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Evaluation of Chemical Residues Originated from Automatic Hematological Analyzers in the Municipality of Guarulhos, State of São Paulo, Brazil

ORIGINAL

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Abstract

Introduction: If incorrectly managed, dangerous chemical residues produced by clinical analysis laboratories are worrisome. These residues can represent serious environmental and human health hazards if disposed improperly in the sewage system. Currently, the laboratories take over strategies with the potential to minimize the negative environmental impacts and public health risks. To demonstrate the current scenario and contribute to the sustainable development of these laboratories, it is necessary to evaluate the toxicity of hematological equipment´s chemical residue effluents.

Methods: A questionnaire was addressed to employees of 15 clinical analysis laboratories of the Municipality of Guarulhos, São Paulo/Brazil. All these laboratories dispose the hematological equipment's residues into the sewage system. The objective of the questionnaire was to appraise the daily average hematological exams performed in 2012. Through the data collected with equipment suppliers and analysis of the concentration of dangerous chemical residues diluted in the municipal sewage network, it was possible to calculate the volume of dangerous chemical residues generated by this equipment.

Results: The data showed a daily average of 2,800 examinations per laboratory, generating a daily disposal of 131,600 mL of chemical residues. Only formic acid was identified as dangerous chemical residue. About 1,680 mg per day of this residue is disposed. Diluted in the average daily sewage volume of 32,500 m^3, it represents a concentration of 0.052 mg/m^3 or 5.2 x 10-5 mg/L.

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Conclusion: Despite the large volume of chemical residues generated by hematological analyzers and disposed into the sewage system of Guarulhos, the data indicates low toxicity concentration in the sewage system. Therefore, there is no evidence of enough toxic residues to be responsible for creating environmental risks.

Keywords
Health Services Residues; Dangerous Residues; Formic Acid; Environmental Health.

Introduction

After industrial revolution, society's new consumption patterns caused a continuous increase of residues production, reaching levels beyond nature's capacity to decompose. Furthermore, there is an increasing product diversity, made of materials difficult to be degraded and with greater toxicity. In this scenario, municipalities have difficulty to implement and manage their solid wastes and fulfill all requirements for the environmental licensing process, making the final disposal of these residues even tougher [1].

According to Conselho Nacional do Meio Ambiente: CONAMA: *National Environmental Council*, if inappropriately managed, solid residues are a threat to the public health and worsen the environmental degradation, compromising the life quality of the population [2].

Aiming at a proper management, ABNT 10004/04 Technical Standard *ABNT: Brazilian Association for Technical Standards]* [3] and Politica Nacional dos Residuos Sólidos PNRS: *National Solid Waste Policy*, Law No. 12305/2010 [4] classify solid wastes by their function and origin: domestic, urban cleaning, commercial establishments, service providers, industries, health care, public sanitation services, agro-forestry & animal husbandry activities, among others. As for the solid wastes hazard assessment, the waste is classified as dangerous residue (Class I) and non-dangerous residue (Class II) [3, 4]. The dangerous residues present one of the following characteristics: flammable, corrosive, reactive, toxic or pathogenic.

As for Health Service Residues: RSS: *Resíduos de Serviços de Saude,* although they only represent 1% of the produced solid waste, several authors widely discuss about the real size, risk level and how to handle these residues. This concern is based on the RSS's infecting potential. There is great risk for disease transmission by inadequate handling [5] these type of residues and their toxicity can cause negative environmental impacts and public health risks [5, 6], if they are incorrectly discarded.

According to the Collegiate Directory Resolution RDC*: Resolução de Diretoria Colegiada,* 306/04 of the National Health Surveillance Agency, ANVISA*: Agência Nacional de Vigilância Sanitária* [7], the companies generating health service residues RSS include all those engaged in the area of human and animal health. This definition comprises health products analytical laboratories, educational and research establishments in the health industry; pharmaceutical product distributors, importers, material manufacturers and controllers for *in vitro* diagnostics, mobile healthcare units; among others [4, 7].

