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Overview Management Chemical Residues of Laboratories in Academic Institutions in Brazil

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1. Introduction

In the last decades the discussion regarding the environmental theme has acquired concerning proportions for planetary order. Taking into account the civilization crisis in which we are immersed, the environment has been associated to a problem.

During the process of civilization, we perceive an accelerated growth of human population and the various wastes generated as byproducts of their activities surpass the resilience capacity of the environment, generating imbalances in their original cycles. Large discharges of artificial elements in high concentrations (many of them toxic and harmful to life) are constantly deposited in regions where its subsystem revolves around nature's own dynamics. This flow of residues deposition returns to human beings life cycle as pollution, radiation, contamination, acid rain, among others (Jardim, 1993).

In this sense, generation and fate of wastes have been one of the themes treated by environmental education means and the media. This outcome is a consequence of a capitalist society in which consumerism is required for its own maintenance. It is no surprise that the issue of waste generation and its fate are present in scientific discussions, as well as in common sense. It could not be different since each of us has its own direct contribution to this framework.

The technical solution for the problem is fundamental and represents a challenge and an important research field for professionals in the area. But that technical knowledge alone is not adequate to solve the problem. Most waste management initiatives in universities emphasize the importance of environmental education, but merely quote them without exploring their full potential in addressing these issues. These works point out that one of the obstacles for the success of such management programs are the people, and more precisely, their understanding.

Working with people in regards to environmental issues is exactly the field of action of environmental education in which, in general, universities employ professionals set in departments of biology, education, among others. It is worthwhile to ask ourselves: why do not these professionals working at universities communicate with each other? Another important inquiry: why cannot a university composed of professionals that comprise different fields of knowledge work in an interdisciplinary fashion on a problem generated by the university itself? Such discussion has been intensively investigated by universities and disseminated to society.

Next we will try to answer these questions from reflections addressed by environmental education firstly contextualizing this matter in a broader perspective for we do not agree that a punctual approach could satisfactorily explain the complexity of this subject, incurring the risk of simplification, which would be insufficient to the quest for a more effective solution.

1.2 Overview of universities and institutions of higher education and research developed in Brazil

The 2009 census on Higher Education in Brazil, carried out by INEP (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira; "National Institute of Educational Studies and Research Anísio Teixeira", http://www.inep.gov.br/) showed that the number of Brazilian Higher Education Institutions (HEI) grows every year (Figure 1).

In 2009, 2 314 HEI were registered, being 89.4 % (p <0.001) private and only 10.6% public institutions. Colleges still account for most HEI's, representing 85 % of them. Nevertheless, the majority of courses are conglomerate on universities, with 49.8% of undergraduate courses.

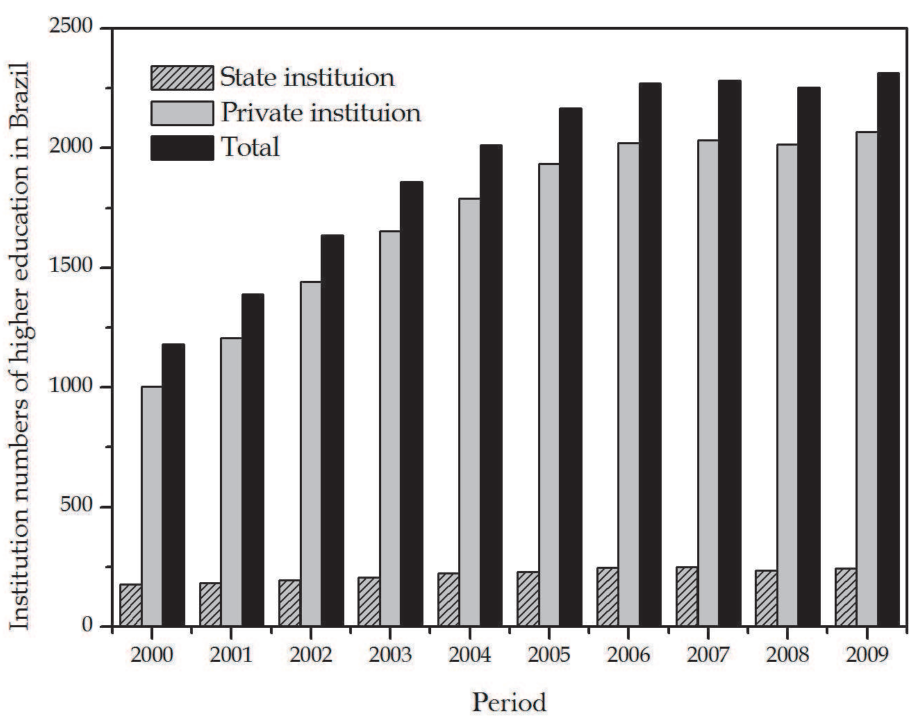

Fig. 1. Evolution the number of Institutions of Higher Education (HEI) - Brazil - 2000/2009.
Source: INEP, http://www.inep.gov.br/.

In Brazilian HEI's, the top ten courses in number of enrolled students are: administration, law, pedagogy, engineering, nursing, accountancy, communication, languages and literature, physical education and biology. These courses comprise 66.4% of students enrolled in Brazilian higher education institutions.

Modern Chemistry has revolutionized mankind for many years and is undoubtedly one of the basic sciences more present in people's lives through closely related segments (e.g., textile, chemical, food and pharmaceutical industry). Chemistry has also contributed to develop human life's quality for the last 40 years (Coelho, 2001). Institutes and departments of Chemistry at universities, as well as all segments that make use of chemicals in their daily work, have been confronting the issues linked to treatment and disposal of wastes brought forth in their teaching and research laboratories for many years (Gerbase et al., 2005). This is the reason why Chemistry courses are the target of discussions in this text, as it presents certain intrinsic features concerning the organization system of laboratory classes.

