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Recyclable Recovery of Hospital Waste: Holistic Innovative Methodology

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ABSTRACT
The health area seeks sustainable management models for making decisions with socio-environmental responsibility. This study uses a holistic methodology applied to understand the generation of solid health waste (RSS) between 2016 and 2022 in a large hospital in Goiânia-Goiás. Data available by the hospital administration were collected and RSS masses were collected. Procedures were applied for the reduction and segregation at the generating source. The exploratory approach with qualitative and quantitative aspects shows that the main residues are non-hazardous (Group D). Infectious, chemical and sharps wastes were distinguished. Training and environmental education activities were developed.

Keywords: Health care waste, Waste management, Source segregation.

1 INTRODUCTION

According to Lovelock (1976), Planet Earth, Gaia, continuously works in balance (homeostasis) and in continuous feedback process, whose goal is to maintain the supremacy of the conditions and standards that guarantee life and its continuity. Based on the homeostatic process of balance and depurative processes of "Gaia" (of the Earth), it is necessary to the responsibility of individuals, legal entities and public authorities in promoting a society that transcends the current paradigm of alienated reductionism and exacerbated consumerism, aiming to reposition consumption within the limits of the planet's support and regeneration capacity.

Capra (1996) declares that the sciences have been affected by reductionism since the seventeenth century, where René Descartes conceives nature in a fundamental division between two independent and separate domains, being the thinking mind (rés cogitans), and matter, the "extensive thing" (extensive rés), composition of science that prevails in the Western model, both in the medical sciences, environmental sciences. Human society has distanced itself from the planet. The human being, in his inventive and technological process, created conditions for the mastery of the phenomena of nature. Natural phenomena suffer the interference of the human being, with continuous disposal of chemical and synthetic substances

and inadequate management of tailings and residues deposited directly in nature. Human interferences are observed absent from holistic integrative and ecosystem practices.

Environmental quality has been degraded in its chemical composition of soil, water and air parameters, generating pollution that deregulates planetary homeostasis and subjects life to uncontrollable phenomenological reactions. Environmental quality deals with the state of integrity of the environment, from the measurement of parameters of its components (KRIEGER *et al.,* 2008).

The legal requirements on waste and tailings in the hospital environment are in Law 6938/1981 of the National Environment Policy - PNMA (BRASIL, 1981). Pollution in its 3rd Article, III is defined as:

> pollution, the degradation of environmental quality resulting from activities that directly or indirectly: harm the health, safety and well-being of the population, create adverse conditions to social and economic activities; unfavorably affect the biota; affect the aesthetic or sanitary conditions of the environment; throw materials or energy in disagreement with the established environmental standards, yet it is polluting " natural or legal person, under public or private law, responsible, directly or indirectly, for activity causing environmental degradation. (BRAZIL, 1981).

A health unit as a resource user organization and energy or matter launchers in the environment can be classified as potential polluter, which links the application of mitigating measures and systemic approach in management (holistic thinking) with life cycle analysis (LCA) in the taking of ecoefficient measures. Law 12305/2010 (BRASIL, 2010) displays the concept of life cycle evaluation LcA (ABNT NBR ISO 14040, 2001) as a series of steps in product development, including obtaining raw materials and inputs, the production process, consumption and final disposition, and this understanding is relevant for stakeholders (supports and agents in processes) to understand that they are entirely dependent on inputs (inputs) of raw materials and generate outputs (solid or liquid waste and tailings that require life cycle evaluation for proper disposal or disposal. This for each stage of the process, such as, from a dressing, rinse processing, bedside assistance, dilution of sanitizing for terminal and concurrent sanienizations, environmental asepsis processes, surgeries, examinations, others.

This article deals with environmental aspects of relevance, such as the generation of waste and tailings, as well as public policies, integrated management plans and integrated management from production/acquisition (cradle) to final disposal or disposal (tomb or cradle respectively). In its text, health waste and waste or hospital waste from health service (SSC) are evaluated, as well as mitigating measures in its management, from cradle to grave. Also, in this work, actions such as management and strategic management for the awareness and promotion of integrated environmental management, based on ESG models (environmental, social and governance), strengthening the model of support triad of corporate environmental management.

