Quality-Quantitative Identification of Dangerous Waste From FOB-Usp: Waste Management

Identificação quali-quantitativa dos resíduos perigosos produzidos na FOB-usp: gestão de resíduos.

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ABSTRACT

Introduction: Hazardous waste is defined by the Environmental Protection Agency of the United States (EPA) as any waste that because of its quantity, concentration, physical, chemical or infectious characteristics, may cause or significantly contribute to increased mortality, serious irreversible or incapacitating reversible diseases, or pose a present substantial or potential hazard to human health and the environment when improperly managed. **Objective:** Aiming to comply with the laws, the Bauru Dental School (FOB) in 2003, installed its first Laboratory of Chemical Waste (LRQ). However due to increased demand and new waste generated, there was the need to build a new laboratory. Therefore, this study conducted a qualitative and quantitative survey of hazardous waste generated in different sectors of the FOB, Hospital for Rehabilitation of Craniofacial Anomalies (HRAC) and Prefecture of Campus, beyond its current mode of handling by responsible. **Material and Methods:** This survey was conducted through a questionnaire. **Results:** After analyzing the data, we saw that were generated 433 liters of waste in 2013, mainly: developer liquid, fixer liquid, alcohol, ethylenediaminetetraacetic acid (EDTA), xylene and formaldehyde. In addition, we found the key points for a better management of waste. **Conclusion:** This work was important to quantify and qualify the hazardous waste on the USP campus of Bauru. The implementation of a specialized laboratory in management and treatment of waste on campus, for the recovery of these, beyond to proper disposal, is important for both environment and people.

Keywords: Hazardous waste, Environment, Management.

RESUMO

Introdução: Resíduo perigoso é definido pela Agência de Proteção Ambiental dos Estados Unidos (EPA) como qualquer resíduo que em razão da sua quantidade, concentração, características físicas, químicas ou infecciosas, pode causar ou contribuir consideravelmente para o aumento da mortalidade, de doenças graves irreversíveis ou incapacitantes reversíveis, ou ainda representar um risco substancial atual ou potencial à saúde humana e ao meio ambiente quando gerenciado indevidamente. Visando a atender às legislações, a Faculdade de Odontologia de Bauru (FOB), em 2003, instalou o seu primeiro Laboratório de Resíduos Químicos (LRQ). Porém, devido ao aumento da demanda e de novos resíduos gerados, houve a necessidade da construção de um novo laboratório. **Objetivo:** Sendo assim, este trabalho

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realizou um levantamento quali-quantitativo dos resíduos perigosos gerados nos diferentes setores da FOB, Hospital de Anomalias Craniofaciais (HRAC) e Prefeitura do Campus, além de seu modo atual de manuseio pelos responsáveis. **Material e Métodos:** Esse levantamento foi realizado por meio da aplicação de um questionário. **Resultados:** Após analisar os dados, visualizamos que foram gerados 433 litros de resíduos no ano de 2013, sendo que os principais foram: líquido revelador, líquido fixador, álcool, ácido etilenodiamino tetra-acético (EDTA), xilol e formaldeído. Além disso, foi possível verificar os principais pontos para um melhor gerenciamento dos resíduos. **Conclusão:** Este trabalho foi importante para quantificar e qualificar os resíduos perigosos no campus USP de Bauru. A implantação de um laboratório especializado em gerenciamento e tratamento de resíduos no campus, visando à recuperação destes, além do descarte adequado, é importante tanto para o meio ambiente quanto para as pessoas.

Palavra-chave: Resíduos perigosos, Meio Ambiente, Gerenciamento.