In Brazil, only larger universities have programs for waste management and treatment. Among them are: IQ/USP - Instituto de Química da Universidade de São Paulo ("Chemistry Institute of São Paulo University"); IQSC/USP - Instituto de Química da Universidade de São Paulo do Campus São Carlos ("Chemistry Institute of São Paulo University at São Carlos"); CENA/USP - Centro de Energia Nuclear na Agricultura da Universidade de São Paulo ("Center of Nuclear Energia in Agriculture of São Paulo University"); UNICAMP - Universidade de Campinas ("Campinas State University"); IQ/UERJ - Instituto de Química da Universidade do Estado do Rio de Janeiro ("Chemistry Institute of Rio de Janeiro State University"); DQ/UFPR – Departamento de Química da Universidade Federal do Paraná ("Chemistry Department of Paraná Federal University"); IQ/UFRGS - Instituto de Química da Universidade Federal do Rio Grande do Sul ("Chemistry Institute of Rio Grande do Sul Federal University"); UCB - Universidade Católica de Brasília ("Brasília Catholic University"); UFSCar - Universidade Federal de São Carlos ("São Carlos Federal University"); FURB – Universidade Regional de Blumenau ("Blumenau Regional University"); URI – Universidade Regional Integrada do Alto Uruguai e das Missões ("Alto Uruguai e das Missões Regional Integrate University"); UFRJ – Universidade Federal do Rio de Janeiro ("Rio de Janeiro Federal University") (Afonso et al, 2004); UNIVATES – Centro Universitário Univates ("Univates University Center").

Usually in Brazilian universities, Chemistry departments, in addition to their practice classes in laboratories for their own students, they also attend to other undergraduate courses.

A survey taken into account reagents used in basic experimental subjects within five major areas of Chemistry at Brazilian universities is presented. It includes about 180 substances among the ones applied and developed in laboratory activities. The curricular program for Chemistry undergraduates comprises five areas of experimental Chemistry: Experimental General Chemistry, Analytical Chemistry, Physical Chemistry, Organic Chemistry and Inorganic Chemistry.

Experimental General Chemistry covers the initial concepts of Chemistry, when students start their learning process in experimental classes in laboratories. The subject program involves the following topics: laboratory safety, nomenclature and characteristics of glassware, measures of mass, volume, density and temperature, physical and chemical processing, standardization of substances, acid/base titrations and determination of levels of substances in our daily lives. Although this course is an introductory practice, in which students carry out their first experiments in Chemistry, a certain number of substances are required for the development of such laboratory experiments.

The second area of experimental subjects is Qualitative and Quantitative Analytical Chemistry. Chemical reactions experienced in these subjects aim to identify and isolate cations and anions by reactions of neutralization, precipitation, complexation, oxidation-reduction, release of gases, as well as volumetric and gravimetric determinations.

Students are divided into groups of three or four for laboratory practices. A laboratory technician prepares and organizes the class so that students, under the professor's

supervision, carry out experiments. In these practice classes, the volume of substances generated is relatively small when compared to industries; however, there is a wide range of chemical wastes generated. The list of chemicals produced in practice classes is considerable, so we listed some of the most important shown in Table 1.
The third area of experimental subject in Chemistry is called Physical Chemistry (Table 1) and deals with concepts of energy associated with molecules and chemical reactions, electrochemistry, the laws of ideal gases, chemical kinetics and chemical and physical adsorption.
The fourth area is Organic Chemistry, which studies carbon compounds and their reactions. There are two experimental subjects, organic Chemistry I and II. In those subjects, most compounds that are required and generated in these classes are organic and are also presented in Table 1.

Chemistry area	Chemistry products
1. Experimental general Chemistry	sodium hydroxide, oxalic acid, hydrochloric acid, benzoic acid, gasoline, solid iodine, phenolphthalein, methyl orange, thymol blue, magnesium, ammonium dichromate, phenol red sodium salt, alizarin yellow R sodium salt, methyl red sodium salt, bromo phenol, bromocresol green sultone, sodium bromide, sodium iodide, strontium chloride, copper(II) sulfate, chromium(III) chloride, potassium chloride, nickel(II) chloride, potassium iodate, potassium iodide, ethylene glycol, aniline, sodium sulfate, manganese(II) sulfate, iron(II) sulphate, aluminum sulfate, potassium nitrate, barium chloride, ferric chloride, butanol, ammonium carbonate, calcium hydroxide, cobalt(II) nitrate, lead II nitrate, sodium phosphate monobasic, ascorbic acid, lithium chloride, potassium permanganate, calcium cyanide, cobalt(II) sulphate.
2. Analytical Chemistry	sodium hydroxide, nitric acid, sulfuric acid, Hydrochloric acid, potassium thiocyanate, nickel salts, potassium ferrocyanide, and heavy metals in the form of their salts, as salts of silver, chromate and potassium dichromate, lead salts like lead II chloride, mercuric chloride, copper II salts and cadmium salts.
3. Physical Chemistry	chromate and potassium dichromate, ammonium thiocyanate, ethyl acetate, acetone, acetic acid, ethanol, naphthalene, diphenylamine, sodium dodecyl sulfate, copper sulfate, potassium chlorate, manganese(IV) oxide, phenol, zinc sulfate, nickel sulphate and silver chloride.
4. Organic Chemistry	glycerin, benzoic acid, dinitrobenzene, glucose, copper(II) oxide, barium hydroxide, sodium ferrocyanide, aminobenzene, benzoic acid, ethoxy ethane, hydrochloric acid, ethanol, cyclohexanol, sulfuric acid, cyclohexene, potassium permanganate, nitrobenzene, acetanilide, 2-propanol, acetone, n-butyl ether, phenylamine, sodium nitrite, copper sulfate, adipic acid, carbon tetrachloride, liquid bromine, eugenol, urea,

