REPUBLIC OF RWANDA

RWANDA ENVIRONMENT MANAGEMENT AUTHORITY (REMA)

NATIONAL SURVEY ON CHEMICALS AND HAZARDOUS WASTES AND UNDERTAKING AN INSTITUTIONAL CAPACITY ASSESSMENT

FINAL REPORT

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Executive summary

Over the past two decades, Rwanda has witnessed substantial economic growth and rapid industrialization in different sectors with the recent real gross domestic product (GDP) grew by 8.2% in 2022. This growth has definitely stimulated various sectors of the economy including the import and production of chemicals for their use in different sectors such as agriculture, commercial and industrial use purposes. For example, this observed development has generated an increased volume of solids and liquid waste which is causing a serious environmental pollution if not treated or handled with care and appropriately.

It is in this framework that the country joined hands with the international communities for sound management of chemicals and hazardous waste by acceding chemicals and hazardous waste-based conventions. In addition, Rwanda created its home solution to face the challenges in increased municipal, hazardous, and toxic wastes as well as minimizing the environmental consequences of rapid industrialization impacting land, air, and water quality and threatening the health of humans, water bodies, and ecosystems.

By consideration of the projected population growth in the near future where its population is projected to be 23.6 million by 2050 and current rapidly growing sectors in Rwanda especially, manufacturing industries, agriculture, transportation, education and healthcare, the Government of Rwanda through the Rwanda Environment Management Authority (REMA) in partnership with United Nations Development Programme (UNDP) and Global Environmental Facility (GEF) have launched a five years project for decoupling hazardous waste generation and harmful releases from economic growth by enhancing the introduction of the 4R approach (Reuse, Reduce, Recycle and Recovery) in priority industries and economic sectors, while at the same time enhancing private sector-led national waste treatment capacity to ensure the sound management of wastes.

Therefore, the primary objective of this report was to conduct a national comprehensive inventory of chemicals and hazardous wastes by focusing on mercury (Hg), Asbestos, Persistent Organic Pollutants (POPs) including per and polyfluoroalkyl substances (PFAS), medical wastes, motor oil, tires, and other chemical wastes from the above mentioned rapidly growing sectors in Rwanda. Moreover, the institutional capacity regarding chemical waste management was assessed to illustrate the current situation and inform policymakers for support, and future interventions to achieve reductions in hazardous waste generation and releases including priority setting, and potential waste management approaches.

Particularly, this report was developed by consulting concerned both public and private stakeholders in Rwanda *via* questionnaires and organized interviews to generate detailed inventory results and interim storage plan on chemicals and hazardous wastes in Rwanda.

Regarding the key findings for this survey, it was found that the imports of items containing mercury have been reduced from 11,897 kg in 2011 to 156 kg in 2022. However, the cumulative import of items containing mercury in the past 10 years equals to 84,775 kg according to records from MINICOM. All these items may end up into the environment if they are not properly managed. For instance, the Enviroserve Rwanda has a store of around 1.5 tons of mercury wastes from electronic and electrical wastes, whereas at Rwanda Medical Supply ltd. there is around 150 kg of phased out thermometers containing mercury. This survey pointed out the proper disposal of mercury containing waste as a key gap. There is a phase out of the items containing mercury, but the challenge is the management of those items while waiting the environmentally sound solution for their disposal.

The collected data for PCBs oil and waste containing PCBs has shown that to date there are only 4 transformers in activity containing PCBs. Other 21 transformers contaminated with PCBs are stored at the warehouse of REG located in Jabana, Kigali City with only 2 transformers containing askarel PCB oils while the remaining 19 transformers are empty but contaminated with PCBs and their oils were incinerated. Thus, there are around 1.1 tons of PCB oil and 12.7 tons of PCB contaminated wastes. However, the transformers containing or contaminated by PCB oil are stored outside in the garden.