This study has been applied in a large public hospital in the city of Goiânia, capital of the State of Goiás, observing legislation that regulates and regulates environmental aspects of high relevance in the face

of social and environmental health impacts. In an exploratory, observational and participatory way, the unit's health service has been researched and evaluated, historically warning about the level of maturity and engagement of stakeholders in the face of participatory and holistic environmental management policy.

2 METHODOLOGY

The methodology of applied research comprised qualitative and quantitative approaches to the solution of hospital management problems and their waste generation. At the research site, a public hospital in Goiânia, State of Goiás, needed statistical techniques and systemic approaches to examine the routine of generating SSC and its management. With authorization and collaboration of the hospital administration, both the survey and data collection were initiated from 2016.

The actions of sensitization and environmental education were applied, considering the didactic material elaborated in order to instruct on management and sustainable management of SSC.

Also in the methodology, reuse techniques, selective segregation (screening) were applied in the sites of sources that generate SSC. Data were collected in these locations, observing the stages and processes of separation, packaging and destination or final disposal. In the study, contexts of the SSRgenerated in an interval of 82 months, between 2016 and 2022, are evaluated, comparing the masses (kg) and the percentage index (%) (gravimetric fraction) of the types of SSC, according to RDC 222/2018 and the resolution of CONAMA 358/2005. Regulations and resolutions on guiding health rejects were THE RDC 222/2018 of ANVISA and that of CONAMA 358/2005, which bring relevant technical specifications in the understanding of tailings as subgroups of group A (biological tailings) A1, A2, A3, A4 and A5, tailings and residues of group B (chemicals), rejects C (radioactive), residues and tailings of group A (common residues) and rejects from Group E (sharps). Concepts and instructions of the National Solid Waste Policy -PNRS (BRASIL, 2010) were applied.

The emphasis on methodology was given in the **stage of selective separation of SSRs in the generating source**, comparing over time certain components, such as changes in scenario, changes in routines and processes, as well as the impact that the COVID-19 pandemic caused in the health unit studied. The management scenario with the new CORONA virus impacted the unit, especially in the volume of hazardous tailings, and these tailings, from the change in epidemiological profile, intensified and brought challenges in the environmental performance process.

In the focus of research, systemic thought contemplates the system studied as a living organism, since the whole becomes more than its parts (German philosopher Christian von Ehrenfels sec. XVIII). The technique of interrelation of the systemic approach treats the problem of research in 4 (four) phases, not only being a chronological sequence of phases, but constituting the search for the influencing elements, understanding of the influencing parameters and the change of understanding of the problem, with

interconnectivity of causes and effects. Systemic notation assists in the elaboration of systemic maps (SENGE, 1999; ANDRADE *et al.*, 2006; GOMES *et al.*, 2014).

Management and decision-making in the search for **solutions and innovation** involved the analysis of flows outside the research site, such as the production chain of health products and reverse logistics. Thus, the search makes use of the PDCA tool (abbreviated to terms in English plan, do, check and act). Life cycle analysis (LCA) was included in the investigation of the selective collection of the public hospital in Goiânia.

An intense search for data was conducted in order to support and subsidize the study, thus Silvia, Tatiane and Angela (2016) report that according to the literature, 10 to 25% of the waste production generated by a health facility are considered infectious waste (MOREL, 1993; TAKAYANAGUI, 2004).

3 RESULTS AND DISCUSSION

Given the study scenario, milestones were evaluated and inserted in the environmental management of the SSC, and these transformers were in view of the non-existent scenario prior to the project. The culture of selective collection was also introduced, training was carried out in order to raise awareness among the employees of the health unit (Chart 1).