	formaldehyde, salicylic acid, methyl salicylate, acetic anhydride, acetylsalicylic acid, 4-aminoazobenzene, caffeine, ethyl acetate, methanol, dichloromethane, benzanilide, 4-nitroacetanilide, methyl benzoate, hydroquinone diacetate, benzocaine, 1,3-dibenzoylacetone, butyraldehyde, benzaldehyde, dimethyl phthalate, phthalic anhydride, 2,4,6-tribromoaniline, methyl salicylate, isopropyl bromide, among others.
5. Inorganic Chemistry	potassium permanganate, sulfuric acid, hydrogen peroxide solution, sodium thiosulfate, sulfur, potassium iodate, sodium metabisulfite, potassium hydroxide, sodium hypochlorite, ferrous sulfate, nickel(II) nitrate, cobalt(II) chloride, calcium carbonate, magnesium carbonate, magnesium chloride, ammonium chloride, ammonium hydroxide solution, strontium chloride, ammonium sulfate, barium chloride, acetic acid, sodium tetraborate, aluminum sulfate, sodium carbonate, nickel(II) nitrate, lead(II) nitrate, barium sulfate, calcium sulfate, magnesium sulfate, strontium chloride, sodium acetate, ferric chloride, ammonium thiocyanate, sodium chloride, potassium chloride, sodium bromide, potassium iodide, ammonium chloride, calcium hydroxide, ammonium iron(II) sulfate hexahydrate, potassium fluoride, potassium thiocyanate, copper(II) sulfate pentahydrate, lithium chloride, methanol, potassium oxalate, ethanol, cobalt(II) sulfate heptahydrate, sodium silicate, potassium chromium(III) oxalate trihydrate, tris(ethylenediamine) nickel(II) chloride hydrate, cobalt (II) nitrate, tris (ethylenediamine) cobalt(III) nitrate, tris (ethylenediamine) nickel(II) chloride hydrate, nickel(II) acetate tetrahydrate, ammonium nitrate, tetra amin cobalt (III) carbonate, pentaamminechlorocobalt(III) chloride, tris (oxalate) chromate (III), potassium copper chloride (II), tartaric acid, formaldehyde solution.

Table 1. A survey of reagents used in basic experimental subjects in five major areas of Chemistry in Brazilian universities.

The last but not the least important area listed herein is Inorganic Chemistry. It is the branch of Chemistry that studies chemical elements and nature substances that do not display carbon in their structures, investigates structures, properties and explains the mechanism of their reactions and transformations. In Experimental Inorganic Chemistry, various chemicals are necessary for reactions (Table 1), as well as other several chemicals are formed after reactions.

The great variety of substances used or generated during practice classes usually makes waste management in educational and research institutions or similar service providers more intricate than in industry. Unlike industries, these institutions generate small amounts of waste, most of which in laboratories. These wastes consist of a wide variety of substances, toxic or non-toxic, including new compounds of unknown toxicity. Besides, their compositions change on every new research project or experiment (Gerbase et al., 2005; Tavares & Bendassolli, 2005; Jardim, 1998; Ashbrook & Reinhardt, 1985).

Implantation of a Program Management of Chemical Residues (PMCR) should whenever possible accomplish the priority scales or hierarchy (Jardim, 1998):

- Prevent waste generation (hazardous or not);
- Minimize the amount of hazardous wastes that are inevitably generated;
- Segregate and concentrate waste currents in order to make possible and economically viable a managing activity;
- Reuse internal or external wastes;
- Recycle material or energetic components of the waste;
- Keep all waste at its most treatable conformation;
- Safely treat and dispose wastes.

In this context, can we achieve this premise if we promote changes in daily activities of professionals: professors, researchers and laboratory technicians directly involved in the generation of chemical wastes (Nolasco et al., 2006; Tavares & Bendassolli, 2005; Singh, 2000):

- a modification of a certain process (or analytical method), substitution of raw materials or inputs;
- minimization using microscale techniques;
- segregation of waste into different classes of compatibility;
- reapplication of waste inevitably produced by recycling or reuse;
- treatment through acid/base neutralization and chemical precipitation of metals.

In addition, practices of advanced oxidation processes (AOPs) (Pera-Titus et al., 2004; Perez et al., 2006), treatment and heavy metals recovery (Kurniawan et al., 2006), are already commonly used in several treatments of substances generated in laboratory. We can recommend other easily handling practices to reduce generated chemical wastes.

One example is the preparation of the dye 1 - (p-nitrophenylazo)-2-naphthol from p-nitroacetanilide. Initially in experiments performed in Organic Chemistry I, where the p-nitroacetanilide is prepared, serving as a substrate for the next reaction, the production of 1 - (p-nitrophenylazo)-2-naphthol. This last reaction is performed in experimental classes of Organic Chemistry II. Therefore, the product generated in a practice class is applied in another, minimizing then generation of chemical wastes in class.

We may also employ an alternative related to separation and identification of cations and anions in the subject Experimental Analytic Chemistry. Cations and anions not harmful to environment could be normally determined, but the identification of heavy metals, such as copper, silver, cadmium, lead, mercury and chromium, could be applied a single time. In experiments to be performed with these metals, procedures could be filmed and photographed step-by-step. Later, this material would be used to set a database with films and pictures containing all steps developed in the identification and determination of these elements. Then, the same experiments with these metals would not be conducted later, in the way that students of the following years would attend to audio-video classes, decreasing generation and supply of toxic residuals in laboratories.

The final disposal of wastes may be achieved in industrial disposal sites or other adequate locations, avoiding the misinformation that incineration and co-processing are ways of disposal. In such processes residual material is burnt, gases that should be treated are produced and ashes are subsequently sent to landfills (Nolasco et al., 2006).

The number of scientific publications coming from Brazil has grown steadily over the past 26 years, culminating in 26 482 in 2008 (Figure 2). In parallel, Brazil´s international contribution with articles has climbed from 0.8 % in 1992 to 2.7 % in 2008. There is a correlation between this increase and the growing number of PhDs awarded annually (UNESCO, 2010).