Other POPs containing biocides were disposed in the past at Nyanza in Kicukiro and Nyamagabe, Southern Province, and are still there. At Nyanza there are 3,028 kg of solid POP wastes, including lindane and endosulfan stored in plastic drums. In addition, at Rwanda Agriculture Board Rubungo Station, there is a metallic drum containing 200 litters of the obsolete insecticide Methamidophos which is highly toxic.

Through the Asbestos Removal Project, Rwanda Housing Authority has managed to remove around 80.1% of the inventoried asbestos from buildings and disposed them into prepared asbestos burial sites. In other word, from the previously inventoried 1,692,089.2 m^2 of asbestos, about 1,356,173.2 m^2 of asbestos materials were removed from buildings countrywide. The removed materials are deposited in 19 burial sites countrywide from which 6 sites have been closed and 13 sites are still operational.

Chemical wastes were also inventoried from schools, higher learning institutions, research institutions, agriculture sector and industries. In all consulted secondary schools, it was found

that there is a total of 26.98 tons of expired chemicals which need to be disposed. The common issues in schools are the lack of plan and budget to dispose the expired chemicals and the lack of staff with waste management skills as well as the lack of safe place for the disposal of such waste.

Chemical Waste generated in higher learning institutions in Rwanda and research institutions were also estimated at 15.1 tons. The survey findings in agriculture sector also recorded around 472.3 tons of chemical wastes from the expired and damaged fertilizers, pesticides, biocides and other chemicals used in research. In addition, most of the visited industries produce fewer chemical wastes but a great number of hazardous wastes was observed in some industries and was estimated at around 85.54 tons per year.

The assessment of medical waste quantities and types generated was also conducted in 54 health facilities. These health facilities had a total number of 686,215 inpatients and 1,793,310 outpatients. Based on the quantification of daily medical waste generated and recorded in health facilities waste registers, an estimated national average of 10,515 ton per a year of medical waste was registered. About 82% of these medical wastes comprises liquid waste and non-infectious waste, while the remaining 18% comprises infectious waste, pharmaceutical waste, chemical waste, sharps waste and radioactive waste. SterilWave 250 incinerators are the most used for the treatment of such hazardous waste in Rwanda Hospitals.

In addition to the key indenting, the report shed light on the best available techniques and best environmental practices on these chemicals and hazardous wastes management and disposal. Finally, this report provided recommendations and future perspectives for sound management of chemical and hazardous wastes in Rwanda.

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Abbreviations

REMA	Rwanda Environmental Management Authority
BAT	Best Available Techniques
BEP	Best Environmental Practices
CAPI	Computer-Assisted Personal Interviewing
CEOs	Chief Executive Officers
CHUB	University Teaching Hospital- Butare
CHUK	University Teaching Hospital- Kigali
EC	Effective Concentration
RFDA	Rwanda Food and Drug Authority
GEF	Global Environmental Facility
GDP	Gross Domestic Product
MINICOM	Ministry of Trade and Industry
MoH	Ministry of Health
NIP	National Implementation Plan
NIRDA	National Industrial Research and Development Agency
PAP	Paper and Pencil
PBDEs	Polybrominated Diphenyl Ethers
PCB	Polychlorinated Biphenyl
PFAS	Polyfluoroalkyl Substances
POPs	Persistent Organic Pollutants
PPE	Personal Protective Equipment
PSF	Private Sector Federation
RAB	Rwanda Agriculture Board
RBC	Rwanda Biomedical Centre
REB	Rwanda Basic Education Board
REG	Rwanda Energy Group
RFI	Rwanda Forensic Institute
RMS	Rwanda Medical Supplies

RP	Rwanda Polytechnic
RRA	Rwanda Revenue Authority
RSB	Rwanda Standards Board
SPSS	Statistical Package for Social Sciences
STATA	Statistical Software for Data Science
UNDP	United Nations Development Programme

Chapter 1: General background

Rwanda's economy has been growing gradually over the last two decade with the recent real GDP grew by 8.2% in 2022. This growth has definitely stimulated various sectors of the economy including the import and production of chemicals for their use in different sectors such as agriculture, commercial and industrial use purposes. To implement chemicals and hazardous waste-based conventions, the country has joined hands with international community for sound management of chemicals and hazardous wastes. In addition to that, the country has created its own home-grown solutions to address the challenges caused by the increased municipal, hazardous, and toxic wastes as well as minimizing the environmental consequences of rapid industrialization impact on land, air, and water quality and threatening the health of humans, water bodies, and ecosystems.