Table 1 – Environmental education actions undertaken in the health unit and its chronology, according to legal aspects applied to the project.

ear	Action taken
012	The waste shelter, RDC 50 ANVISA, was renovated for building health buildings, the area of the infecting tailings A4 was structured, area of A1, area A3, area of group B, area of tailings D and specific space for storage of recyclable waste.
014	Polypropylene containers were purchased to guard common tailings, at the time it was collected by the city and there was damage to the equipment.
014	A higher level professional was hired to elaborate, monitor and plan the execution of the PGRSS.
015	Training was carried out with all employees on waste and health waste, at the time there was a lot of resistance and disagreement of segregation, because the norm at the time, RDC 306/204 of ANVISA was incomplete, subjective and unexplanatory, all professionals discarded gloves as infectants and in the wards there were only trash cans with milky white bag, which grotesquely raised biological waste and the cost for treatment.
015	It was acquired and inserted in the purge areas (spaces for guarding waste and dirty clothes), as well as a place for disposal of aspirated secretions from patients, trash bins in red (plastic) and blue (paper), in line with CONAMA 275/2001 - color code for selective collection.
016	A scale was acquired for the waste shelter in order to provide weighing of tailings and waste and the completion of excel spreadsheets was started, at the time, an indicator was structured, whose objective was to keep the infectant at 25% and the common tailings and waste 75%<>
	The tailings as anatomical parts (subgroup A3) were destined for burial, paying an average rate of R$ 200.00

017	per transfer to the burial city hall, a freezer was purchased and allocated for incineration, paying for kg of tailings, with high economy.
018	It was mapped through the study of the Chemical Safety Information Sheets - FISPQs, the sanitors used and were evaluated from the form their toxic risks, also, from the biodegradable sanitist forms, the vials were relocated for selective collection, and previously they were paid to provide heat treatment by incineration.
018	In March, RDC 306/2004 was repealed and RDC 222 came into force, this standard declares environmental concepts of Law 12305/2010 as reverse logistics, difference between waste and tailings, still, standardizes and exemplifies discards not previously mentioned in the RDC 306 standard, the new standard brought regulation of good practices for the management of health service waste.
018	In December, the trash cans of infectious waste were removed from the wards, because the new standard brought that gloves can be discarded in dumpsters with black bags, and before white bags were kept due to the glove being interpreted as biological tailings, however, today it is pacified that gloves are biological only when in contact with blood or body fluids (cerebrospinal, amniotic, pleural, pericardial, ascitic or articular)
019	It began a reverse logistics partnership with the company that suppliers of laundry sanitizers, where all the sanitize containers began to be removed in reverse logistics, bringing a decrease in plastic production in the Unit, even so, it is an eco-efficient measure, in the same year, third-party laundry and practice did not continue, because the processing of rinses began to be carried out in the company's space.
020	Hospital through benchmarking at Hospital Israelita Albert Einstein, Morumbi, São Paulo, held in 2019, implemented changes in the hygiene routine, modifying the product chart, and replaced 3 products by 1, that is, removed sodium hypochlorite (toxic and pH disruptor), alcohol 70% and soap, by a product of high effectiveness, hydrogen peroxide, which has a report for a large spectrum of microorganisms and inscription in ANVISA, as much as, is nontoxic according to FISPQ, which led to reduction of plastic bottles and water consumption, because this product allowed to clean and disinfect simultaneously without rinsing.
020	This year we had the beginning of challenging actions, in March 2020 was decreed pandemic scenario of SARS-COVID-19, and hospitals had to prepare for the confrontation of the pandemic, drastic changes were placed in the Health Units, for example, we had to resume infectious waste dumps to the wards, since there was a change in the epidemiological profile, most of the hospital's wards were available for hospitalizations of critically ill patients and with respiratory complications, there was a change of the whole scenario for waste and tailings management and the goals and indicators were compromised. The elective health units stopped attending and performing surgeries, accumulating the demand queue and need for health, only in September 2022 did the studied Unit resume its demands in full.
021	Hospital acted 100% in coping with COVID, allocated ward blocks for exclusive care of patients with infectious diseases, and beds were blocked for isolation of precautions, increased number of ICU beds and all wards of the blocks became infectious, that is, there was an increase in kg of biological, perforating and chemical waste, because we had a greater demand for medication and tests for COVID. In March 2021, even with the whole scenario, the Social Organization managing large Health Units in Goiânia declares the search for environmental certification ISO 14001, an environmental policy was defined.
022	In August 2022, reverse logistics for sanitizing sanitizing bottles began, the hydrogen peroxide bottles were destined for the supplier company, decreased amount of plastic bottles compared to the eco-efficient measure adopted, still ceased hospitalizations for COVID in September 2022. Throughout this year was hired company for training internal auditors for ISO 14001, environmental policy was disseminated, environmental aspects and impacts were mapped in matrix defined survey of environmental aspects and impacts (LAIA), intelligent solution was hired to map legal requirements. In July 2022, standard operating procedures were built for FISPQs of hazardous products in the cleaning process, being POP for hydrogen peroxide, POP for TASK product and POP for virex, both products used for surface cleaning and stones. The waste and tailings indicator was revised in January, linking a target of 25% for hazardous tailings (infectors A1, A2, A3, A4 and A5, hazardous B groups and group E - perfurocortante) different from previous years that this target was only for biological ones and 75% for non-hazardous (common waste and tailings).<>