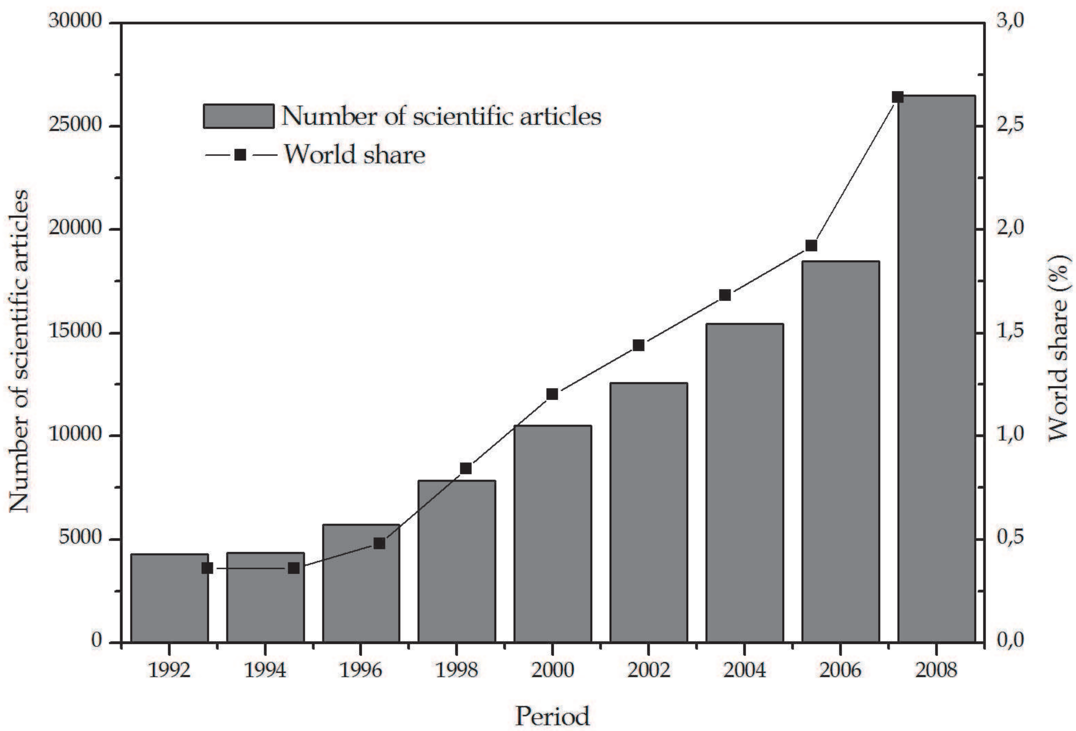

Fig. 2. Evolution of number of scientific publications from Brazil in period 1992 to 2008. Source: UNESCO, 2010.

We must be aware that benefits from our professional and scientific activities (publications, patents, scientific recognition, development of new products and technologies) may generate, on the other hand, chemical residues from varying degrees of dangerousness. They may require appropriate chemical treatment before being sent to final disposal (Afonso et al., 2003).

Universities represent places where scientific knowledge is produced, from where usually their new products and technologies arise, building up its part in society and directly interfering in it. We know that training goes well beyond the execution of a specific undergraduate program, experiences through contact with professors, laboratory technicians and staff, apprenticeships, basic scientific research activities, tutoring and degree dissertations, among others. They surpass content or technical aspects of each area. Thus, we are concerned about the example being given to students when professionals apparently turn their backs to such problem. That is, students experience a total lack of accountability before an issue present in their own immediate environment. There is no denying that such experience will be part of this future professional education with possible repercussions in their professional future.

Universities, as opinion builders, should take advantage of all opportunities to create conditions for self-evaluation, seeking the formation of future professionals with environmental awareness, ethics and co-responsibility. In this sense is relevant to emphasize the fact that there is no sustainability in the social-environmental structure of universities, either in the relationship among people, or the relationship among nature, people and their residuals.

Another aspect to be taken into account is that, in the structure of the university, still prevail the issues created by knowledge fragmentation. This criticism is made by some parties in the university itself through scientific papers, books and lectures, though it does not resonate inside its own walls.

We should not forget that universities are embedded in a social liberal context that seeks to adapt the principles of economic liberalism to the conditions of modern capitalism. Then, the entire academic community is suffocated by a "market" that requires high productivity and consequently hinders an integrated vision and a careful look to itself.

In this context, environmental education plays a crucial role which can manage hazardous wastes in universities. In order to start wondering how could be this performance of environmental education, it is important to comprehend the significance of environmental education and what are its principles.

1.3 Brazilian legislation relevant to the theme

There is a tendency in our society to consider harmful to the environment only those activities that generate large amounts of wastes. Consequently, these are great generators always under the supervision of state environmental protection agencies and subject to punishment. Small waste generators, such as educational and research institutions, biochemical and physicochemical laboratories, are usually considered not harmful to environment by inspection agencies and, therefore, rarely investigated as for discarding their chemicals wastes (Jardim, 1993).

Solid, industrial, radioactive and health services wastes are under control of a specific legislation with standard rules and procedures for storing, transportation and final disposal. In these cases the national and state legislations indicate specific controlling agencies, and a valid principle is that polluter pays for its violations. This principle is part of the environmental law that forces the polluter to compensate all damages caused to the environment.

In Brazil, Law 6.938/81 concerning the Environment National Policy establishes a "Objective Liability" which does not require proof of guilt in case of possible environment damage. That is, for a potential polluter to be punished it is solely necessary to demonstrate the link cause-effect between an activity developed by an organization and the given environmental damage. In summary, it means that a pollutant, even though being produced in acceptable concentrations established by current law, may cause environmental damage, subjecting responsible to compensation. Moreover, even if any indirect damage is detected, and since its connection to an organization is testified, the latter will be held responsible (Machado, 2002).

Applying the “Objective Liability” Law is hindered by the difficulty in inspection procedures in several industry areas, research institutions and universities, inducing environmental risks and contributing to its degradation. This problem is almost always avoided until more serious threats, iniquities and environmental conflicts may reach people directly engaged to these contexts, such as inhabitants surrounding a degraded area where residuals present potential and effectively high levels of pollution and contamination (Penatti , 2008).

ABETRE (Associação Brasileira de Empresas de Tratamento de Resíduos; “Brazilian Association of Waste Management Companies”) estimate that only 22% of approximately

2.9 million tons of industrial hazardous wastes annually produced in the country receive adequate treatment (ABETRE, 2002). It is also plausible to assume that waste production is not exclusive of industries, once laboratories in universities, colleges and research facilities also generate chemical residuals in high diversity and low volume, yet it may represent 1% of all hazardous wastes generated in a developed country (Ashbrook & Reinhardt, 1985).

Such verification leads us to the fact that the matter of chemical residuals management, originated from research and teaching activities, should be taken as discussions and research themes that deserve more space in the Brazilian academic cycle. This should also be motivated by the important role that research and educational institutions play towards formation of human resources accustomed to environmental management practices (Afonso et al., 2003; Alberguini et al., 2003; Jardim, 1998).

A survey regarding several management programs at institutions of higher education shows that management of their own wastes is an actual concern for most of them, and they are aware of the issues related to environmental degradation. However, between a spoken or written commitment and effective actions, there is a great distance.