However, the country still has growing sectors like industry and agriculture which pose numerous waste streams that require a proper attention even though healthcare is implementing some cleaner production measures. Consequently, the remain significant shortcomings is exposing the country to the severe impacts of improper waste management, which lead to releases of persistent organic pollutants (POPs) and mercury (Hg) though air emissions, waste disposal, effluent discharge, and soil contamination such as unintentionally produced POPs, and Hg. Releases of such chemicals, in particular releases to water sources and air, have a global impact.

As mentioned in terms of reference for this task, to enhance the introduction of the 4R approach (Reuse, Reduce, Recycle and Recovery) in priority industries and economic sectors while at the same time enhancing private sector-led national waste treatment capacity and to ensure the sound management of wastes, the Government of Rwanda through Rwanda Environment Management Authority (REMA) in partnership with UNDP and GEF received funds of a five-year project aiming to support the Government of Rwanda and its private and public sector in decoupling hazardous waste generation and harmful releases.

Therefore, this report provides the proposed technical approach, methodology and work plan with the aim to:

(i) Undertake an up-to-date detailed chemical and hazardous waste inventory and quantify each type to inform policy, support, and future interventions to achieve reductions in hazardous waste generation and releases including priority setting, potential waste management approaches, best available techniques/Best Environmental Practices and financial needs for the long-term operations of waste management mechanism.

(ii) Conduct a comprehensive polychlorinated biphenyls (PCB) inventory including quantification and undertaking sampling and analysis of transformer oil for all transformers in Rwanda.

(iii) Identify the sector use and quantify the per and polyfluoroalkyl substances (PFAS) commonly known as "forever chemicals" in Rwanda, provide the effects to the environment as well as to human health.

(iv) Assess which type of wastes present or generated in Rwanda which require interim storage at the national/regional level while awaiting disposal/treatment and proposal technical specification for each required interim storage.

(v) Assess the existing interim storage facilities for chemicals and evaluate their environmental standards minimum compliance.

(vi) Develop interim storage facilities management plan and.

(vii) Undertake an institutional capacity assessment in chemical and hazardous waste management.

1.1 Overall objective of the survey

The overall objective of this assignment is to conduct a national survey on chemicals and hazardous waste and undertake an institutional capacity assessment.

1.2 Scope of the survey

The assignment aims to conduct a national survey on Chemical and hazardous waste by focusing on mercury (Hg), Asbestos, Persistent Organic Pollutants (POPs) including per and polyfluoroalkyl substances (PFAS), medical wastes, motor oil, tires, and other chemical wastes from the rapidly growing sectors in Rwanda that are: manufacturing industries, agriculture, transportation, education and healthcare.

This assignment was conducted to undertake an up-to-date detailed hazardous waste inventory (including current stocks and production rates) to inform policy, support, and future interventions to achieve reductions in hazardous waste generation and releases including priority setting, potential waste management approaches, Best Available Techniques/Best Environmental Practices (BAT/BEP), and financial needs for the long-term operation of waste management mechanisms.

1.3 Legal and Policy Framework on chemicals and hazardous waste in Rwanda

This section describes laws, policies and institutional framework relevant to the assignment. Both international and national regulations are described under this section. Rwanda is equipped with institutions, laws, regulations, and policies enacted to protect environment. Rwanda has also adhered and ratified international treaties and conventions' aiming at the promotion and the protection of environment either, nationally or internationally. It is for a paramount to note that effective environmentally sound management of waste and implementation of waste management policy depends on the institutional capacity of national and subnational waste management related agencies. At continental and regional levels, our country has been fully participating in meetings and has adhere to the Africa Union (AU) Agenda 2063 as well as to the East African Community (EAC) Vision 2050 as guiding documents for a sustainable development[1].