Waste and tailings weighing data were collected during the months 2016 to 2022, resulting in a historical series of RSS production (Table 1). The pandemic changed the epidemiological profile and, consequently, changed the scenario of SSC production.

Table 1: Weighing of waste and tailings from January 2016 to October 2022. Unit kg.

Year	Subgroup A1 Kg	Subgroup A3 Kg	Subgroup A4 Kg	Group B Kg	Group E Kg	Ppe Kg	Group D - tailings Kg	Group D - waste Kg	Class I rejects Kg
2016	410,3	23,2	65935,60	4531,50	2177,60	961,50	259434,86	8924	
2017	1071,9	50,2	69401	5365,50	3770	54,54	293960	17994	
2018	1710,5	29,20	68601,50	3939,80	4654	15,08	281207	23422	
2019	1580,10	122,10	71527,60	2971,30	6167,50	136,80	339078	20640	
2020	848,4	64,60	52014,80	1514,50	4980	47,50	261940	12740	
2021	1363,10	58,10	71871,60	1284,60	6368,90	0,2	238680	13863	1169
2022	1318	24,55	63755	1656,50	6410,50	0	239656	9677	

From table 1, a trend graph was constructed from the weighing of recyclable waste, from 2016 to October 2022, demonstrating the performance and evaluating whether the actions of good practices corroborate with increased performance and environmental efficiency, see figures 1 and 2.

Figure 1 - Rannual presentation (kg) of recycled waste from January 2016 to October 2022.

