Vol.17,n.2,pp.68-73 (Dez 2016 – Fev 2017) Brazilian Journal of Surgery and Clinical Research - BJSCR

XYLENE: FEATURES, RISKS AND MANAGEMENT OF WASTE

ELISA PARCERO **HERNANDES**[1], RODRIGO PAWLOSKI **SCHOFFEN**[1], HÉLIO **CONTE**[2]

1. Graduated in Biomedicine by State University of Maringá (UEM), MSc in Environmental Biotechnology State University of Maringá (UEM); **4.** PhD in Biological Sciences by State University of São Paulo Júlio de Mesquita Filho.

Colombo Avenue, 5790. Bloco H67 Sala 07, Maringá, Paraná, Brazil. ZIP CODE: 87020-900. hconte@uem.br

Received: 10/24/2016; **Accepted:** 12/14/2016

ABSTRACT

Improper disposal of laboratory waste is a neglected problem that can cause serious damage to the environment and therefore to humans. The management of this waste is carried out by means of specific legislation, waste management plans (SWMP), created by specific regulatory agencies for this purpose. Xylol, also known as xylene or dimethylbenzene, is a liquid naturally found in the oil but can also be synthesized from the same. It is primarily used as a solvent in addition to being used as a clarifying agent in histological slides. The objective of the study was to describe the main aspects related to the disposal of potentially hazardous waste to the environment, by focusing on the disposal and management of xylene at the State University of Maringa. The information was raised from online data media and scientific journals related to the topic. The findings allow a contribution to the proposition of management models for institutions, contributing further to the use, handling and proper disposal of these substances, as well as awareness of the risks to human and environmental health, it is also possible to evaluate the viability of alternatives presented like reuse, reduction and replacement of xylene, taking into account the acquisition costs and the impact caused by it.

KEYWORDS: Health, environment, recycling, xylene, residues, universities.

1. INTRODUCTION

The Since 1990, there has been an increase in discussions on the management of chemical residues in teaching and research laboratories in Brazil. During this period, the waste generated by the institutions was discarded in the laboratory sink without any concern. This improper disposal was responsible for environmental pollution, material waste and poor management of the synthesized or handled products. However, several federal, state and private institutions have created a new habit, and have been committed to managing and treating their waste, thereby reducing environmental impact[1].

The risk involved in the management of chemical substances makes it even more important to implement effective waste management programs, thereby reducing the risk of contamination of both workers dealing with this type of material and the environment. As a result of these facts, laws pertaining to environmental management in several countries have become more rigid by regulatory agencies[2]. In Brazil, there are several entities that regulate waste management, among which are the Brazilian Association of Technical Standards (ABNT), the National Sanitary Surveillance Agency (ANVISA), the National Environment Council (CONAMA) and the state and local governments[3].

According to the Agency for Toxic Substances and Disease Registry[4] xylol, also known as xylene or dimethylbenzene, is a liquid found naturally in petroleum but can also be synthesized artificially. It is primarily used as a solvent, in addition to being used as a clarifying agent being found in small quantities in aeronautical fuels and gasoline[4].

In Brazil, according to resolution nº 358, of April 29, 2005 of CONAMA, xylol is classified within group B, which are chemical substances that have the potential to cause health or environmental risks[5]. Since xylol Is a substance widely used mainly in paints, varnishes, dyes, pharmaceutical preparations, plastics production, petroleum industry and as solvents in laboratory analyzes, the knowledge of its correct treatment and disposal becomes an action of extreme importance[6]. The present work aims to describe the main aspects related to the disposal of potentially harmful residues to the environment, focusing on the disposal and management of xylol at the State University of Maringá.

2. MATERIAL AND METHODS

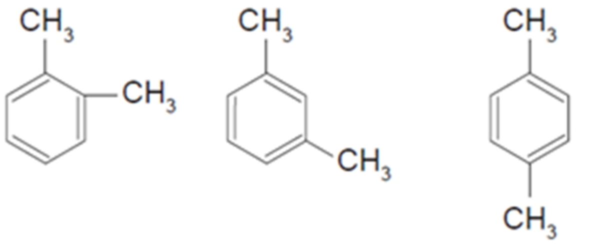
To perform the bibliographic review, online data, scientific journals and articles published between 1999 and 2016 were used.