In accordance to RDC ANVISA 306/04 [7] and CONAMA Resolution 358/05 [2], the RSSs are classified by their characteristics and potential risks to environment and health. This paper evaluates the handling and final disposal of RSS. The characteristics of each group, as well as their subdivisions, are described in **Table 1** and **2** [2, 7].

Despite the clear need to handle RSS residues, only producers of large volume of residues are monitored by competent government agencies. Small volume generators, like laboratories for physical,

Table 1. Health Services Residues Classification and Treatment, based on their characteristics.

Classification	Characteristics	Treatment
Group A Infectants	Residues posing potential public health risks & environmental hazards due to the presence of biological agents	Microwave, incineration
Group B Chemicals	Residues posing potential public health risks & environmental hazards due to their chemical characteristics	Recycling, incineration, specific disposal
Group C Radioactive	Radioactive rejects: fit into this group the radioactive materials or the contaminated with radionucleotides from clinical analysis labs, nuclear medicine services and, radiotherapy	As per CNEN guidance. CNEN: Nat'l. Nuclear Energy Council
Group D Regular/Unsorted	Harmless residues to public health and to the environment in regards to biological, chemical or radiological risks	Composting or sewers.
Group E Perforating/Cutting & Sharps	Residues containing perforating/cutting/sharp materials like needles, glass vials/ampoules, etc.	Bacterial inactivation as per Group A

Source: Adapted from ANVISA-RDC 306/04 [7], CONAMA Resolution: 358/05 [2].

Table 2. Residues classified in Group B, as per CONAMA Resolution 358/05.

Residues in Group B
Hormonal products and antimicrobial products; cytostatics; antineoplastic; immunosuppressives; digitalis; immunomodulators; antiretroviral, if discarded by health services, pharmacies, drugstores and distributors of drugs or seized and pharmaceutical waste and supplies of prescription drugs by Order Ministry of Health (MOH) 344/98 and its updates.
Residues from sanitizing products, disinfectants; residues containing heavy metals; lab reactants and, their contaminated containers included,
Effluents from image processing (developing and fixing agents)
Effluents from automatic clinical analysis equipment
Other products considered dangerous, according to ABNT: NBR 10004 (toxic, corrosive, flammable, reactive)

Source: Adapted from CONAMA Resolution 358/05 [2].

chemical and biological analysis are not inspected on how they discard their chemical residues. However, although these laboratories are responsible for a small part of the residue disposed, they produce high-risk residues, demanding special and expensive final destination to comply with environmental regulation [8].

According to current legislation and technical standards, the ANVISA RDC 306/04 and the CONAMA 358/05 Resolution determine the process to manage RSS and classify the effluents from automatic equipment as high-risk chemical residues [2, 7, 9]. This definition is further supported by the technical standard of the São Paulo State Environmental Protection Agency, CETESB: *Companhia Ambiental do Estado de São Paulo,* P4.262 [10]

The management of Dangerous Chemical Residues, RQP: *Resíduos Químicos Perigosos,* generated from the RSS should be prioritized by municipalities, once they are a major source of serious problems to workers and public health [11]. The majority of the professionals at clinical analysis laboratories accept the responsibility for the residues. Nevertheless, they assume that they do not know the proper way to handle these residues. Many of them dispose their diluted residues with their wastewater, which is directly discharged into the sewage system network [1].

According to CONAMA's Resolution 430/11, art.16, §3, which prescribes sanitary standards, effluents coming from health services may be discharged into a system connected to a wastewater

treatment station or, after a special treatment, directly into the wastewater system. In these cases, CONAMA's Resolution art. 23 regulates that the local environmental agency must request effluents' ecotoxicity tests for the wastewater treatment systems [12].

In this scenario, there is a need to evaluate the toxicity of the hematologic chemical residues discarded into the sewage system. The evaluation can contribute to demonstrate the current situation. Additionally, it serves as input to the development and standardization of technologies, which contributes to minimize the environmental impact generated by the clinical analysis laboratories.

The study performed was descriptive and exploratory, with a quantitative and qualitative approach. The main goal was to assess the characteristics and properties of the chemical residues generated by automatic hematological analyzers.

