



## THE IMPORTANCE OF DANGEROUS WASTE MANAGEMENT IN A UNIVERSITY: STUDY CASE OF TEACHING AND RESEARCH LABORATORIES

Beatriz Antoniassi<sup>1</sup>, Mariana Cristina Kempa da Silva<sup>1</sup>

<sup>1</sup> Sagrado Coração University (USC)

### ABSTRACT

With the offer of new programs at the Sagrado Coração University (USC, in Portuguese) in the Brazilian city of Bauru, there was an increase in the production of chemical and/or dangerous waste in the teaching and research laboratories, which there was a need to manage the material more effectively, according to present legislation, as well as to not impact the environment. Therefore, this study generated a quali-quantitative survey, which was composed by a questionnaire applied to the ones responsible for the laboratories in the University, in order to identify the type, the quantity, and the format of discharge of the generated waste. The analysis of the results demonstrated the necessity of guidelines in some areas, which were not considered waste generators, but were discharging the waste incorrectly. From this study it was proposed a program of management and storage of dangerous waste and training programs, in which present economic and environmental results in a short period of time. On the other hand, it is expected to recover and reuse the generated waste in the future, in order to reduce the costs of incineration.

**Keywords:** Waste management. Dangerous waste. Natural environment. Legislation.

### 1. INTRODUCTION

Today, industries, universities, and government agencies have worked to find alternatives to properly dispose the waste generated by their daily activities, based on the awareness given by the 5 Rs: refuse, reduce, reuse, repurpose, and recycle (Nolasco *et al.*, 2006; Dionizio, 2013).

According to State Bill #12,300 (São Paulo, 2006), the generator of solid waste and those who control it are responsible for any damage to the natural environment and must fully repay all expenses that the public administration may require to correct or repair the environmental damage. This bill also preconizes the standardization of waste disposal and establishes the responsibilities of the generators according to their consequences. Universities are also required to abide for the Environmental Crimes Act, Bill #9,605 of 1998 (Brasil, 1998), which later was complemented by the Bill #12,305, the National Solid Waste Policy (Brasil, 2010). These laws foresee that all activity or conduct that might generate waste have the obligation to manage them according to present legislation. Therefore,

it is imperative that universities develop management programs that provide proper destination to the waste produced by them.

The United States Environmental Protection Agency (EPA) defines that solid waste can be classified as dangerous depending on: the quantity, the concentration, the physical, chemical, infectious characteristics, and if the waste causes or contributes to the increase of mortality, serious illnesses (irreversible or reversible impairment), if it harms human health of the natural environment when being treated, stored, transported, discharged, or managed (Vesilind et Morgan, 2011).

Besides that, companies and laboratories have the obligation to manage all waste produced, according to present legislation, being the legal person, either by being the author or the co-author of the environmental violation, can be penalized. However, fees can be waved if it is proven that the damaged environment was recovered (Brasil, 1998).



Despite the fact there are laws, until the 1970s there was no preoccupation by the part of the universities to properly discharge waste, let alone programs for the management of dangerous waste (Alberguini *et al.*, 2005). In the laboratories of universities there are two types of waste being generated: the active, which is produced daily during the activities of teaching and research, and the passive, quite common, which are stocked without labeling (Jardim, 1998). The universities and technical schools in Brazil are responsible for around 1% of the chemical waste generated in the country (Ashbrook *et Reinhardt*, 1985 apud Tavares *et Bendassoli*, 2005). According to Vogel (1981 apud Faria *et al.*, 2010) even if the percentage is very low, it is alarming once the elements sent in the waste will be placed in the environment, which can lead to serious harm to fauna and flora.

Based on the demonstrated arguments, it is observed the importance to properly manage the waste generated inside a university. Hence, this study aims to diagnose the present situation of the dangerous waste management of the Sagra do Coração University (USC, in Portuguese), trying to measure the quantity of waste generated, stored, and disposed, and then later, to identify alternatives that can generate economical and environmental benefits.

## 2. THEORETICAL REFERENCE

### 2.1 World awareness of the natural environment

The discussion about sustainable development is not new, starting in the end of the decade of 1960, early 1970s. at this time, it was published "The Limits to Growth" (Meadows *et al.*, 1973), describing the main conclusions from the Club of Rome, which gathered scientists who designed a databank to project future tendencies of the planet's environment (Hobsbawm, 1995 apud Baumgarten, 2004). The book brought up the idea that, in a long run, there would be a complete depletion of non-renewable resources if the population continues to grow at the present rate (Meadows, 1984 apud Baumgarten, 2004).

