9	22.0	16	39.0	-	-	41	100.0
VII. FINAL DISPOSITION										
Collection by an external company for the final disposal of waste	3	7.3	7	17.1	31	75.6	-	-	41	100.0
Manifests returned within established deadlines	3	7.3	38	92.7	-	-	-	-	41	100.0
Daily log of hazardous waste	15	36.6	23	56.1	3	7.3	-	-	41	100.0
Final disposal is carried out in a sanitary landfill with security cells	3	7.3	3	7.3	35	85.4	-	-	41	100.0

Source: Survey applied to people in charge of 41 laboratories of the Technical University of Ambato

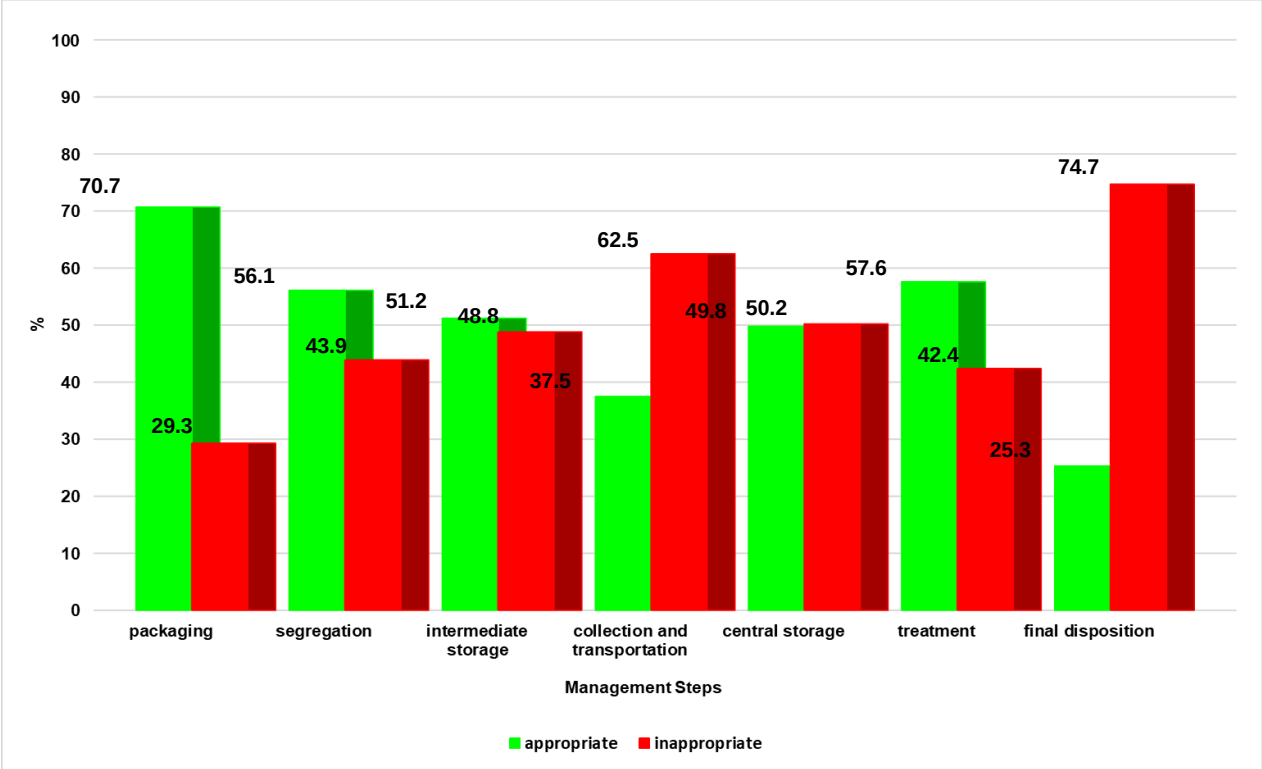
Regarding the external management steps of the waste generated at the Technical University of Ambato, there is an important lack of knowledge about what happens with the waste in these steps and outside the institution.

The cleaning and disinfection of containers or cars used in the packaging and transport of hazardous waste is an example, in which 26.8% of respondents are not aware of compliance with applicable legal standards, in addition to the aggravating percentage of 48.8% that is known to do not apply the specific rules provided for in the legislation. Regarding the external storage center, the following steps also deserve to be highlighted for lack of information: delimited and marked storage (21.9%), internally lined storage (29.2%) and biocontaminated waste does not remain more than 48 hours (63.4%). About treatment and final disposal steps, it is important to highlight the steps treatment by the university or external company, the treatment system is approved and collection by an external company for the final disposal of waste, which do not have known information on compliance with the relevant legislation by 41.5% and 75.6% for the last two cases, by the waste generators.