The information described in the sources was organized and analyzed in order to describe the characteristics of xylol and its risk to health and the environment.

3. LITERATURE REVIEW

Characteristics of xylol and its use

According to the Merck Index (2001), xylene, also known as xylene or dimethylbenzene, represented in Figure 1, whose molecular formula is C8H10, is classified according to ABNT NBR 14725-2 as a flammable substance. It is a colorless liquid, poorly soluble in water, miscible with absolute alcohol, ether and other organic solvents.



1 2 3

Figure 1. 1-ortho-xylene; 2-meta-xylene; 3-para-xylene. **Source:** Merck Index, 2001.

There are three xylene conformations in which the methyl groups vary in the benzene ring: meta-xylene, ortho-xylene and para-xylene (m-, o-, and p-xylene), such forms called isomers. Xylene is a synthetic chemical produced from petroleum[4], it is widely used as solvent for paints, varnishes, dyes, dyes, pharmaceutical preparations, plastics production and in the oil industry. In addition to being widely used in clinical analysis laboratories, hospitals and laboratories of pathological anatomy, this compound is handled during the process of diaphanization of the histological slides, acting on the removal of alcohol, making the tissues translucent and improving the penetration of paraffin[6,8,9].

Risks to health and the environment

Because xylene is very volatile, the airway is usually the most common route of exposure, where concentrations of 0.08 to 3.7 parts of xylene per million parts of air (ppm) can already be detected. Composed by the human olfactory system. Exposure can also occur through ingestion of contaminated food and water, in addition to direct contact with the skin[4, 10].

Before being excreted, this compound undergoes biotransformation, that is, oxidation of one of the methyl groups with the formation of methylbenzoic acid occurs, which after conjugation to glycine, is excreted in the urine as methylhippuric acid[6].

The three isomeric forms of xylene have very similar effects during intoxication. Short-term (<14 days) exposure to high levels of xylene may cause irritation to the skin, eyes, nose and throat, respiratory distress, delayed response to visual stimuli, Of memory, stomach discomfort in addition to damage to the liver and kidneys[4]. Most known information on the health effects of humans exposed to xylol for long periods of time were obtained from studies with workers in the paint and solvent industries, exposed to levels of xylene present in the air much larger than the levels normally found in the environment[4].

Effects on the CNS

Both short- and long-term exposure (> 365 days) at high concentrations of xylene can cause a number of effects on the nervous system, such as headaches, lack of muscle coordination, dizziness, confusion, changes in the sense of Balance and depression of the central nervous system. Such effects occur after exposure to xylene concentrations greater than 100 parts per million (ppm), in addition, the effects worsen as the concentration of the compound increases during the exposure, as shown in Table 1[4, 11].

Table 1. Effects caused by xylene in the CNS.

Concentration of Xylene (ppm)	Symptoms
100 - 200	Nausea and headache
200 - 500	Dizziness, weakness, irritability, Vomiting, decreased reaction time.
800 - 10.000	Mental confusion, slurred speech, loss of balance, ringing in the ears.
> 10.000	Drowsiness, loss of consciousness and death.

Source: Kandyala *et. al,* 2010.

Liver and Kidneys

After severe exposure, the compound may cause reversible damage to the kidneys and liver, but such changes are more difficult to perform because the first symptoms affect the CNS, that is, causes the exposed individual to seek help or be rescued by stopping the exposure and consequently damage to these organs[11].

Effects on the hearing aid

Xylene can also cause functional problems and degeneration of the sensory organs present in the inner ear, especially in the nerve fibers of the cochlea and the vestibular apparatus (ototoxicity)[12].

Effects on pregnant women

Xylene inhaled by a pregnant woman can reach the fetus in addition to contaminating her breast milk during the breastfeeding period[11], so the author reports that it is recommended that pregnant and nursing women minimize their exposure[11,13]. Still according to the author, xylene can produce fetotoxic effects such as delayed ossification.

Effects on eyes, nose and mouth

Concentrations greater than 200 ppm after 5 minutes of exposure may cause irritation of the nose and throat. Direct contact with the eyes can cause damage to the ocular surface[11].