In 1972, there was the United Nations Conference on Environment, and it started the idea of Eco-Development. Twenty years later, another Conference took place in Rio de Janeiro in 1992, with the purpose to "save the planet" (Bursztyn, 1995).

Between these two conferences, in 1983, the United Nations (UN) created the World Commission on Environment and Development, which is defined as a significant benchmark in the debate over environment and the capitalist development (Baumgarten, 2004).

According to Baumgarten (2004), in 1991, the UN designed the document "Brundtland Report", under the title "Our Common Future", which had the results from the studies of the World Commission on Environment and Development. The main topics discussed were: the relationship between population and food, ecosystems and biological resources, energy production and industry, urbanization, peace, natural environment, development and international cooperation, all of them calling attention to the risks to humanity.

Only in 1995, it was established in San José, Costa Rica, an organization with a focus on the universities, the International University Organization for Sustainable Development and Environment (IUOSDE). Its goal was to work as a network of universities to develop programs and researches in the field of natural environment and sustainable development (Ouidmsa, 2002 apud Tauchen *et Brandli*, 2006; Furiam *et Gunther*, 2006).

Recently, in the year of 2012, the RIO+20 Conference took place in the city of Rio de Janeiro, and according to the UN Secretary Ban Ki-moon, the document generated from the conference "provides strong support for a social, economical, and environmental well-being". RIO+20 had as theme "The Future We Want" and it was summarized as "a historical opportunity to define the paths for a safer, more egalitarian, cleaner, greener, and prosperous world for everyone".

Based on the facts, it is seen that various nations are searching for years to put in place green policies related to sustainability, but the only visible fact is that some companies are searching for green certificates, in order to show that they are taking part to preserve the natural environment. The government does not provide incentives (most of the times) so the whole population is aware and that all are required to have sustainable practices, from a simple correct discharge of the waste produced at home. In order to all to acquire a more sustainable lifestyle, it is necessary to change the culture of the population, starting by a sustainable education in schools, and then, becoming a routine to manage waste to everyone.

### 2.2 Universities history

The universities have signed a commitment with the management of their waste, aiming to minimize the environmental impacts, through an awareness campaign directed to professors, students, and staff (Furiam *et Gunther*, 2006). Since the decade of 1970, many universities implemented waste management programs, such as the University of California, of Wisconsin, the New Mexico State, of Illinois, of Minnesota, and of Princeton (Izzo, 2000 apud Nolasco *et al.*, 2006).



According to Delgado *et Vélez* (2005 apud Tauchen *et Brandli*, 2006), there are around 140 universities that have environmental policies (Demaman *et al.*, 2004; Sassiotta, 2005; Tavares *et Bendassolli*, 2005, Araújo *et Viana*, 2012), being only ten of them with the ISO 14,001 certification (ISO, 2004), such the United Nations University, in Tokyo, Japan (Delgado, 2005). The standard NBR ISO 14,001:2004 specifies the requirements related to a system of environmental management, which enables the development and the implementation of a policy with the goal to respond to the legal and other requirements seen by the standard regarding the environment (Oliveira *et Pinheiro*, 2010; ISO, 2004; Brasil, 1997).

There are reports of institutions in Brazil that manage their waste, as described in the book “*Gestão de Resíduos em Universidades*” (“Management of Waste in Universities”, in Portuguese), being produced by the universities: UCS (Caxias do Sul University), UFRGS (Rio Grande do Sul Federal University), UNICAMP (Campinas State University), UFSM (Santa Maria Federal University), UNISC (Santa Cruz do Sul University), ESALQ (Luiz de Queiroz School of Agriculture of São Paulo University), IQ (Chemistry Institute of São Paulo University), UFPEL (Pelotas Federal University), UEFS (Feira de Santana State University), and Unisinos (Vale do Rio dos Sinos University), the later as the first university in Latin America to have an Environmental Management System (EMS) under the standards NBR ISO 14,001:2004 (Conto, 2010; 2012).