The occurrence of "unknown" information is especially important, as it can mean non-compliance with legislation and failures in the management process, capable of causing environmental damage and human health. This also demonstrates the need to deepen the diagnosis and pay special attention to these places, aiming to reduce institutional vulnerability in the face of the possibility of accidents and criminal offenses. The commitment of the waste management process at ATU by the unknown answers can be especially high, if the percentages obtained mean, in the real situation, non-compliance with environmental legislation. The percentage indices of null value for evaluating compliance with legal aspects reach 10.2% for collection and transport, 12.8% for segregation, 23 and 23.6% for central and intermediate storage, respectively, 42.1% for final disposal and 52% for the stage of treatment.

Figure 2 presents an overview of waste management at the TUA concerning compliance with the legal norms recommended in the technical regulation of the Peruvian Ministry of the Environment. The "unknown" and "not applicable" results were not considered in order not to compromise the evaluation.

FIGURE 2 - Evaluation of the steps of waste management at TUA, in accordance with the current technical regulations of the Ministry of Environment of Peru at ATU (2021)



Source: Survey applied to people in charge of 41 laboratories of the Technical University of Ambato

The analysis of figure 2 allows us to clearly see that the quality of waste management at ATU is deficient and needs improvement in several stages of the management process. Except for the step defined as packaging, in which 70.7% of the generating laboratories meet the legal aspects, only 3 stages reach percentages close to 50%, which confirms inconsistencies in the current management system. Note that the final disposal of waste generated at ATU presents the worst result, reaching 74.7% of laboratories that do not send their waste for proper disposal. Subsequently, among the valid responses, the step of waste collection and transport also presents an unsatisfactory rate, reaching 62.5% of non-compliance with the legislation.

The high percentages of inadequate management in the steps of segregation, storage, treatment and in particular collection and transport and final disposal deserve dedicated institutional attention. Irregularities in the segregation stage can compromise the quality of the entire management process, in addition to offering serious risks of accidents directly involving human resources (17). Equally important, inadequate final disposal of waste can seriously compromise environmental quality and public health in general, with the potential to cause soil, water or air contamination and affect living species, including humans.

The results show the importance of carrying out an environmental diagnosis to assess the quality of the management process implemented or to be adopted. In this way, the diagnosis reveals itself as an essential tool for understanding a reality and, in this case, the results obtained will be able to guide decision-making by university governance, with a view to socio-environmental preservation, minimization of the risks of accidents inherent to waste management. hazardous materials and, still, better allocation of resources used in waste management.

In the risk of hazardous waste management, it is established that in 40 laboratories (97.6%) the managers have knowledge about health risks, likewise in 35 laboratories (85.4%) they do not present occupational diseases.

TABLE 3 - Risk of hazardous waste management

RISKS ABOUT THE MANAGEMENT	LABORATORIES OF THE FACULTIES OF THE TECHNICAL UNIVERSITY OF AMBATO					
	COMPLIES		NO COMPLIES		TOTAL	
I. COLLECTION AND TRANSPORTATION	Nº	%	Nº	%	Nº	%
Knowledge of health risk	40	97.6	1	2.4	41	100.0
Full use of biosafety equipment	18	43.9	23	56.1	41	100.0
Occupational health evaluation	16	39.0	25	61.0	41	100.0

Source: Survey applied to people in charge of 41 laboratories of the Technical University of Ambato

At the level of the laboratories of the Technical University of Ambato, the majority of biological, chemical and sharps waste are generated in the FCS and FCA, followed by chemical and anatomopathological waste, in the FCIM, construction, electronic and radioactive waste and the FCIAB chemical waste, unlike the research carried out by Pourzamani et al., at the University of Medical Sciences of Isfahan, toxic, corrosive, flammable, carcinogenic and infectious residues are produced (4), in the work of Nolasco et al., it is shown that in the University of Brasilia, the largest amount of waste produced in laboratories are chemical, organic, biological, plastic and special (30). On the other hand, Talsania and Nainesh, reveal that in the Faculty of Sciences of the University of Gujarat, common waste, construction (plastic, ceramic, glass, metals and wood), garden waste and food waste predominate (31), In addition, Fagnani and Gimarães, affirms that at the School of Civil Engineering, Architecture and Urban Design, the waste produced is domestic (recyclable and non-recyclable), chemical and microbiological (sanitary analysis and environmental samples) and construction (rubble, scrap metal and wood) (32).

In the current research, in the internal waste management step, in the packaging the 97.6% of the laboratories have containers with lids, but 80.5% considers that the containers are not enough according to the needs of each laboratory. In the segregation step, 75.6% eliminates the sharps in rigid containers and 68.3% does not store damage according to class. On the other hand, Letho et al., indicates that the classification of waste in the Jigme Dorji Wangchuckse University Hospital, Bhutan is carried out according to international standards, so they have adequate containers and 93.5% of the garbage containers were coded by colors, 58.1% of the garbage containers were covered with a lid and 74.2% were operated with the foot; 90.3% had a biohazard symbol, and 61.3% of units had a correct classification of waste (23). Unlike Rodrigues de Oliveira's research, where no laboratory at the Federal University of Minas Gerais had a sharps collector instead, 50.0% used cardboard boxes for their packaging and 8.3% reused plastic boxes or Petri boxes, at TUA, 75.6% of generators adequately store these hazardous wastes.