Effects on gastrointestinal tract

Exposure to xylene vapors may cause nausea, vomiting and abdominal discomfort[11].

Skin Effects

Solvents such as xylol can degrade the lipid layer present in the epidermis, so prolonged contact with this compound can cause dermatitis, dryness and peeling of the skin, and burns if it becomes impregnated with gloves and clothing[11].

Effects on the environment

Currently, most of the population is exposed to some kind of solvent at work or at home, however, the number of workers regularly exposed to solvents is greater [12]. According to Costa *et al*. (2007)[6], the majority of employees of pathology and cytology laboratories do not know the risks caused by this compound, showing that only 6.6% of the interviewed workers checked the presence of xylol in the organism, by the dosage of Urinary methylhippuric acid. In this same study, it was evidenced the lack of proper manipulation and disposal of xylol. In addition, most laboratories discard waste from xylol in the sink which is harmful not only to the sewage system but also to the environment 6, evidencing negligence in relation to this compost.

Xylene can contaminate the environment during its manufacturing process, packaging, transportation, use or during its disposal, especially when inappropriate. Most of the xylene that is released into the environment evaporates into the atmosphere and can discharge into the soil, surface water (streams, streams and rivers) and groundwater in cases of persistent spills[4]. As xylene is very volatile, most of this compound is found in the atmosphere where it is broken by sunlight into other less harmful chemicals within a few days, for this reason, xylene is rarely found in high concentrations in soil or water (River, streams), unless a recent leak or continuous contamination has occurred. Still on the ground, non-evaporating xylene can penetrate groundwater and remain for several months before being finally degraded by microorganisms, yet very small amounts are absorbed by plants, fish and birds[4]. However, there are few studies on The concentrations and presence of xylene in soil and water.

According to the information provided to date, the risk of exposure to xylene is more frequent in industrial parks, followed by their presence in the atmosphere from the burning of fossil fuels, and less likely to be found in soil or aquatic collections. In addition, such a compound can also be classified in the group of volatile organic compounds (VOC's), already reported in studies carried out on residential buildings[14,15].

Legislation and waste generation programs

Resolution RDC 306 of December 2004 of ANVISA defines as health service waste generators (RSS) all services related to the care of human or animal health, including home care services, field work, product analytical laboratories For health, mortuary, funerary and services where embalming activities are carried out (tanatoprax and somatoconservation), legal medicine services, drugstores and pharmacies including manipulation, health education and research establishments, zoonosis control centers, distributors of pharmaceutical products, importers, distributors and producers of materials and controls for in vitro diagnostics, mobile health care units, acupuncture services, tattoo services, among others. In addition, it classifies the RSS into five groups, which are: A, infectious waste, this, subdivided into five groups (A1, A2, A3, A4 and A5); B, chemical residues; C, radioactive tailings; D, common or household waste; And group E, the sharps[16]. As in ANVISA's legislation, CONAMA Resolution No. 358, of April 29, 2005 also classifies in this way, and xylol is classified in group B, which are chemical substances that may present risks to public health or the environment environment[17].

Another classification in the legislation, the NBR 10004 of ABNT, where garbage or solid waste is defined as being the result of human activities, being able to present risks according to its dangerousness and the potential of risk offered to the environment and public health. This standard classifies solid waste according to the potential risks to health and the environment, such as: Class I or Hazards, wastes that have one or more characteristics such as: flammability, corrosivity, reactivity, toxicity or pathogenicity; Class II or non-hazardous, subdivided into A (non-inert waste), are residues which may exhibit properties such as: biodegradability, combustibility and water solubility; And B or inert, which are rocks, glasses, certain plastics and rubbers, so xylol is classified in class I of hazardous waste[17].