Besides there are more examples of universities that are in the process of adoption of waste management programs since few years ago, such as the CENA (Center for Nuclear Energy in Agriculture of São Paulo University) (Tavares *et Bendassolli*, 2005); DQ/UFPR (Chemistry Department of Paraná Federal University) (Cunha, 2001); EACH (School of Arts, Sciences, and Humanities of São Paulo University) (Araújo *et Viana*, 2012); FURB (Blumenau Regional University Foundation) (Zanella, 2004 apud Nolasco *et al.*, 2006); IQ/UERJ (Chemistry Institute of Rio de Janeiro State University) (Barbosa *et al.*, 2003); IQ/UFRGS (Chemistry Institute of Rio Grande do Sul Federal University) (Amaral *et al.*, 2001); IQ/USP (Chemistry Institute of São Paulo University) (Di Vitta *et al.*, 2002 apud *et al.*, 2006); IQSC/USP (Chemistry Institute of São Paulo University in São Carlos) (Alberguini *et al.*, 2003); UCB (Catholic University of Brasília) (Dalston *et al.*, 2004 apud Nolasco *et al.*, 2006); UFRJ (Rio de Janeiro Federal University) (Afonso *et al.*, 2004 apud Nolasco *et al.*, 2006); UFSCar (São Carlos Federal University) (Sassiotta *et al.*, 2004 apud Nolasco *et al.*, 2006); UNAERP (Ribeirão Preto University) (Alberguini *et al.*, 2005); UNICAMP (Campinas State University) (Alberguini *et al.*, 2005); UNIVATES (Vale do Taquari University in Lajeado) (Bersch *et al.*, 2004 apud Nolasco *et al.*, 2006); URI (Integrated Regional University of Alto Uruguai and das Missões) (Demaman *et al.*, 2004); UT-

FPR (Technological Federal University of Paraná in Francisco Beltrão) (Gonçalves *et al.*, 2010).

Then, based on the facts, it is seen that some universities initiated some actions regarding the management of chemical waste used in teaching and research activities; on the other hand, the protocols of laboratories and administrative proceedings to ordinary waste disposal are still not fully aligned with the public policies, therefore few colleges fit the legal requirements (Jardim, 1998; Afonso, 2003 apud Tavares *et Bendassolli*, 2005).

### 2.3. Sagrado Coração University

The history of Sagrado Coração University (USC, 2014) started in October 20<sup>th</sup> 1953, and since then it aims to train future professionals under the premise of consciousness of social obligations. Today, the university is under the command of the Rector Sister Susana de Jesus Fadel, and the student body has around six thousand individuals, from undergraduate to doctoral programs.

USC has extension programs, in order to transmit the ethnical, philosophical, pedagogical, and scientific principles that are inseparable from teaching and researching. One of its main goals is to include environmental and sustainable development education as part of the extension activities.

The extension projects are divided in thematic areas that correspond to the theoretical fields of the knowledge, according to the recommendations of the Forum of Extension Pro-Rectors of Public Universities, which are: communication, culture, education, environment, health, technology and production, socio-economical development, management, and citizenship and work.

The theoretical field of environment follows the orientation for preservation and sustainability, environment and sustainable development, regional sustainable development, environmental aspects and sustainability of urban and rural developments, training and qualification of human resources and managers of public policies in environment, environmental education, natural resources management, and integrated systems of regional basins.

In 2009, the extension projects in the area of environment performed in the university were: EPE (Studies in Ecological Issues), Urban Flora of Piratininga and Igarçu do Tietê, Interactive Natural History Museum, and the Araribá Project. In 2010, the projects were: Development of the USC's Sustainability Website, and Design of Sustainable Products for the Elderly. In 2011: Physical-Chemical Control in Treating Effluents, Urban Flora of Piratininga, the Araribá Project, Urban Trees Immune to Cutting of Bauru, Zoology