INTRODUCTION

Hazardous waste is defined by the EPA - the United States Environmental Protection Agency such as any residues that because of their quantities, concentrations, physical, chemical or infectious characteristics, can cause or contribute significantly to the increase in mortality, in number of cases of serious irreversible or reversible disabling diseases, or to represent a large risk to human health and to environment when treated, stored, transported, disposed or managed inappropriately.¹ The residue may be classified by laboratory test as having any of the following characteristics: inflammability, reactivity, corrosivity and toxicity.^{2,3}

The management of hazardous waste, from generation to final disposition, it's of major importance for the health of human, preservation of the environment, natural patrimony and sustainable development. In this way, waste management consists in applying a set of solutions/actions that find to prevent possible damages to human health, certifying the prudent and rational use of natural resources, which preserve, protect and improve the quality of the environment.⁴⁻⁷

From 1960, began the first movements to discuss the preservation of the environment and the international and national meetings resulting in norms, protocols and legislation to control and punish those that caused environmental damage. In the last decades, some important Laws come in force, such as, Law of Environmental Crimes (Number 9.605

of 1998/02/12) with civil punishment, fine and even the closure of companies under the allegation of environmental impacts, leading the leader to respond criminally, as well, as the Law of National Environmental Policy (Number 6.938 of 1981/08/31), which defines that the polluter is bound to recompense the environmental damages caused by himself, independent of the guilt and Public Ministry can propose actions of civil responsibility for damages to the environment, imposing on the polluter an responsibility to recover and/or recompense damages caused.^{8,9}

Educational and research institutions and industries, although they are not mentioned directly in the current laws, due to the fact they experience the problem of waste generating daily, start to worry, search solutions, treatment programs and awareness of the population. In the 1970s, universities start timidly to implement hazardous waste management programs.¹⁰ The diagnosis of waste management and environmental conformation in educational institutions is of great relevance, considering the marked activities research, teaching and extension aiming a work place and a healthy social environment.^{3, 5, 6, 11, 12}

Thus, the implantation of a laboratory and a waste management assists and collaborates with the reception, storage and proper disposal of the contaminants. Another positive aspect is that with the right structure it is possible to recover and reuse, avoiding waste and providing money savings.

To combat this problem and to comply with

existing legislation, the Bauru Dental School (FOB) of the University of São Paulo (USP), in 2003, built its first chemical waste laboratory, which was inaugurated in January 2004. Initially were treated amalgam residues to recovery mercury¹³ and silver¹⁴, in addition xylene and ethyl alcohol, from FOB and the Hospital for Rehabilitation of Craniofacial Anomalies (HRAC). With this laboratory, it was expected the treatment and reuse of the generated waste in FOB and HRAC themselves, as well, some laboratories and clinics in the region. Faced with the awareness that exists in society today regarding the environmental perspective and the strict punishments for those that harm the environment and due to the great demand for chemical residues, there was a need to build a new laboratory and also an implementation of a Waste Management

The purpose of the present work was to accomplish with a qualitative and quantitative survey of hazardous wastes at FOB-USP, HRAC and Campus prefecture, in order to guide the implementation of the waste management plan for the new Chemical Waste Laboratory. In addition, formatting, application, tabulation and statistical analysis of the technical data, to propose information and procedures that can collaborate with the application, monitoring and updating of the plan, enabling a discussion on several environmental aspects.

METHODOLOGY

Initially a bibliographic analysis was performed and then documents were searched in the institution to delineate the other stages.

An interview in different sectors of FOB-USP, HRAC and Campus prefecture. Among them, clinics and research laboratories, using a questionnaire (Figure 1 and 2), containing open and closed questions.

The questionnaire was developed using the ABNT standards related to waste, the Law of the National Environmental Policy nº 6.938 from to 1981/08/31 and the Law of Environmental Crimes nº 9605 from to 1998/02/12.

Results were tabulated using Microsoft Excel®, so that they could be analyzed.

RESULTS AND DISCUSSION

The development of research by the interview method provided a greater proximity to the employees and representatives of the sectors (interviewees), so it was easier to obtain clearer and more detailed data. Another positive aspect was the information to them, because this way we were able to transmit knowledge about environmental subject, dangerous waste, treatment forms, care, among others. The same result with this method were observed by Antoniassi and Silva⁷ (2017) and Muller et al.¹⁵ (2013), which reported that this way it was possible to carry out environmental education actions.