Methods

The authors designed a survey and submitted it to the 15 clinical analysis laboratories in the Municipality of Guarulhos - State of São Paulo (Brazil). Guarulhos has the 13th greatest population in Brazil, with 1,2MM inhabitants, and is de 13th greatest economy in Brazil, among all Brazilian municipalities. All 15 laboratories responded to the survey. The totality of them discharge their chemical residues in the municipal sewage network. The labs not surveyed in the Municipality are only operating as collecting units, forwarding their samples to be processed in other municipalities, in the same State. The name confidentiality was assured at all surveyed establishments.

Through a questionnaire submitted to the responsible employees of each one of the surveyed laboratories it was possible to calculate: (1) the daily average number of hematological exams performed in 2012; (2) the hematologic reagents used in the automated hematologic analyzers and their concentration; and (3) the quantity of chemical residues for each blood test, (informed by the suppliers of hematological reagents).

The daily average concentration of toxic residues originated from the hematological analysis equipment and discarded into the sewage system was calculated by dividing the daily average volume of total toxic residues discarded into the Guarulhos sewage system by the daily sewage volume collected in 2012.

Results

In 2012, the 15 laboratories together performed an average of 2,800 hemograms per day **(Table 3)**. Based on the information given by the blood tests

Table 3. Year 2012 twelve months period daily average from clinical analysis laboratories.

Laboratory	Daily average number of clinical analysis												Daily Average
	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	
1	4095	4059	4170	4107	4158	4129	4200	4191	4138	4149	4158	4158	4143
2	3689	3655	3646	3645	3666	3641	3645	3666	3695	3702	3646	3684	3665
3	2445	2448	2458	2467	2454	2435	2467	2397	2469	2485	2477	2458	2455
4	3299	3224	3313	3328	3267	3279	3223	3335	3345	3358	3324	3329	3302
5	2867	2966	2987	2985	2990	2984	2979	2593	2639	2667	2649	2654	2830
6	2595	2515	2640	2680	2676	2698	2679	2626	2934	2860	2889	2896	2724
7	2520	2490	2556	2534	2532	2558	2567	2535	2589	2609	2645	2569	2559
8	2770	2758	2896	2908	2979	2996	2992	2996	2978	2978	2977	2986	2935

Laboratory	Daily average number of clinical analysis												Daily Average
	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	
9	2906	2907	2998	2996	2982	3016	3094	3026	3017	3013	3006	3005	2997
10	2964	2947	2995	2996	2969	2986	2989	2978	2945	2976	2956	2399	2925
11	1482	1974	1976	1569	1985	1493	2090	2083	2068	1488	2077	2067	1863
12	1453	1489	1499	1498	1491	1508	1547	1513	1508	1516	1509	1505	1503
13	2906	2977	2998	2996	2982	3016	3094	3026	3010	2976	3006	3005	2999
14	2975	2980	3115	3190	3167	3286	3179	3181	3203	3199	3199	3192	3156
15	1852	1875	1988	2002	1989	1896	1957	1899	1968	1993	1968	1959	1946
Daily average													2800

reagent suppliers, **Table 4** describes the substances in the reagents used to process the exams. Moreover, **Table 4** presents the concentration of the substances and the chemical residues per exam. The totality of the chemical residues produced by the automatic hematologic equipment was discarded into Guarulho´s sewage system.

Table 4. Hematological reagent quantity per analysis.

Reagent	Substance in Reagent*	Concentration*	Quantity per Analysis*
		g/L	mL
A	Sodium Sulfate	15.0	45.0
	Sodium Chloride	10.0	
B	Ammonia Salts	40.0	1.0
	Sodium Sulfate	20.0	
C	Formic Acid	1.2	0.5
	Calcium Carbonate	6.0	0.2
	Sodium Chloride	14.5	
	Sodium Sulfate	31.3	
Sample	Blood & EDTA -		0.3
	Total residues per analysis		47
	Total residues in 2800 analysis		131,600
*: data informed by hematological reagents supplier			

According to the safety data sheet of the reagents, none of them contains dangerous components, exception made to reagent C, which contains formic acid **(Table 4)**.