In addition, the regulatory standard, NR-15, which deals with unhealthy activities, in Annex 11 where chemical agents are described, whose insalubrity is characterized by tolerance limit and inspection in the workplace, in this case xylene offers an average degree Occupational exposure limit is 78 ppm (parts per million) or 340 mg/m^3 for up to 48 h per week. Xylene is a compound that can be absorbed by the skin, this recommendation is now already present in the Brazilian Legislation, in the updated NR-15, but there is no recommendation regarding the ototoxic potential of this compound. In this context, the use of xylol in histopathological laboratories, especially in university laboratories, should take into account NR's 6, 7, 9, 15 and 32 (EPI, Occupational Health Medical Control Program, Environmental Risk Prevention Program, Unhealthy Activities and Operations, and Health and Safety at Work in Health Services, respectively)[10]. Regarding the disposal of this waste, Resolution No. 358 of 29 April 2005 and Resolution No. 283 of 12 July 2001 of CONAMA deal with the final disposal and treatment of such waste. Therefore, these should be submitted to specific treatment and final destination according to their hazardous characteristics. Where they are not subject to a re-use, recovery or recycling process, they must undergo specific treatment and final disposal[17]. Therefore, for the disposal of these residues there are some minimum criteria regarding the location, and the selection of the disposal area should have restrictions regarding the environmental zoning, that is, it should be away from conservation units or related areas; Must respect the minimum distances established by the competent environmental bodies of fragile ecosystems, surface and underground water resources. Also regarding safety and signaling, you must have an access control system for vehicles, unauthorized persons and animals, under continuous surveillance and warning signs with educational reports regarding the hazards involved. In addition, in terms of technical aspects, the site should have rainwater drainage systems, proper collection and disposal of percolates, collection of gases, waterproofing of the base and embankment, and environmental monitoring[17]. Regarding the process of final disposal of health services waste (RSS), the disposition of the waste should happen directly on the bottom of the site, its accommodation should occur without direct compaction, daily coverage with layering soil[20].

According to resolution RDC 306/2004[16], waste management encompasses a set of management procedures to be planned and implemented from scientific, technical, regulatory and legal bases, in order to minimize the generation and provide waste generated secure routing, performed efficiently, aiming, in addition to the protection of human health, the preservation of the environment. The concept of waste management involves activities such as strategic decision-making involving political institutions, instruments and means for this purpose. Therefore, when applied and monitored, the management of Health Services Waste (SSR) has a significant impact on the generation indices and, consequently, the inherent risks of residues as well as the costs with the management[21]. As teaching and research institutions generate small amounts of chemical waste compared to industries, they are treated as non-impacting activities by environmental protection agencies and are therefore poorly audited[22]. The occasional use, sometimes constant within the routine of the institutions, of these solvents, generate chemical residues of different degrees of danger, and may require adequate physical, chemical-chemical or chemical treatment before being sent to the final disposal[1]. The xylol is among one of the chemical residues most generated by health institutions[21]. Due to its hazardous characteristics, good waste management within the university is essential, since the responsibility of implementing a disposal process that preserves the safety of users and the environment, verifying who generates the chemical residue, minimizing the generation, recovering the waste when possible and promoting the correct disposal is of its generators[21]. As institutions that have the commitment to train professionals, educational institutions must then be models of public policies for environmental preservation with sustainable practices and supported by current norms[23].

In this context, the State University of Maringá (UEM) has a well-established waste management program, and the company " Serquip Waste Treatment PR Ltda " is responsible for collecting, transporting, treating and disposing of waste The Health Services of the University Hospital (HUM) and the teaching and research laboratory (LEPAC) of the State University of Maringá. The other wastes generated by other university laboratories follow the procedures adopted by PRÓ-RESÍDUOS[24]. The policies adopted by the UEM Campus are: environmental education program, with personnel training, lectures and courses; recycling and handicraft workshops, selective collection with recyclable waste donation to cooperative waste collectors, composting, incineration on the campus of animals used in teaching and research laboratories, maintenance of a chemical waste station, provision of environmental project services[24]. In the University Hospital of UEM, the policies adopted were the institutionalization of a specific sector for the management of health services waste, environmental education and training of personnel[24]. Only the chemical residues generated by the EMP Clinical Analysis and Research Laboratory (LEPAC) have a disposition cost that ranges from R $ 38,000.00 to 10,000 kg of waste. Using other alternatives could reduce the amount of waste generated and the costs.