For the accomplishment of this work, interviews were made in 34 sectors, being 25 of the FOB, 8 of the HRAC and 1 of the Campus Prefecture, according Table I.

Table I - Sectors where the questionnaires were applied

FOB	HRAC	Campus Prefecture
Anatomy Proteome -Biochemistry Central -Biochemistry Vivarium Integrated Research Center Surgery Clinic Periodontics Clinic Endodontics Stomatology Pharmacology Histology Pediatric Dentistry Laboratory Orthodontic Laboratory Periodontics Laboratory Postgraduate Laboratory Microbiology Pediatric dentistry Pathology Prosthesis 1 Prosthesis 2 Radiology Urgency / Screening	Surgery Center Dental Center Injection / Sterilization Drugstore Cytogenetics Laboratory Clinical Pathology Laboratory Medical X-ray Dentistry X-ray	Administration

University of São Paulo
Bauru Dental School

QUESTIONNAIRE - CHEMICAL WASTE
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PLACE: _____ DATE: _____

RESPONSIBLE NAME: _____

RESPONDENT NAME: _____

1) This place is used as (more than one alternative can be selected):

☐ Clinic ☐ Research laboratory ☐ Teaching ☐ Extension

2) In this place there is awareness regarding the discard of chemical waste by:

☐ Employees ☐ Student ☐ Visited ☐ Patients

Justify: _____

3) How the discard of waste is done at this location? (Consider: storage, identification, separation and destination).

4) Would you reuse the treated waste if it was recovered on campus?

☐ Yes ☐ No

Justify: _____

5) Do you think it is interesting that the campus has a chemical waste laboratory? Why?

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Figure 1 – Waste questionnaire: part1

6) Among the items below, what and how much is generated as waste at this place?

Waste	Quantity*	Waste	Quantity*
Anesthetics		Ethers	
Lead acetate		Phenol	
Acetone		Fluorides	
Acids		Formaldehyde (Formol)	
Acrylamide		Plaster	
Hydrogen peroxide		Glutaraldehyde	
Alcohols (others)		Ammonium hydroxide	
Alginate		Hypochlorites	
Amalgam		Iodides	
Ammonia		Metal alloys	
Bases		Methanol	
Batteries, batteries		Naphthol	
Benzine		Neoditocaine	
Bis-Acrylamide		Nitrates	
Ethidium bromide		Oxypropylene	
Wax		Paraffin	
Chlorides		Paraplast	
Doublefem		Resins	
EDTA		Developer / Fixer	
Chloroform		Sulfates	
dyes		Sulfides	
Endo Frost		Carbon tetrachloride	
Ester		Osmium tetroxide	
Ethanol		Xylol	

*Monthly estimate

Other Wastes: _____

7) Are the materials listed above discarded by you or someone else from the laboratory in the public sewage system?

☐ Yes ☐ No ☐ Some yes, others not

8) What, in your opinion, would be necessary for this place to actively participate in waste management?

I declare that I am not omitting information and that all the answers provided by me are true. I am aware that this questionnaire is part of a survey and I authorize the use of these data for study purposes. _____

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Figure 2 – Waste questionnaire: part 2

Of the interviewed sectors, 24 are used as clinics, 21 as research laboratory, 15 as teaching and 15 as extension. It is worth mentioning that in some cases, the same sector is used in more than one function.

Awareness, storage, identification, discard and reuse of chemical waste

It was found that in most sectors there is awareness about the suitable waste discard by employees (58.82%) and students (41.18%), but the same does not occur in none sector by visitors and/or patients. As for the storage of products, the campus offers good installations and in relation to identification, they have the original factory labels or simple labels with only the name of the reagent.

Regarding the reuse of treated waste, 91.2% of the sectors interviewed said that they would reuse only if they were within the parameters of quality and 8.8% said that they would not accept the treated waste because the experiments carried out require high standards of purity. It is worth to emphasize that the residue with the highest acceptance rate for reuse after recovery is ethyl alcohol.