and Natural History Museum, Maintenance of the Sustainability Webpage, Living Flowerbed, and Treatment of Waste: Recovery of Silver by Electroplating and X-rays. In 2012, they were the following: Absorption of Estrogenic Hormones Present in Water and Sewage in the Region of Bauru, Living Flowerbed, Sustainable Design and Social Inclusion, Habit – a Social Action, Recovery Program of the Permanent Preservation Site of the Campo Novo Creek, Recycling of Edible Oil to Produce Soap, Solidarity Economy as a Principle in Labor Organization: Training and Technical Support for Garbage Collectors, Reuse of Wood Residue and the Eco-design + Digital Recycling, Citizenship and Environmental Sustainability, and Reuse of Residues and the Eco-Designing. In 2013, they were: Solidarity Economy as a Principle in Labor Organization: Training and Technical Support for Contramat Garbage Collectors, Living Flowerbed, and Reuse of Wood Residue and the Eco-design. From 2014 on, the projects were grouped in programs, and in the environmental area there was the Garbage Selection, combined with the REGER projects (Reduction of Waste Production and Management Systems of Garbage Collectors Cooperatives) (USC, 2014).

All these projects performed by USC showed the concerns the institution has with the natural environment and its preservation, however, in the university did not have a proper management and storage program of dangerous waste, specially the chemical ones, not even a project in that area, thus this research was extremely important to generate the implementation of a plan of dangerous waste management.

### 3. OBJECTIVES

To identify and quantify the dangerous waste produced at Sagrado Coração University (USC), in order to propose strategies so the waste produced is treated and reused inside the university when possible, and when necessary to discharge, a design of a management and storage plan for the dangerous waste, as well as training the people from the institution to properly accommodate the waste produced.

### 4. METHODOLOGY

To perform this research, first it was required a review of literature to define the best type of questionnaire to be applied in field research, thus adopting the quantitative-descriptive method, which is corresponding to empirical research, with the goal to compare hypothesis, alignment of an issue, analysis of a fact, evaluation of a program, and isolation of main variables. It is a quantitative research, using data collection techniques, which can be in interviews, questionnaires, surveys, using a sampling procedure (Marconi *et al.*, 1996).

After the initial research, there was an interview with employees from all teaching and research laboratories of the university, using a survey method, defined as the means to acquire data about the characteristics, actions, or opinions of a certain group of people, indicated as representative of a target population (Pinsonneault *et al.*, 1993 apud Freitas *et al.*, 2000).

To design the questionnaire, as seen on Image 1, it was used the Brazilian Standards of ABNT, related to waste and residues (ABNT, 2004a; 2004b; 2004c), the Environmental Crimes Act #9,605 (Brasil, 1998), the National Environmental Policy Act 6,938 (Brasil, 1981), and the National Solid Waste Policy Act (Brasil, 2010).

Field research was performed using the questionnaire in presence interviews with the person in charge in each area. The Sagrado Coração University presently has 58 laboratories that are used for teaching, researching and for the extension programs, being used not only by students and the staff, but also by the community. On the other hand, as this research is focused on the management of dangerous and chemical waste, the description of the disposal of this material will be the ones pointed out by the respondents.

Therefore, the study was produced from the answers of the 13 laboratories that confirmed they generate dangerous waste: Anatomy, Biology, Vivarium, Design, Civil Engineering, Aesthetics, Photography, Herbarium, Clinical Analysis (CAL), Dentistry, Graduate (research laboratories), Chemistry, and Sugar and Alcohol.

### 5. RESULTS

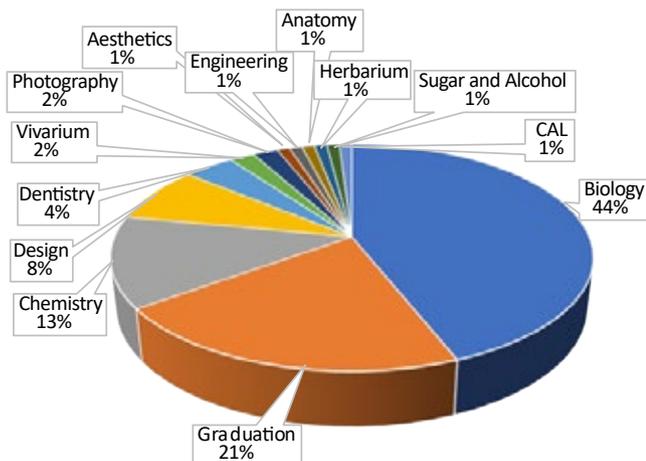
Based on the proper disposal of dangerous waste, it is seen there is an awareness coming from the staff and students in ten locations mentioned previously, and only by the staff in three laboratories. However, it was noted that none of the laboratories visited there are indications that visitors and/or patients are aware of the proper disposal of dangerous waste, even in locations where these people can also generate the waste under investigation. Then, it is observed the necessity to generate manuals and to publicize the good practices of dangerous waste disposal among the population in general, who, in majority, only acknowledges the proceedings of disposal of solid waste. And this fact was pointed out by the interviewees, who declared the occurrence of such actions due to a lack of a plan for waste management.