In the step of treatment of hazardous waste in the laboratories of the TUA, 39.0% have a treatment system in the waste management plan, but the same percentage does not have waste treatment. Unlike what was proposed by Santos et al., at the University of Sao Paulo uses different forms of waste treatment known by its laboratory experts, 10.7% uses neutralization, 65.9% degradation, 16.5% distillation, 5.8% precipitation and 1.1% incineration, all of which are used with due precautions and as a last resort after applying reuse protocols (33).

In the external management of hazardous waste, in the step collection and transport waste, 53.7% of the laboratories have bins and wheeled cars, 68.3% does not have duly marked routes, a different case is about Moqbel, who states that in the University of Jordan exists a transportation system with a specific route of a truck twice a day regularly, and on rest days once a day (34). Likewise, Orjuela, at the Manuela Beltrán University there is evidence of a regularization of waste removal (21). In research by Letho et al., At Jigme Dorji Wangchuckse University Hospital, Butan indicates that only 48.0% of waste is transported according to the transport guideline (23).

In relation to the storage step, the 61.0% considers that the storage is far from the medical and food services, while only the 4.9% affirms that the biocontaminated waste remains in storage for more than 48 hours and 63.4% do not know; according to Stanford University, the laboratory design considerations indicate that these are completely separated from the outdoor areas (35), the results of a study carried out by Moqbel, at the University of Jordan the residues are collected immediately at the end of the day, with the absence of treatment, storage and transportation to an open landfill and without any processing system (34), Pourzamani et al., at the University of Isfahan, asserts that the waste is treated and later transported by truck to the landfill directly, because few laboratories of the university stores the waste and has a specific plan (4).

In the present investigation, in the final waste disposal step, 75.6% of the laboratories do not have detailed knowledge about the external collection carried out for the final disposal of waste, 92.7% do not receive the documents proving the destination and proper management of the material within the established deadline and 56.1% do not record the daily generation of waste, a similar trend at the Federal University of Minas Gerais, as described by Rodrigues de Oliveira et al. Unlike Nolasco et al. which states that the University of Brasília has a private company responsible for packaging, collecting and correctly disposing of waste; therefore, final disposal is carried out safely and in accordance with legislation (30).

Regarding the risk involved in waste management, 97.6% of the laboratory employees have knowledge about health risks, likewise 85.4% does not have occupational diseases; unlike Rodrigues de Oliveira et al., who states that at the Federal University of Minas Gerais, comply with all the established occupational safety requirements, including personnel vaccination in a 58.3% (7). Likewise, Letho et al., refers that in the Jigme Dorji Wangchuckse University Hospital, Butan, only 35.4% uses the appropriate personal protective equipment, 32.3% do not use it (23).

The relationships initially identified between the management steps were also confirmed by statistical tests. The statistical study using the Q-square test revealed that all the variables analyzed have some type of statistical association between them, that is, they have $p < 0.05$. In general, the results obtained are in accordance with expectations, since all the variables or steps analyzed are part of a set of intrinsic practices of the waste management process. The statistical test showed that the diagnostic answers obtained for the number of containers according to the need, containers with lids and waste disposal according to their class are the ones with the highest statistical association with the steps of the waste management process.

CONCLUSIONS

The laboratories of the Technical University of Ambato generate mainly biological, chemical, sharps, anatomopathological and construction waste. Regarding the internal stages of waste management, it is concluded that the stages of packaging, segregation and treatment have the best percentages of compliance with the legislation, however, they have a large capacity for implementing improvements. In general, there are not enough containers according to the needs of the waste, they are not disposed according to the corresponding classes and the special waste is not packed in safety containers, in addition to irregularities in the intermediate storage. The satisfactory results in the internal management of waste at ATU refer to the use of containers with lids, colored bags according to the type of waste, black bags for common waste and red bags in the toilets,

including the disposal of sharps in rigid containers and restricted and signposted access to infrastructure. Regarding the external stages of management, the only indices that exceed 50% of compliance with the legislation are those related to bins or cars with necessary wheels, final or central storage and storage away from healthcare and food service. The steps that have high levels of non-compliance with legislation include marked routes for the transport waste, the containers or cars do not use for other purposes, waste stored according to its class in corresponding areas, manifests returned within established deadlines and daily log of hazardous waste. Regarding the risks associated with the management of waste generated in ATU laboratories, the personnel responsible for the laboratories have the necessary knowledge about the health risk involved in the management of hazardous waste and most of them have not presented related occupational diseases so far, however, the equipment biosafety measures are not used properly and the necessary occupational health controls are not complied with, which demonstrates the need for improvement in these aspects.

The present study provides information relevant to the scientific literature and university governance. The results undeniably demonstrate the importance of diagnostics for knowledge of the real situation, implementation, evaluation and adoption of practical measures for proper waste management. In addition to contributing to solving the environmental problem inherent to waste, this work also offers an important applied contribution to the environmentally appropriate disposal of waste generated in universities, minimization of associated risks and creation of a collective environmental awareness on the subject.

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