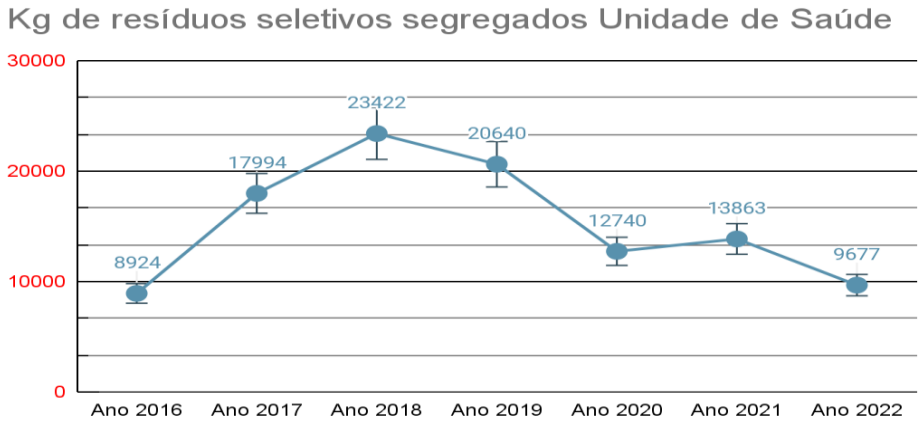
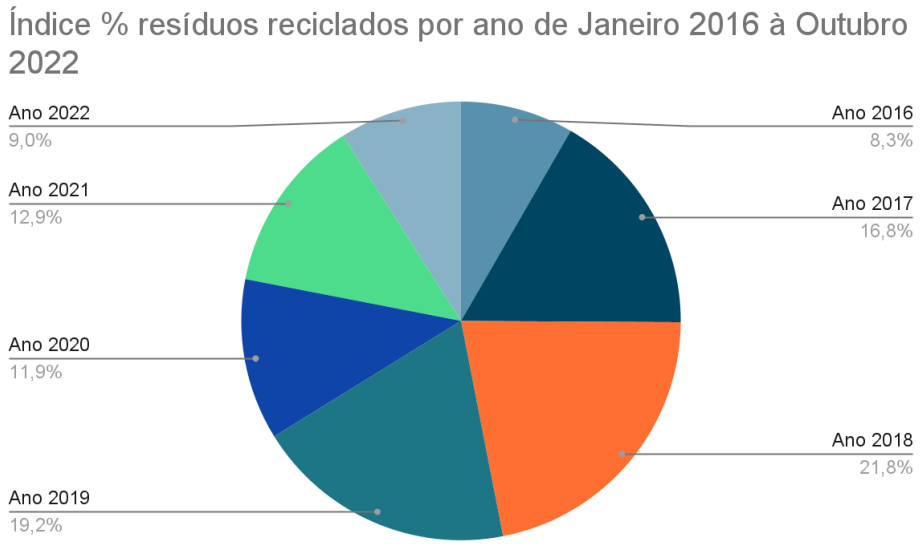


Figure 2: annual representation (%) of recycled waste from January 2016 to October 2022.



The hospital studied was able to demonstrate throughout the historical series of the 82 months evaluated, that with the insertion of a cohesive environmental policy and with strategic alignment, as well as the continuous strengthening of institutional culture, it is possible to increase environmental performance, associated with this, when continuous improvement based on appropriate tools, such as PDCA, being a powerful tool to establish performance management and high performance, there have been gains in results (Figure 3).

Figure 3 - Istoric h of process change and insertion of selective collection applied in hospital management.

In the historical context and in the temporal period from January 2016 to 2022, there were changes in techniques, routines and outsourcing, but what most impacted the process was the pandemic, as the isolation beds were raised and consequently mitigated the strategies of selective collection and also increased biological waste. Even so, until the moment studied, the Hospital has had dangerous tailings lower than that compared to studies and as much as that observed by PAHO and WHO, which points up to 25%, as the recyclable, focal point of this study, in all years, when 2016 is used as a reference, had significant growth and reductions, corroborated by changes in routines, processes and associated pandemic, as already reported (ADUAN *et al*., 2014).

Figure 4 shows the results of table 1 for subgroups Of RSS A1, A3, A4, and B.

Figure 4 - Graphs showing results from table 1 on mass of RSS (kg) subgroup A1, subgroup A3, subgroup A4 and Group B period 2016 to 2022.