Reuse of xylol and Reduction of use

For an improvement in waste management systems a good strategy would be the reuse of these solvents. According to Manfredini (2014)[21] organic solvents such as xylol can be reused by distillation techniques, preceded by a cleaning and followed by a purity analysis, as demonstrated in the study by Levada (2008)[8], which obtained effective results in the recovery of xylol by treatment by fractional distillation. After distillation the recovered xylol is characterized by refractive index measurements and ultraviolet spectroscopy analyzes. They also showed that the recovery and recycling of xylene provides great benefits to the environment, both by reducing the volume of waste disposed and by saving in the acquisition of new products[8]. With these processes, it is also possible to reuse up to 80% of the volume of xylene Which would be neglected in the environment, with a higher degree of purity than initially acquired. Therefore, the reuse of xylol would provide benefits such as environmental education, recovery of alcohol and paraffin used, production of a product of higher quality than commercially purchased, as well as saving the incineration of the product, which generates compounds such as dioxins and furans, Harmful to the environment[25].

It is also possible to reduce the use of this substance in the study of Cazari *et al.* (2013)[26] the structural quality and microscopic visualization of different human tissues submitted to a histological processing in hematoxylin and eosin (HE) staining were evaluated, reducing the use of xylol solvent, the author observed that the histological slides of epithelial tissue , Liver, gallbladder and uterus, prepared without the use of xylol in the final diaphanization stage, presented no differences when compared to laminae of the same tissues, routinely processed, using xylol in the diaphanization process. In another study, Falkeholm *et al.* (2001)[27], Xylol was removed from other stages of histological processing, thus, the quality of blades stained in HE and periodic acid-Schiff (PAS) were smaller, with 74% of the slides being as good as those using xylol. Further, in the study by Dergovics *et al.* (2012)[28], it was evaluated the efficiency of the use of a varnish and xylol mixture for the assembling of buccal and cervico-vaginal cytological slides after Papanicolau staining. The material was submitted to this staining, with changes only in the stage of assembly of the slides, where they were divided into five groups with the different proportions of the varnish and xylol mixture, being: 75% / 25%, 70% / 30% 60% / 40%, 50% / 50% and 40% / 60%. Thus, the group that maintained the quality of the biological material and showed good results was the ratio of 75% of varnish to 25% of xylol.

Other studies have attempted to demonstrate the possible substitution of xylene in sheet Buesa & Peshkov (2009)[29] who studied the use of some compounds to replace xylol, such compounds, derived from vegetable oils such as D-limonene and cyclic terpene, found in citrus fruits. However, the slides where the vegetable oils were used did not maintain the quality of the tissues, as well as being able to induce health problems and cost higher than that of xylol. Another study with the same objective is that of Chen *et al.* (2010)[30], who attempted to replace xylene with propylene glycol methyl ether, in HE, PAS, Masson trichrome stains and the Gordon/ Sweet silver staining method, it can be seen from the tests performed that the quality of the blades Was maintained. This substitute was also efficient in immunohistochemical processing for actin, CD3, CD4 and Ki-67. The reagent also has low toxicity when compared to xylol. Another alternative that can be used, according to Buesa & Peshkov (2011)[31] is the use of isopropanol (2-propanol) mixed or not with paraffin and mineral oil, can be a good alternative to xylol, since it presents lower toxicity and cost. This also occurs in the substitution of xylol for n-heptane during the processing of HE-stained and Masson's trichrome blades. However, the study by Premalatha *et al.* (2013)[32], showed that the substitution of xylene by refined mineral oil, in the dewaxing step, was efficient and cost-effective. Also in this same context, in a more recent study by Adeniyi *et al.* (2016)[33], slices of wood sections were compared using palm kernel oil, coconut oil, peanut oil, xylol and clove oil, it was observed that palm kernel, coconut and peanut oils clarified the slides as well as xylol and clove oil. Being able to be good substitutes since they present less danger and also lower cost.

4. CONCLUSION

Through this study, it is possible to make some proposals that may be of future studies objects. Bringing contributions to the proposition of management models for institutions, thus contributing to the use, handling and proper disposal of these substances, as well as awareness of the risks to human and environmental health. By means of this information it is also possible to evaluate the technical, economic and environmental alternatives presented reuse, reduction and replacement of xylene, taking into account the acquisition costs and the impact caused by it. It would be applicable to analysis of continuous exposure to chemicals, in the case of technical and occasionally in the case of students, verifying the presence of the hippuric acid in urine and to assess the potential harmful effects of long-term, and enhance the use of equipment personal protection (EPP) specific for the substance mentioned in the study, and fabricate risk maps in handling volatile products in order to prevent labor implications.