In this sense, we cannot just criticize universities for not complying with legislation, because, in most cases, the lack of infrastructure and resources, as well as public policies focused on the matter, limits the adequate disposal of wastes.

As many industries do, colleges and universities encounter thorny problems dealing with hazardous wastes. Industry and academia alike are saddled with the rising cost of waste management and face sensitive liability for costs of waste cleanup (Ashbrook & Reinhardt, 1985). One institution experiencing problems with the dramatically rising costs of hazardous waste management is the University of Illinois. In 1977, the University spent $2,000 to dispose of 100 drums of chemical wastes. By 1982, the cost of disposing of 265 drums had risen to $46,000, an 87 % annual increase in the cost of storing, transportation and disposing of wastes in a landfill (Ashbrook & Reinhardt, 1985).

Gerbase et al. (2005) suggest some actions meant to funding, research and teaching regulation agencies in Brazil, in order to defeat financial difficulties inherent to the installation of programs for managing hazardous waste, such as:

- resource allocation and specific convocations to Environmental and Hazardous Waste Management (chemical, biological and radioactive) in research and educational institutions;
- establishment of working groups of experts in order to propose standard rules for Safety in Chemistry for research and educational institutions;
- a quality criterion to be included as an item for evaluation by Ministério da Educação e Cultura ("Ministry for Education and Culture"; MEC) and Coordenadoria de Aperfeiçoamento de Profissional de Ensino Superior (" Coordination for Improvement of Higher Education Professional"; CAPES), the existence, or project implementation, of a program for hazardous waste management in graduate and undergraduate institutions for education and research.

Orloff and Falk (2003), discussing international perspectives on hazardous waste practices, suggest that an effective hazardous waste management program is a collaborative effort and must include input from all relevant parties: federal, state, and local government officials, citizens, academia, and representatives of industry and non-governmental organizations. Citizens are important stakeholders and their input about waste management is crucial to ensure acceptance of society.

2. Environmental education (EE) as a tool in the process of toxic waste management

Several authors have addressed the lack of environmental awareness within academic communities as an obstacle to greening (Riera, 1996; Meyerson & Massey, 1995; Creighton, 1999). The consensus is that people must be educated before a change can take place. As for the sampled institutions, a double set of morals seems to exist. On the one hand, they all considered the lack of awareness to prevent a greening process within energy and waste management from taking place. However, practically nothing had been done to raise environmental awareness.

The lack of environmental awareness was considered significant because people do not know how to act sustainable. In other words, investing in waste and energy reducing devices has no meaning unless people know how and why it should be carried out. Decision makers must be familiar with the benefits of greening to establish environmental policies and to invest in green devices, and academics must realize the necessity of being "green" role models to their students (Dahle & Neumayer, 2001). The importance of raising environmental awareness at high education institutions is now being recognized from various bodies; the UK Sustainable Development Education Panel (1999) notes that:

"All further and higher educational institutions should have staff fully trained and competent in sustainable development, and should be providing all students with relevant sustainable development learning opportunities."

In Brazil, EE is guided by the Treaty on Environmental Education for Sustainable Societies, Environmental Education Policy and PRONEA (National Environmental Education Program) and has sought to build an interdisciplinary perspective to understand the issues that affect relationships between human groups and their environment and to intervene on them, activating several areas of knowledge (Carvalho, 1998).

For the education to integrate in the process of Environmental Management, it is required that "conditions necessary for production and acquisition of knowledge and skills are provided and attitudes are developed attempting to individual and corporate participation in dealing with environmental resources and in conceiving and applying decisions that affect quality of physical-natural and sociocultural means" (Quintas, 2000).

Thus, it is clear that we cannot expect a ready recipe for how environmental education deals with the management process. We may however start out a discussion on the principles of environmental education, having in mind that one of the aspects to be considered is the quest for the solution of a problem through a dialogue amongst actors involved in the problem. Therefore, the construction of a management process will be conducted considering the several contributions by the actors involved, as well as its adequacy to local reality.

The environmental educator must look for the meanings of human action that are in the roots of socio-environmental processes that seem to synthesize the core of interpretative making of environmental education. By demonstrating cultural and political meanings taking place in the interactive processes society-nature, the educator would be a translator of perceptions – which are also, on their turn, social and historical interpretations – that mobilize several interests and human interferences in the environment. In the opposite direction of an objective vision, in which interpreting the environment would mean conceive it in its factual reality, describe its laws, mechanisms and operation, one should demonstrate the horizons of historical-cultural sense that configure relationships with the environment for a certain human community and in a given time (Carvalho, 1998).

Our consideration on the contribution of environmental education is twofold. The first would be a broader approach, whose fundamental idea would be the accomplishment of an Environmental Education Policy for Sustainability at the University. The implementation of such policy, involving the entire academic community prioritizing the search for solutions for experienced environmental issues and often generated by the university itself, which would be extremely desirable, then, includes the toxic residues problem on a broader context, due to the complexity of the environmental problems nature. In this sense, the hazardous wastes problem would be treated like the solid wastes, sewage contamination, the rationalization of water and energy consumption, the quality of environment and interpersonal relationships at work, the institutional master plan, among others. Such an environmental policy would contribute in the sense of giving direction to where the toxic wastes matter resides in broader context. The acceptance of a systemic approach would be suggested, with the possibility to become clearer, as some problems may bear a common cause or a common solution. Hence, the possibility to combine financial resources would be eased, as well as the so much recommended interdisciplinary integration.

The other approach would be associated to more technical aspects directly linked to management of self-generated wastes. In this sense, the interview methodologies, environment social representations, among others, would be applied at all times according to necessity, mainly during the development of work immediately with involved actors.

3. Overview of PMCR implanted and proposition integrated management of chemical residues (IMCR) based on a environmental education policy for sustainability in universities (EEPSU)

The system of environmental management is characterized by promoting sustainable development through a local procedure, aiming to develop a sense of global environmental responsibility. This system establishes in its execution general and specific processes for each section of activity in order to engage and involve all organization members. That is the reason why the institutional support is essential and the commitment of the highest hierarchies is an essential and ideal condition. Nevertheless, even when unconditional and unrestricted institutional support is lacking, is no reason for the process not to occur.