With the data collected, Image 2 presents the percentage of residue generated by each laboratory.



<p><b>UNIVERSIDADE SAGRADO CORAÇÃO</b></p> <p><b>QUESTIONNAIRE - CHEMICAL WASTE</b></p>						
<p>DAY:</p> <p>NAME OF THE PERSON IN CHARGE:</p> <p>NAME OF THE RESPONDENT:</p>						
<p>1) This location is used as (can be more the one option)</p> <p>Clinic</p> <p>Research Laboratory</p> <p>Teaching</p> <p>Extension</p> <p>Graduation</p>	<table border="1" style="border-collapse: collapse; width: 30px;"> <tr><td style="height: 20px;"></td></tr> </table>					
<p>2) In this location there is awareness of the disposal of chemical waste by:</p> <p>Staff</p> <p>Students</p> <p>Visitors</p> <p>Patients</p>	<table border="1" style="border-collapse: collapse; width: 30px;"> <tr><td style="height: 20px;"></td></tr> <tr><td style="height: 20px;"></td></tr> <tr><td style="height: 20px;"></td></tr> <tr><td style="height: 20px;"></td></tr> </table>					
<p>3) How is the discharge of waste in this location?                  (Consider storage, identification, separation, and final destination)</p>						
<p>4) Would you reuse the treated waste, even if it was recovered inside campus? Explain.</p> <p>Yes</p> <p>No</p>	<table border="1" style="border-collapse: collapse; width: 30px;"> <tr><td style="height: 20px;"></td></tr> <tr><td style="height: 20px;"></td></tr> </table>					
<p>5) Do you think interesting to have a chemical waste laboratory inside campus? Why?</p>						
<p>6) The materials signaled above are discharged by you or someone in the lab into the public sewage system?</p> <p>Yes</p> <p>No</p> <p>Partially</p>						
<p>7) What, in your opinion, would be necessary so this location participate more actively in waste management?</p>						

**Image 1.** Questionnaire applied in the laboratories of Sagrado Coração University  
 Source: The authors themselves



**Image 2.** Percentage of dangerous waste produced at USC laboratories

Source: The authors themselves

The high production of waste by the biology, graduation, and chemistry laboratories are justified by the amount of courses and the number of students that use these facilities in undergraduate courses, or in scientific initiation researches, Master's programs, or Doctorate programs. The biology laboratory belongs to the Health Sciences Center, which has ten undergraduate courses and a total of 1,384 students that use this lab for practical activities of several disciplines. The chemistry laboratory belongs to the Exact Sciences Center and it is used by nine undergraduate programs, with a total of 838 students. The graduate laboratories are used by the scientific initiation students (143 individuals), Master's (18 students), and Doctorate (18 students), and these numbers show that the production of waste in research is higher than in the undergraduate classes.

When questioned how the discharge is performed in a certain location, the respondents affirm that it is stored in bottles, but without a proper separation or identification tags. The biology laboratories and the vivarium do have a previous neutralization of contaminants, and discharge the material in public garbage collecting system. The CAL, dentistry and graduate labs do the correct storage procedure and send their residues to a third-part company. However, it was seen that the laboratories where it was believed there was no production of dangerous waste, it was found some, as for example, in the design lab. In this location, it was found the residue accumulated from the washing of containers used in class and stored in a small water tank under the laboratory tanks, and which were supposed to have a proper discharge once they are contaminated, but due to a lack of a management plan and of information, these residues were being discharged in the public sewage system.