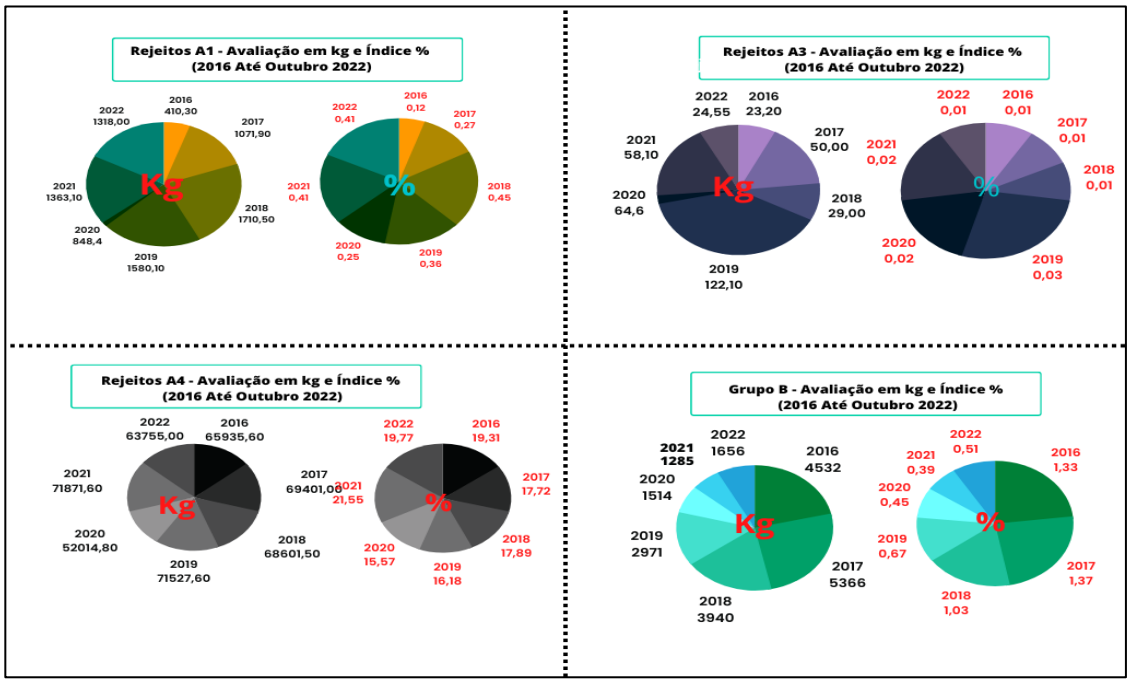


Figure 5 – Graphs showing results from table 1 on mass of RSS (kg) group E, group D tailings and Group D residues and their general percentages of hazardous periods 2016 to 2022.