In this study, with a daily average of 2,800 blood exams made at the clinical analysis laboratories, the authors quantified the volume of residues discarded in the sewage system. Formic acid **(Table 5)** is the sole dangerous residue discarded.

The formic acid was diluted in the total volume of sewage collected in the municipality along 2012, which was 11,710,000 m^3/year, with a daily average of 32,082 m^3 [16]. The average daily formic acid concentration in the sewers was 0.052 mg/m^3 or 5.2 x 10-5 mg/L **(Table 6)**.

Table 5. Daily quantity of formic acid disposed into the sewer system.

Toxic Reagent	Volume per hemogram*	Total number hemograms	Total volume of disposed residues	Concentration of formic acid/L*	Disposed Volume of formic acid
Formic Acid	0.5 mL	2,800	1,400 mL/day	1.2 g/L	1.68 g/day
*: data informed by supplier					

Table 6. Daily quantity of formic acid disposed into the sewer system.

Formic acid quantity	Sewer system daily volume	Toxic residue dilutionin the sewers
1,680 mg/day	32,082 m³	0.052 mg/m³

Discussions

The only dangerous chemical residue found was formic acid. It is a corrosive substance, with a strong odour and generates dangerous vapors. If the vapour is inhaled, it causes problems in the respiratory tract, eye and skin irritation. If formic acid is ingested, it causes severe and painful ulcers in the digestive tract and nausea. Extended exposure to it can cause liver and/or the kidney damage [13, 14].

Furthermore, if found in high concentration, formic acid can cause severe environmental risks. Because it is biodegradable, it can contaminate sewers, rivers, streams and other water bodies. Its ecotoxicity in aquatic organisms has a broad range of variations, depending on the species, time of exposure and habitat. For instance, in fishes, the disturbing level for the *Truta Iridea* is 1mg/L in 24hrs and for the *Lepomis macrochirus* is of 5.000mg/m³ in 24hrs in salt water and, 175.000 mg/m³ in 24 hrs in continental waters. In crustaceans, the disturbing level for the *Daphnia sp* is 120.000 mg/m³, with non-specified exposure time and for the algae *Scenedesmus sp* is 100.000 mg/m³, without specified exposure time [15].

For humans, the American Occupation Safety and Health Administration (OSHA) determined the exposure limit to the formic acid at 9 mg/m^3 for an average period of 8 hours [14]. At CETESB, the environmental agency of São Paulo State, the ecotoxicological information referring to humans is not available [15].

However, formic acid is only dangerous if found in high concentration. The calculated concentration of formic acid disposed in Guarulho´s sewage system by automatic hematological equipment was 0.052 mg/m³. Based on the ecotoxicology criteria established by CETESB and in accordance with the CONAMA Resolution 430/11At, the concentration of chemical residues produced by the automatic hematologic equipment has no potential to cause toxic effects to the aquatic environment. The ecotoxicology criteria is based on the results of ecotoxicological tests, with a minimum of two different trophic levels of aquatic organisms [12]. Therefore, the residues disposed in Guarulhos´ sewage system is not considered a risk to the environment.

Conclusion

This paper presents an assessment in all 15 clinical analysis laboratories of the Municipality of Guarulhos that dispose chemical residues into the sewage system. The authors surveyed the laboratories to verify the concentration of residues disposed and the toxicity of these residues. All the 15 laboratories responded to the survey. The authors found that formic acid generated in the hematologic exams of the hematologic analyzers is the only substance able to cause environmental damage and, consequently, to public health. However, the concentration of this dangerous chemical residue detected in the municipal sewer system was of 0.052 mg/m^3. This volume does not cause chemical toxicity risk and/or aggression to the environment.

Nevertheless, because the effluent of an automatic equipment is a Health Service Residues, which is considered a dangerous chemical residue, it is necessary to adequately manage the residues coming from clinical analysis laboratories. Additionally, this fact highlights the importance for additional specific studies in this area.

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