After the implementation of this research, the waste from many laboratories started to be sent to the chemistry

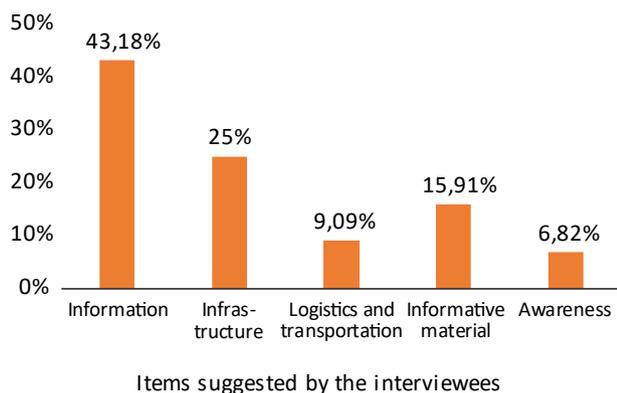
one, which became the only sector to properly manage and store these residues. According to the Resolution of the Collegiate Board of the Brazilian National Sanitary Surveillance Agency (RDC #306/04) (Brasil, 2004), chemical waste that demonstrate hazardous results to human health and/or animal, or to the environment, if they are not submitted to recovery, reuse, or recycling, must receive treatment or a specific final disposal.

In regards to the reuse of treated waste in the 13 locations, only in the graduate laboratory will not find a use for the waste produced due to the necessity of purity demanded for the experiments that take place in that location. Although, it is unanimous that they would work with reused material if it fulfills the quality control requirements.

It was seen that, from this research, the larger quantity of residue is originated from ethyl alcohol, used for various purposes, from cleaning and sanitation, to chemical reactions or experimental procedures, and the xylene, commonly used for histological and immunological experiments, as well as it is a great solvent. Other composts discharged are the acids, which could be reused for metal precipitation, in the case the university had a laboratory for treatment and recuperation of waste. Alcohol and xylene could be also easily recovered by fractional distillation, thus generating a savings when purchasing these products. However, when dealing with dangerous waste, some of the used elements have no use to be treated and recovered, thus the best indication is to be sent to incineration.

Based on these factors, for a possible implementation of a Waste Laboratory, which was demanded by many interviewees, it will be necessary a technical-economic viability study, not only focusing on the environment, as costs for these operations are high (energy, personnel, materials), and fixed, while hiring a third-party company to be responsible for the discharge generates semester spending. Thus, in the beginning, the ideal would be to manage and store, with a third-party company performing the correct discharge, and in the near future, analyzing the viability to build a laboratory to recover the waste.

After qualifying the waste generated it was evident another very important element, the human being (Brasil, 2009a). The great result of the waste management program is intimately linked to the change of attitude of all participants in the institution, such as students, staff, professors, directors, and third-parties. Through the interviews, it was possible to observe that, in the opinion of the respondents, it is necessary to change the paradigm so the laboratories participate actively in a waste management program, as seen on Image 3.



**Image 3.** Necessities demonstrated by the interviewees of the laboratories in managing their dangerous waste

Source: The authors

It is also seen that there is a need to improve the infrastructure, as some interviewees mentioned there are not enough and appropriate bottles to properly store before final discharge. In order to do so, it is suggested that, when the bottle is filled with the residue, another bottle for discharge is provided. When this investigation came to public, it was created a central location to receive all waste, and a standardization to properly identify the bottles.

Another item that needs to be taken into consideration in the process of implementation of a management plan is the logistics of the transportation of the waste, once it needs to be more effective, as if performed in inadequate manner can cause serious damage to human health and to the environment (Brasil, 2009b).

And again, it is clear that the success of any program is the awareness of the people involved, as if they do not believe and do not know the hazardous consequences of an inadequate discharge of dangerous waste, nothing can be done. A large portion of this awareness is built in the formation of the human being, but when it is lacking, there is a necessity to have seminars, demonstration of real facts, texts, books, and awareness about the topic.

This study shows the importance to implement a management and storage plan of dangerous waste of universities, once the quantity generated by many universities is significant, thus harming the environment.

## 6. FINAL CONSIDERATIONS

The analysis of the waste generated by the Sagrado Coração University performed from the interviews with the people involved had a significant importance when detecting which types of waste and the quantity they are generated, how they are discharged today, the ideas and thoughts of

the staff about dangerous waste, and the implementation of a management and storage plan of dangerous waste, among other things.

The approach of the research suggests that further studies will need to quantify more precisely the waste produced, aiming to produce a technical-economical viability study to implement a Waste Laboratory; to make a comparative analysis with other institutions that have laboratories destined to treat their waste, observing the cost-benefit ratio, and then, having a dataset that other universities can use to put into practice the management of dangerous waste.

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