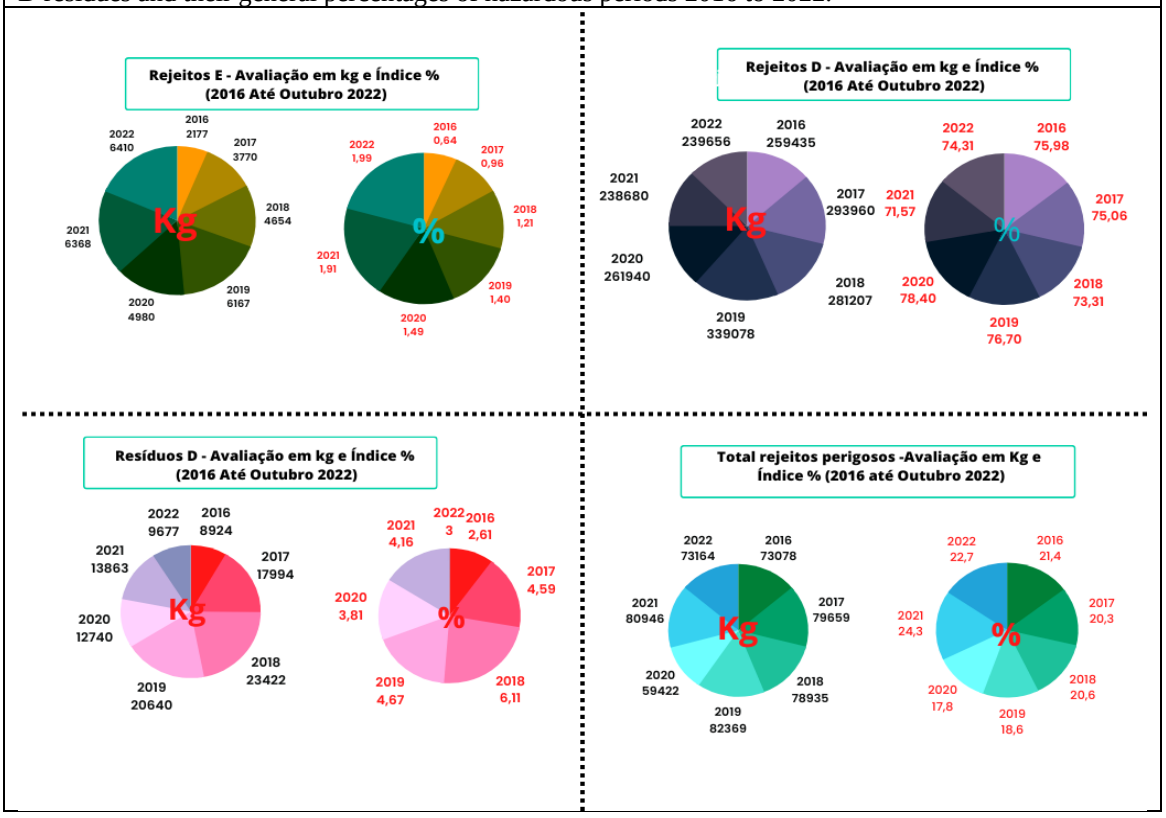
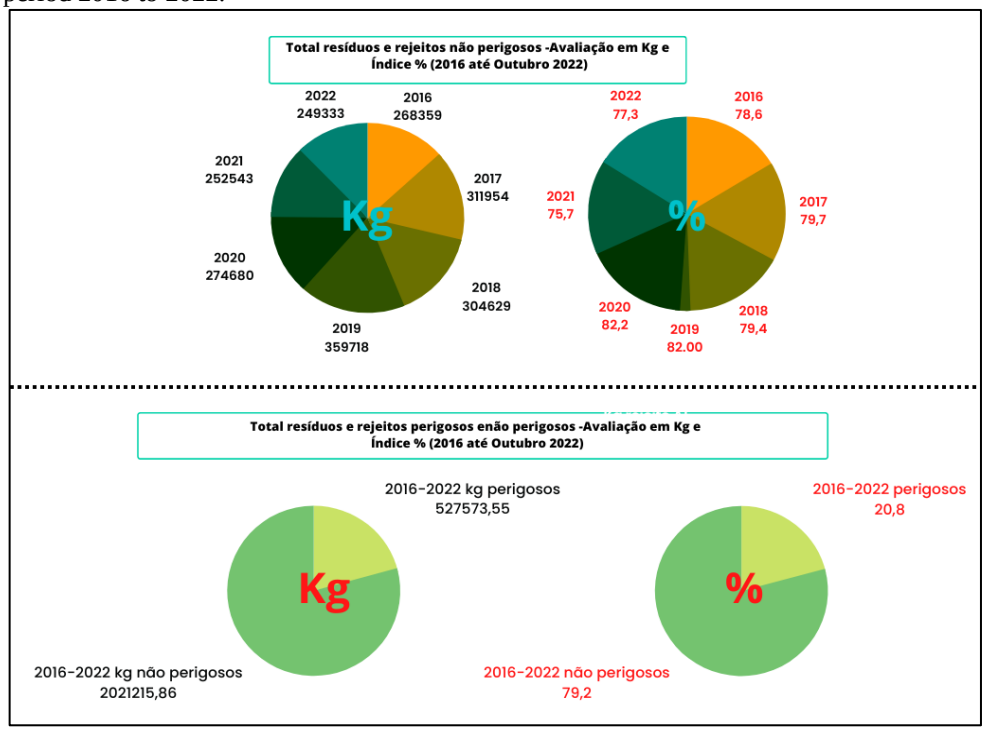


Figure 6 shows graphs showing general percentages of non-hazardous tailings and residues and general percentages of the entire historical series, period 2016 to 2022.

Figure 6 – Graphs showing general percentages of non-hazardous tailings and residues and general percentages of the entire historical series, period 2016 to 2022.



According to Borowy (2019), the World Health Organization in the 1980s, when it began its discourse on hospital waste, evaluated the percentage rate (%) of discards hazards ranging up to 15%, but this performance ratio was the reality of industrialized countries, in underdeveloped and developing countries had another scenario, still discarding was in dump and many waste pickers without EPIs contaminated and intoxicated children while playing in dumps. Also, according to the same author, the percentage rate (%) of hazardous varies by up to 25%, precisely due to low technology and lack of culture and perception of health and environmental risk by health professionals.