REFERENCES

[1] Afonso JC; Noronha LA; Felipe RP; Freidinger N. Gerenciamento de Resíduos Laboratoriais: Recuperação de Elementos e Preparo para Descarte final. Quim. Nova 2003; 26(4):602-611.

[2] Gil ES, Garrote CFD, Conceição EC, Santiago MF, Souza AR. Aspectos técnicos e legais do gerenciamento de residuos quimico-farmacêuticos. Rev. Bras. Cienc. Farm. 2007 Jan./Mar.; 43(1):20-29

[3] Penatti FE, Lima-Guimarães ST. Avaliação dos riscos e problemas ambientais causados pela disposição incorreta de resíduos de laboratórios. Geografia ensino & pesquisa 2011 Jan./Abr; 15(1):43-52.

[4] Agency for Toxic Substances and Disease Registry (ATSDR).

Toxicological Profile for Xylenes. Atlanta, GA: Public Health Service, U.S. Department of Health and Human Services; 2007.

[5] Brasil. Conselho Nacional do Meio Ambiente. Resolução n° 358, de 29 de abril de 2005. Dispõe sobre o tratamento e a disposição final dos resíduos dos serviços de saúde e dá outras providências. Brasília, DF. Ministério do Meio Ambiente, abril de 2005. Disponível em: <http://www.mma.gov.br/port/conama/res/res05/res35805.pdf >. Acesso em: 01 ago. 2016.

[6] Costa KNS, Pinheiro IO, Calazans GT, Nascimento MS. Avaliação dos riscos associados ao uso do xilol em laboratórios de anatomia patológica e citologia. Rev. bras. saúde ocup. [online] 2007; 32(116):50-56.

[7] O'Neil M.J., Heckelman P.E., Koch C.B., Roman K.J. The Merck Index: An Encyclopedia of Chemicals, Drugs, Biologicals. Whitehouse Station (NJ): Merck & Co, 2001.

[8] Levada JC. Gestão e gerenciamento de residuos quimicos e aplicação da tecnologia de destilação na recuperação de solventes orgânicos: estudo de caso da reciclagem do xileno. [Dissertação] São Carlos: Universidade de São Paulo; 2008.

[9] Junqueira CL, Carneiro J. Histologia Básica. 10. ed. Rio de Janeiro: Guanabara Koogan, 2004.

[10] Okamoto AC, Simões AM, Teixeira AJ, Piedade ALM, Santos LT. Condições de uso, manuseio, armazenamento e descarte de xilol em laboratórios de Patologia e Histologia: uma abordagem multidisciplinar. [Monografia] Araraquara: Universidade Estadual Paulista "Júlio de Mesquita Filho"; 2010.

[11] Kandyala R; Raghavendra SPC; Rajasekharan ST. Xylene: An overview of its health hazards and preventive measures. J. Oral Maxillofac. Pathol 2010 Jan/Jun; 14(1):1-5.

[12] Bertoncello L. Efeitos da exposição ocupacional a solventes orgânicos, no sistema auditivo. [Monografia] Porto Alegre: Centro de especialização em fonoaudiologia clinica; 1999.

[13] Niaz K. A review of environmental and occupational exposure to xylene and its health concerns. Excli Journal 2015, 14:1167-1186.

[14] Zabiegala B, Namiesnik J, Przyk E, Przyjazny A. 1999. Changes in concentration levels of selected VOCs in newly erected and remodeled buildings in Gdansk. Chemosphere 39(12):2035-2046.

[15] Hodgson AT, Rudd AF, Beal D, Chandra S. Volatile organic compound concentrations and emission rates in new manufactures and site-built houses. Indoor Air 2000 10:178-192.

[16] Brasil. Agência Nacional De Vigilância Sanitária. Resolução RDC n° 306, de 07 de dezembro de 2004. Dispõe sobre o Regulamento Técnico para o gerenciamento de resíduos de serviços de saúde. Brasília, DF. Ministério da Saúde, 2004.