As for discard, some waste are sent to a contracted company for proper discard, others are discard in the white or common waste and some are dumped into the sewage system. It was verified that there are sectors that carry out the waste discard in an inappropriate way, 11.8% throw all the waste in the sewage and 47% of the places said that discard some waste correctly and others not. The rest of the interviewees (41.2%) do not discard their waste in the public sewage system. According to the interviewees' explanation, there is no information about the correct discard and there is a shortage of waste storage containers.

MAPPING OF THE GENERATED RESIDUES IN GREATER AND SMALLER QUANTITY

After completing the questionnaire, the main and most important wastes generated at the FOB, HRAC and Campus Prefecture (Figure 3) were mapped. According to Jardim¹⁶ (1998) the waste that must be considered as the most important are called active inventory, because they are frequently used in the sectors, and it is through them that the activities of the waste laboratory will be traced.

Monthly amount of waste generated at FOB, HRAC and Campus Prefecture

Figure 3 - Monthly percentage of the different residues generated in FOB, HRAC and Campus prefecture.

Still in relation to monthly percentage of residues generated (Figure 3), it was verified that were generated a total of 433 liters of these residues, and it is important to emphasize that the values obtained are a monthly estimate that we obtained through interviews and that these values can increase or decrease as the need for experiments, classes or appointments on campus.

The largest volumes of waste generated are from developer and fixer from the radiographs performed by the students and/or professionals in patients. Although the substances are used at the same time, they must go through different treatment and discard processes. The developer, according to RDC n°306/04¹⁷ has a simple form of treatment, which can be neutralized to pH of the solution close to 7, and then can be discarded in the public sewage system. However, attention must be given to the directives indicated by environmental, water and sanitation agencies. In relation to the fixative, the great interest is in the silver (Ag) recovery, as it is a scarce metal nowadays and is present in the fixative solution in an amount easily recoverable.¹⁸¹⁹ There are several techniques used for recovery, such as those based on electrolysis, metallic displacement (cementation), as well as some that employ chemical precipitation²⁰, besides technology complementary, of ion exchange, to treat solutions resulting from washing water processes and/or more diluted fixative solutions.^{21, 22} The most used process in large scale operations is based on the electrolysis of the fixative solutions, allowing the direct recovery of silver over a metallic cathode, usually made of stainless steel. Little is studied about the remaining solution (after silver recovery), however according to Nolla et al.²³ (2013) there are tests that suggest that this effluent can be used as liquid fertilizer, since it has ammonium thiosulfate.

Then, in third place is ethanol or ethyl alcohol. Alcohol is used for a variety of purposes, from cleaning and sanitizing to chemical reactions or experimental procedures. Alcohol recovery is simple, accomplished by fractional distillation. It is the most used type of distillation in large industries, but it is also well known in chemical laboratories. Fractional distillation separates the compounds into various fractions, that are separated by the boiling point of the substances.²⁴ It is worth mentioning that the boiling point of the alcohol is approximately 78.5 °C and that this residue was already treated in the old LRQ and will continue to be treated in the new building.

The fourth residue generated in most quantity is EDTA (ethylenediamine tetra acetic acid), normally used for endodontic treatment because it has a chelating function and to remove calcium ions (Ca^{2+})²⁵, it is also used as anticoagulant, in electron microscopy for contrast DNA and disrupt RNA. This acid is mixed with several components and because of this there is no recovery treatment or discard in the sewage system, so for a while the most appropriate is incineration. But is not possible in the University, so this material is send for the company specified for the incineration.

Fifth is xylene or xylol, this is normally used for histological experiments, immunohistochemistry and can also be used as solvent. The recovery of xylene is simple, by fractional distillation.²⁴ It is important to highlight that the boiling point of xylene is 138° C and that this, as alcohol, will continue to be recovered in the new LRQ building. After recovery, it will be able to use again.