To Gonçalves *et al.* (2011), it is mandatory to implement the SSC management program in all health units, including laboratory, and in the research they mapenvironmental aspects and impacts in line with integrated management system (GIS), where they were able to increase common and recyclable waste by 11.2% and 17.7% and reduce the biological by 18.5% and perforating by 25%, demonstrating the importance of providing environmental management in a health environment.

According to Ramos *et al.* (2011), it shows that 1 to 3% of the tailings produced in Brazil includes in the hospital group, even so, effective management is necessary due to the existing chemical and biological risks, still, citing that it is produced on average 0.42 kg/bed/day in Brazil.

For Lúcia e Costa (2005), there is a disinterest of health units in adopting cleaner production models (PmaisL), for example, at the national level technology company had representation of 17% and tannery of 12% in national ranking for eco-efficient practices, already health unit had no representativeness, this may indicate the possible difficulty of insertion of service providers in programs of reduction of waste and pollution control, since the current concern seems to be only compliance with legislation for the proper disposal of waste.

In the selective collection scenario, the health units have several business units, and for Schutte; Niemann; Kotze (2019), organizations need to tie sustainability in the supply chain, since by involving stakeholders, it can mitigate environmental risks, promote co-responsibility and increase selective collection, in addition to instituting a more assertive life cycle analysis.

To Makhura; Matlala; Kekana (2016), in a survey conducted on waste disposal conducted within health units, through understanding questionnaires for segregation with 178 professionals from multiple specialties, demonstrated that 44.9 did not know segregation practices and 7.9% were unsure, which demonstrates the risk and low awareness of care teams in the face of adequate segregation.

According to Aduan *et al.* (2014), when evaluating the segregation of tailings and residues in the state of Espírito Santo, evaluating 6 units with different size and profiles, attested that 41% of Group A - biological risk; 1.5% of Group B - chemical risk and 0.05% of Group E - perforating, i.e., 43% are dangerous rejects and the average generation rate was 2.68 kg. (bed.ocupado.day), which assesses a performance well below what the WHO evaluated in developed countries close to 15% and for developing countries should be close to 25%, with the reservation of opportunities for improvement.

According to André; Veiga, Takayanagui (2016), the amount of SSR generated by a health service varies according to the characteristics of the establishment, where, in the literature, in the literature, 4.1 to 8.7 kg are generated in a university hospital. already in a general hospital, from 2.1 to 4.2 kg.bed-1.day-1, while in outpatient clinics the literature points from 0.5 to 1.8 kg.person-1.day-1, and in primary health care centers from 0.05 to 0.2 kg.person-1.day-1 of RSS (WHO, 1999). In Brazil, the generation of SSC amounted to 2.63 kg.bed-1.day-1, and 15 to 20% of this total represent residues classified in Group A (biological).

This panorama reveals the need to implement and comply with the regulations that establish the management of the RSS (ZDEBA-MOZOLA, 2022).

4 CONCLUSION

Given the proposal of the selective collection project initiated in 2016, whose data were made available by the health unit (hospital) for this research, it is observed that the insertion of holistic and circular thinking in the organization was initiated.

Throughout the historical series, relevant passages were observed in view of the increase in the performance of the health unit regarding the mentality and thinking of sustainable environmental management, being corroborated by the higher rate of selective collection when compared to the year 2016, before the beginning of the research.

Furthermore, all hazardous tailings, when added together, had an index below 21% and non-hazardous waste and tailings when added together had rates higher than 79%, instructing the importance of waste and tailings management and as well as strengthening the environmental mentality, thus allowing high performance and consequently the possible return to the search for environmental certification.

The results and their discussion regarding the knowledge already available show that the innovative applied methodology of holistic management contributed to the understanding of the environmental situation and proposal of Management of SSC in the health unit.

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