A critical analysis on several programs of laboratory chemical wastes management at universities carried out by Nolasco et al. (2006) reveals a significant homogeneity regards adopted principles and emphasizes the opinion of professionals directly related to the execution of such programs. These professionals select as main difficulties the investment need in infrastructure and institutional support.

Coelho (2001) states that within universities there is no lack of technical capability, yet political willingness of institutions in giving proper relevance to the matter, as well as the execution of internal policies, widely discussed and disseminated, involving the entire academic community and also support for scientific research by the responsible organs.

Izzo (2000) acknowledges other aspects that complicates the implementation of PMCR in universities, HEI and research institutes and hinders the program coordination: (1) decentralization of these institutions in which different administration sections and departments work independently; (2) rotation of undergraduate and graduate students; (3) variation on research projects conducted in these institutions; (4) most of them do not present a centralized purchase and storing section.

Variations in research projects and regular changes in lines of work reflect peculiarities in wastes generated in the universities when compared to industries. They present reduced volume, though also a great diversity of compounds, which makes any establishment of a chemical treatment and or a standardized final disposal difficult (Gerbase et al., 2005; Jardim, 1998; Ashbrook & Reinhardt, 1985).

The proposal to establish a Policy on Environmental Education for Sustainability in Universities (EEPSU) aims to unify planning, control and supervision of natural resources appliance that we use during our activities with awareness and always in search for sustainability. It also has to do with us becoming responsible for the consequences of using these resources, trying to minimize our consumerism, avoiding waste of natural resources and promoting reduction of wastes generation of all kinds. All this tends to minimize any type of environmental impact.

The policy established a pathway to best practice by requiring the establishment of an environmental management plan that would set out how the university would manage issues of environmental concern and interest "bearing in mind the commitment to principles of ecology-sustainable development". The universities surveyed (Australian and New Zealand) have an environmental policy. The importance of developing an environmental plan is to establish concrete guidelines. Where a policy states that a university is committed to sustainable development, a plan will outline how sustainability will be included in university operations. Other aspects are that, by outlining future environmental development, plans facilitate accountability and leave the university open to criticism. Plans can foster participation and representation; committees and working groups may be established as representatives of the university community (Carpenter & Meehan, 2002).

Dahle and Neumayer (2001) believed that the most important measure for reducing or overcoming established barriers to green university is to raise environmental awareness within campus communities, i.e. sustainable behavior cannot be expected to take place unless people understand the benefits and importance of doing so. Creighton (1999) suggests that, to achieve a "green" university that uses resources efficiently, creates little or no waste, and takes full responsibility for any waste that it does generate, a fundamental change in the thinking behind routine decisions of university administration, staff, faculty and students is needed.

These alternatives can be achieved through the implementation of EEPSU increasing ethical conscience and co-responsible for the academic community (teachers, laboratory technicians and administrative and academic), which lead to formation of professionals aware of their citizenship and their professional role.

Policies are necessary, it must be remembered that they are abstract statements of principles that, while creating a positive "environment", do little to improve environmental performance; it is only when policies become operationalised through the establishment of a plan and subsequent programs that environmental performance can be improved (Carpenter & Meehan, 2002).

The Integrated Management for Chemical Residues in High Education Institutions (IMCRHEI) proposed by Giloni-Lima and Lima (2008) drew the scientific community's interest, notwithstanding, as it was published in a Brazilian journal and written in Portuguese, its circulation was restrained. In this sense, we take the opportunity to spread it after revision and expansion, aiming to offer an integrated proposal, as its name implies, and in accordance with PEESU and other aspects of this chapter. It is worth mentioning that the MCRP is one of the problems experienced by HEI's and will be addressed by EEPSU, and the former may happen even if the latter does not. On the other hand, if the policy is active, waste management would be part of a wider process.

The participation of academics at all stages of the process would be of great value, because they would have the opportunity to demonstrate their interest in various working groups and act as multipliers, acting in the research for information and generating data applied for management of chemical residues.
The general structure of the flow chart proposed (Scheme 1) consists of four stages which