[17] Brasil. Conselho Nacional do Meio Ambiente. Resolução N° 358, de 29 de abril de 2005. Dispõe sobre o tratamento e a disposição final dos resíduos dos serviços de saúde e dá outras providências., abril de 2005. Disponível em: <http://www.mma.gov.br/port/conama/res/res05/res35805.pdf >. Acesso em: 01 ago. 2016.

[18] ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS – ABNT. NBR 10.004: Resíduos sólidos – Classificação. Rio de Janeiro, ABNT, 2004.

[19] Brasil. Ministério do Trabalho e Emprego. *Norma Regulamentadora n° 15*: atividades e operações insalubres. Disponível em: http://www.ccb.usp.br/arquivos/arqpessoal/1360237303_nr15atualizada2011ii.pdf. Acesso em: 01 ago. 2016.

[20] Brasil. Conselho Nacional do Meio Ambiente. Resolução N° 283 de 12 de julho de 2001. Dispõe sobre o tratamento e a destinação final dos resíduos dos serviços de saúde. Brasília, DF. Ministério do Meio Ambiente, abril de 2001. Disponível em: <http://www.mma.gov.br/port/conama/legiabre.cfm?codlegi=281 >. Acesso em: 01 ago. 2016.

[21] Manfredini KL. Estado atual e proposta de melhorias no gerenciamento de residuos de glutaraldeido, xilenos e formaldeido em um hospital escola e em um laboratorio universitario de anatomia. [Dissertação] Caxias do sul: Universidade de Caxias do Sul; 2014.

[22] Cardoso RS, Souza TAS, Brasileiro JLO, Holanda HD, Cardoso RS. Gerenciamento de resíduos químicos gerados nos laboratórios do Centro de Tecnologia da Universidade Federal da Paraíba. In: I SECITEAC – Semana de Ciência e Tecnologia, Esporte, Arte e Cultura, 2010, João Pessoa. Anais do XIII Encontro de Iniciação a Docência e do XII Encontro de Extensão. João Pessoa: Editora Universitária, 2010.

[23] Braga LO, Souza RR, Soares WA.Resíduos Químicos Gerados em Serviços de Saúde: Um Despertar Necessário. Revista Diálogos – Revista de Estudos Culturais e da Contemporaneidade, 2012; 6:207-220.

[24] Sartor MJ. Politicas de gerenciamento de residuos na Universidades Estaduais Publicas Paranaenses. [Dissertação] Londrina: Universidade Estadual de Londrina; 2010.

[25] Albertini LB, Honorio DH. Tratamento de Resíduos de Xilol utilizado em Laboratórios Histológicos e Citopatológicos. In: 17° Simposio internacional de iniciação cientifica; 2009; nov 6; São Paulo: SIICUSP; 2009.

[26] Cazari VR, Pereira TR, Romera AM, Brandão MC, Filho CZ, Favareto APA. Redução do uso do xilol na técnica de coloracão hematoxilina e eosina. Colloquium Vitae jul/dez 2013; 5(2):135-148.

[27] Falkeholm L, Grant CA, Magnusson A, Moller E. Xylene-free method for histological preparation: a multicentre evaluation. Labor Invest. 2001;81(9):1213-1221.

[28] Dergovics FL, Moura TPS, Shirata NK, Pereira SMM. Avaliação do desempenho da mistura verniz/xilol na diafanização de lâminas de citopatologia coradas com a técnica de Papanicolaou. Rev Bras Análises Clín. 2012; 44(1):35-38.

[29] Buesa RJ, Peshkov MV. Histology without xylene. Ann Diagnostic Pathol. 2009; 13(4):246-256.

[30] Chen C, He T, Mao XL, Friis TE, Qin RH, Jian YT. A novel xylene substitute for histotechnology and histochemistry. Biotech Histochem. 2010;85(4):231-240.

[31] Buesa RJ, Peshkov MV. Complete elimination of xylene in practice of a histology laboratory. Arkhiv Patologii. 2011; 1:54-60.

[32] Premalatha BR, Patil S, Rao RS, Indu M. Mineral oil - a biofriendly substitute for xylene in deparaffinization: a novel method. J Contemp Dental Pract. 2013;14(2):281-286.

[33] Adeniyi IM, Adejoba RO, Akinlabi FM, Alao OJ. Vegetable Oils as Clearing Agents. Achievements In The Life Sciences Jun 2016. 10(1):1-4.