Sixth is formaldehyde an organic compound, widely used in a variety of sectors, such as anatomy laboratories, in the embalming of anatomical specimens and in anatomopathological analysis laboratories. For large quantities, it is recommended the use of incineration or photo-Fenton reaction.²⁶

Seventh is methanol or methyl alcohol. This

compound is highly inflammable and toxic, so doing a new distillation becomes dangerous to the health of the person handling it. Due to this the manufacturers recommendations are that either it is returned to the them or it is sent for incineration ²⁷.

Finally, the discarded acids are mainly characterized by their low pH (about pH 3). Depending on the acid, it can be used for precipitation of metals or to neutralize basic solutions (pH above 7). Because of its very low pH, it cannot be discarded without its pH adjusted to near neutral (pH 7) ²⁸. After that, in some cases, it can be discarding in the sewage system, but it must be analyzed on a case-by-case basis so that the best method of disposal of the acid can be verified.

Some wastes are generated in small quantities, namely: lead acetate, amalgam, alginate, hydrogen peroxide, bases, ethidium bromide, wax, chlorides, chloroform, ethers, dye, gypsum, iodides, hypochlorite, sodium fluoride, metal alloys, phenol, paraffin and resin, which were not mentioned in the graph. These residues are generated in small quantities because there is no continuous use, so it is not possible to make a monthly estimate of

the quantity generated. Although the quantities are minimal, the care in their form of discard or recovery is as important as waste generated in larger quantities. Care should be taken to the properly recover or discard as in accordance with RDC N° 306/04, chemical wastes which present a risk to human and/or animal health or to the environment, if not recovery, reuse or recycled, should receive treatment or a specific final disposition ¹⁷.

In the specific case of amalgam, although it is not managed in large numbers on campus, the University periodically receives these residues from dentists associated with OdontoPrev. FOB and OdontoPrev have an agreement signed since 2004 for the mercury and silver recovery. This recovery is done by means of vacuum distillation for the mercury recovery ¹³, and by means of precipitation using ascorbic acid for the silver recovery ¹⁴.

Effective participation of the sectors

By the application of the questionnaire it was possible to verify what, in the opinion of the respondents, it is necessary to be carried out in order that the sectors participate actively in the treatment of generated waste (Figure 4).

FIGURE 4- Needed Items for the effective participation of the sectors in the management of dangerous waste.

It is important to highlight that the disclosure of information is the main complaint in the interviewed sectors. Asked about the solution to this lack of information, the following suggestions were given: dissemination of informational materials through lectures, mini-courses, booklets and panels, and protocols that should be followed for proper disposal.

The infrastructure for discard containers needs to be improved as some respondents said there were not appropriate nor enough bottles. The suggestion is that the laboratory of chemical residues provides glasses and bottles suitable for the discard. The idea is that when leaving a bottle full of residue, another bottle will automatically be provided for the subsequent discards.

Another item is the logistics of waste transportation, which should be more efficient. One solution would be in the first place an online central of the sectors with the laboratories, which would fulfill a requirement of sending and after authorization this residue would be sent to the laboratory; another solution would be to elect a person in the waste laboratory to be responsible for collecting waste.

And, finally, the awareness of the involved people. The suggestion is that should be provided lectures, dissemination of informative material, clarification on the importance of proper discard of waste, making possible the greater involvement of people.

Waste management at the FOB's Chemical Waste Laboratory, verifying that the discard and/or treatment of waste generated in larger quantities is simple and economically viable, making it more beneficial than continuing to send to the outsourced company that currently operates in the faculty. This same conclusion can be seen by Costa et al.²⁹ (2014), by his statement that the economic viability of the project is linked to the reduction of costs and expenses of Federal University of Alfenas (UNIFAL-MG) with waste treatment, since

there will be no expense with the outsourced company, besides the reduction of reagent purchase, since they can be recovered.

CONCLUSIONS

Through the directly conducted interviews with the employees, which enabled more effective results, we concluded that the treatment of waste in the campus, aiming to the recovery waste, besides allowing the proper disposal, is important for the environment as well as for the people, in addition to being able to generate a financial return for the university. We also conclude that these processes begin in the sectors where the waste is generated, with adequate separation and storage, before being sent to the LRQ.

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