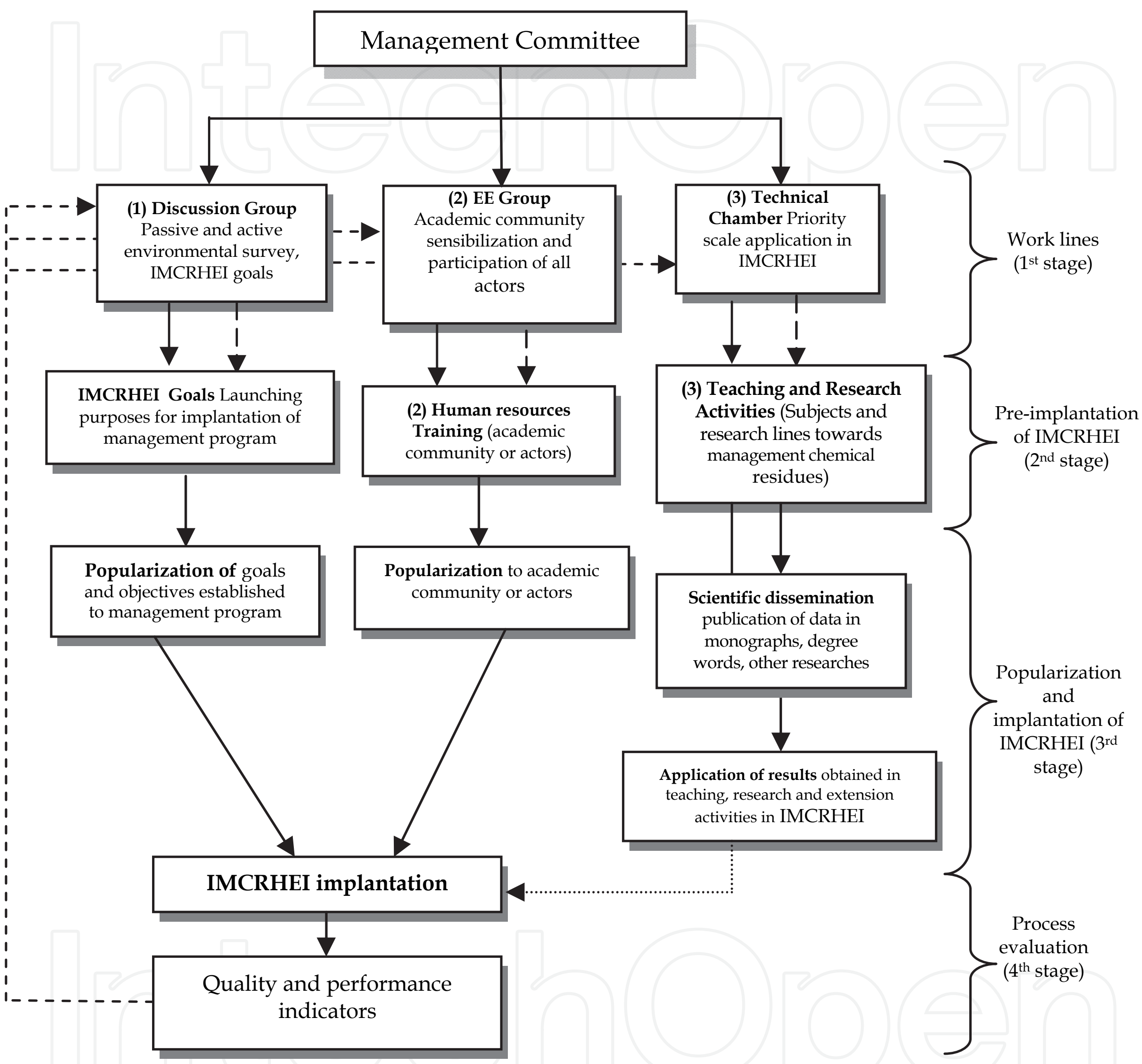

Fig. 3. Basic flow chart to implantation the Integrated Management for Chemical Residues in High Education Institutions (IMCRHEI). Solid lines: direction to basic lines of work; dashed lines: feedback; dotted lines: direct application to results in the implantation of IMCRHEI.

start from the constitution of a Manager Committee, which will coordinate the development process for deploying IMCRHEI, employing the formation of three Basic Work lines - 1st stage, with the formation of (1) Discussion Group, (2) Environmental Education Group and (3) of the Technical Chamber. The results of work developed in the first stage will define the main points to be worked out in stage 2, Pre-implantation of the Management Program. Once initiated this step, after gathering all basic requirements needed, i.e., setting goals and objectives of the management program, as well as a minimum training required for compliance, from where stage 3 - Divulgation and Implantation IMCRHEI can be initiated, one should look for unambitious and real goals, as failure in a first attempt tends to discourage further attempts (Jardim, 1998).

It is worth noting that there is a consensus that environmental education is an important tool in the execution of waste management programs, though they are usually based on activities of passive and active environmental surveys (task proposed to discussion group) and application of hierarchy scales proposed by technical chamber, where EE is only mentioned in almost all programs.

Activities of teaching and research for its peculiarities have a proper time to be concluded and execute the application of its results (dotted line in Scheme 1). The 4th stage, Process Evaluation, is the time to review achievements or failures from the Quality and Performance Indicators established by the basic lines of work, which can forward their findings to promote the necessary adjustments to the process as a whole.

The learning process generate information to permit self-regulatory and self-correcting activities to occur, while involving monitoring, applying systems thinking, and performing self-assessment. Without the use of environmental indicators for monitoring, environmental audits and self-assessments, learning might not take place. These tools enhance learning process (Herremans & Allwright, 2000).

Creation of the Manager Committee is based on a discussion process for the formation of groups of professionals from various fields of training and identified with the EEPSU. The form of constitution of the Manager Committee and groups which are willing to develop the lines of work can follow the own institution dynamics, or still can start from the creation of a discussion forum which may represent an open space for discussions about the theme, circulation of information about the institutional reality regarding the current management of self-generated waste, to exchange experiences, and especially will enable professionals to evaluate the profile that would be more suitable, aware and willing to engage in coordination of the process.

We suggest the formation of a multidisciplinary group, involving faculty members from areas of administration, chemistry and biology, education, and student body of the institution to coordinate the three basic lines of work (Stage 1) of IMCRHEI implementation, aiming to integrate the academic and scientific community in the process, being as follows:

1. Discussion Groups: These groups might work in survey information with two types of waste: the passive (which includes reaction from debris, passing through solid waste and bottles without labels) and active (continuously generated, the result of routines in the generating unit). The characterization of passives shall be equated as well and using simple tests (Jardim, 1998; Armour, 1996).
2. Group of Environmental Education aims to involve professionals in the field of Environmental Education (EE) and to promote a line of work to undertake a process to make the academic community aware of the relevance of the thematic, even before the establishment of plan goals. These professionals may also work in developing an Environmental Education Program based on information provided by discussion groups (1), in order to assist processes of dissemination and training of the academic community.
3. Technical Chamber: this group may act to evaluate the practical activities carried out in laboratories (in conjunction with the teachers responsible for them), the implantation of the priority scale (Jardim, 1998) seeking the best alternatives within its institutional reality. This group can also act as a generator of theme for future research directed to

monographs, works of completion and until the creation of lines of research in order to structure the management of hazardous chemicals or not, the proposition of safety standards chemistry, etc.

The environmental education group, due to its interdisciplinary, contextualized, critical and emancipatory nature must somehow be involved with groups 1 and 3. This situation is justified by the need for this group to understand all relationships involved in the management process. Its performance may occur at all times that involve human relations.

It is worth emphasizing that the participation of all stakeholders is crucial. In order to increase likelihood of successful management, actors must be heard and have opportunity of opinion for it generates commitment. A commonly used method for environmental education to achieve this practice is the research participant. The technique of social representations also brings great contributions. A social representation is the common sense that one has about a given topic (Reigota, 2010), through this technique, one can find out scientific concepts of how they were learned and perceived by people. It can also be understood as a set of principles built interactively and shared by different groups that understand and transform reality through it (Moscovici, 2003).

It is important to note that the information given here should be taken only as suggestions, because, as previously mentioned, the search for the paths to be followed will be built up by the group. Thus, the EE could help at times as in the situations listed below:

- assessment process through investigation of social representations of those involved: professors, students and laboratory technicians;
- in planning, involving results previously surveyed;
- on the destination, by minimizing waste generation or disposal, and proper destination, developing in all groups involved an environmental and ethical conscience;
- disseminating and instruction other laboratories that generate waste and chemicals which are not under the responsibility of professionals in the field;
- internal and external divulgation of the management program implantation.

The training program for the academic community may act in the formation of specialized human resources in the management and disposal of chemical waste, both undergraduates and graduates, which extends beyond technical skills, may further strengthen ethical and co-responsible conscience in regards of chemical safety in workplace and environmental liability.

Training courses could also involve practical actions that try to minimize environmental impact and risk to those involved with direct or indirect engagement with hazardous wastes, including chemical, biological and radioactive ones produced during teaching and research procedures (Gerbase at al., 2005). The acquiring funds could occur through projects submitted to funding agencies that support research through specific calls, or partnerships with public and private organizations that can be later profited with costless courses and supporting programs for social inclusion of people without qualifications. Such actions allow sharing with society the fundamental concepts of environmental wastes management through courses to the community (Bendassolli et al., 2003).

The problems raised by the Technical Chamber in implementing a priority scale (Jardim, 1998), within the activities developed in the generator unit, may guide teaching, research and extension activities to be developed. The creation of specific subjects or others related to the theme and the availabiliby of trainings (Alberguini et al., 2003; Tavares & Bendassolli,

2005; Bendassolli et al., 2003) are able to promote an interdisciplinary approach, stimulating the formation of academic student within a more holistic perspective, working on his technical training and environmental responsibility, and to promote ethical attitudes improving the profile of the future professional. In regards to research procedures, there are innumerable possibilities to include researchers, technicians and undergraduate and graduate students in generating data and information that reach the basic precepts and its major aspects in order to achieve the requirements of current environmental legislation.
Internal and external divulgation (Stage 3) of the Integrated Plan for Waste Management is essential for awareness and dissemination of ideas and attitudes that corroborate the process. Nolasco et al. (2006) posits that utilization of intercommunication ways in the unit eases maintenance and continuity of the program. The World Wide Web (Internet) has been extensively used for this purpose, facilitating communication and access to information relevant to the MCRP.
The fourth stage of the process is extremely important because it will promote an assessment process as a whole, through the use of Indicators of Quality and Performance, which could provide an evaluation of the process efficiency depending on the products you want to achieve allowing the use of feedback mechanisms and recurrence of achievements and failures, redirecting them in order to reach the intended goals and objectives.
Some elements that can assist in structuring indicators of quality and performance are: identifying the goals to be achieved, defining forms of measurement that may be used and for each raised indicator, how these are calculated, how often the assessment will occur and how to interpret results. These can provide information to raise the specific points in which objectives and goals are not yet reached and allowing to evaluate in which line (1, 2 or 3) adjustments are necessary and feedback subsequent actions (dashed lines in Scheme 1).

3. Conclusion

Chemistry is a basic science that has brought great benefits to humanity and is present in everyday life, in textile, food, pharmaceutical, agrochemical, petrochemical industries, etc., revolutionizing our lives in bringing comfort and technologies that translate into improved life quality and expectancy. This science, due to its own features, is linked to progress and development, representative characters of contemporary society, which, in search for life quality, generates concerning environmental impacts. We need to handle environmental impacts as political matters and to conceive the environment as a common public property, as well as its care as a political right, expanding its comprehension and citizenship practice.
The proposal for a Policy on Environmental Education for Sustainability at the University is conceived in order to assess possible environmental impacts related to activities undertaken by universities and by means of technical and scientific competence, the pursuit of interdisciplinary solutions, and more sustainable alternatives for managing, treatment, storage and disposal of chemical wastes generated in their teaching and research activities. The establishment of a sustainability policy can also facilitate access to financial resources, scarce on this issue, but unexpendable.
We regard that environmental legislation in Brazil and in the world is evolving and trying to adjust to technological, economical and social developments. Despite the lack of legislation specifically defined for peculiarities of waste generated in Institutions of Higher Education,

a great deal of universities in Brazil and the world have expressed their concern on the issue, taking on their responsibility for the development of science and technology towards management of chemical waste.

Management of hazardous chemicals in universities is a problem that must be seriously considered and with responsibility, and face the consequences regarding the relevance of professional formation to academics with ability to fairly practice its profession committed to citizenship. The integrated management program for chemical residues in HEI's, pervades legal, educational, scientific and environmental management aspects. It involves the entire academic community where the priority would be the establishment of an environmental policy in the institution. The process begins with the composition of a manager committee that coordinates and directs the formation of the three basic lines of work: discussion groups, environmental education and the technical chamber (1st stage). The second stage is the IMCRHEI pre-implantation that establishes goals and objectives and where the sensibilization process on academic community begins, both encompassing the participation of all actors involved. It is important to emphasize that every line of work has different times for its consolidation, in particular the activities to be undertaken by the technical chamber. The proposal anticipates the circulation of goals and objectives planned cooperatively and, after implantation (stage 3), performance and quality indicators would be used in the evaluation process (stage 4), a feedback mechanism supports good results and indicates alternatives in case of failures.

Environmental education plays an extremely essential role in this process, since through the joint participation of the entire academic community (professors, administrative and laboratory technicians, students), shows where is the lack of sustainability in our activities (wastage, misuse of natural resources, in generating and disposing of solid and chemicals wastes) and, associated with institutional expertise, explains how to more sustainably execute them. Concerning more specific issues, such as the management of chemical wastes, EE presents an integrated proposal, where it is present since the conception of the politic-philosophical proposal, in sensibilization and training of actors involved.

EE may also act to minimize problems caused by knowledge fragmentation, helping to sensibilize skillful professionals to work in an ethical, conscious, responsible, critical and contextualized manner. Professionals able to execute their tasks in a "green" form, knowing the basic procedures of safety and environmental protection, both within and outside the university.

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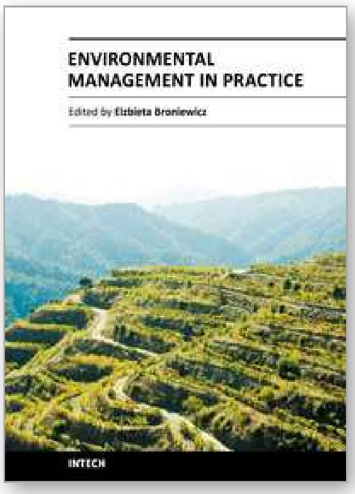

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