[1] REMA, 2018. Short and Medium term hazardous, toxic, and radio-active wastes strategy and plan in Rwanda

1.3.1 Legal Framework

The Constitution of the Republic of Rwanda

The National Constitution of Rwanda of 2003 (amended in 2015) guarantees the right to a protected environment. Article 53 states that everyone has the duty to protect, safeguard and promote the environment that the State should ensure the protection of the environment, and do so by means of a law that determines the modalities for the protecting, conserving, and promoting the environment. In addition, its article 3 contains specific provisions regarding the waste management. Its article 22 on the right to live in clean and healthy environment; article 49 on the duty of each Rwandan to respect of the Constitution and other laws of the country.

Rwanda is part of the international arena, and this implicates Rwanda to share with the rest of world concerns including environmental protection and promotion. In that regard, the Constitution of the Republic of Rwanda, in its article 168 stipulates that "upon publication in the official gazette, international treaties and agreements which have been duly ratified or approved have the force of law as national legislation in accordance with the hierarchy of laws provided for under the first paragraph of article 95 of the Constitution."

Law No 48/2018 of 13/08/2018 on environment

The Law on environment N°48/2018 of 13/08/2018 highlights key principles for environment protection in its different chapters. In chapter 3, the conservation and protection of natural environment is emphasized on soil in article 8 for soil and subsoil conservation. Article 12 on water resources protection state that water resources must be protected from any source of pollution. Furthermore, in its chapter V on obligations of the state, decentralized entities and local communities with regard to the protection, conservation and promotion of environment; in its articles 30 says about the list of projects that must undergo an environmental impact assessment before they obtain authorization for their implementation is established by an Order of the Minister.

Law N° 63/2013 of 27/08/2013 determining the mission, organization and functioning of Rwanda Environment Management Authority (REMA)

The law establishing REMA, the authority in charge of supervising, monitoring and ensuring that issues relating to environment are integrated in all national development program (art.3) with one of the main missions (art.3, 1º) to implement Government environmental policy. The laws highlight the prevention, protection and promotion of the environment. For instance in its article 3, 2° REMA is responsible to advise the Government on policies, strategies and legislation related to the management of the environment as well as the implementation of environment related international conventions, whenever deemed necessary; 7° to participate in the preparation of activities strategies designed to prevent risks and other phenomena which may cause environmental degradation and propose remedial measures; and 8° to provide, where it is necessary, advice and technical support to individuals or entities engaged in natural resources management and environmental conservation.

Ministerial Order N°006/16.01 of 15/07/2010 establishing special regulations relating to burying toxic wastes

With the purpose of "determining the modalities of burying toxic wastes (art.1)", this order, in its chapter related to modalities of burying toxic wastes, specifies about the Application for authorization to burry toxic wastes (art.4), and the Cost of burying toxic wastes (art.5); without giving precisions on burying sites and methodology unless those provided by the burrier (art.4, 10° - 12°).

The Prime Minister's Instructions Nº 002/03 of 05/05/2015 determining procedure for eradication of asbestos materials in Rwanda

Back in 2008, the asbestos legal banning was by the Prime Minister's Order N° 27/03 of 23/10/2008 determining a list of prohibited drugs unless authorized or temporary permitted. In 2009, the Government of Rwanda took the Resolution to eradicate all asbestos containing materials from buildings in order to protect the inhabitants from the health risks of suffering from asbestos related diseases. Starting from 2011, Rwanda Housing Authority (RHA) with various stakeholders (government and private) is implementing the National Action Plan of Asbestos Eradication from buildings as established by the High-Level Consultative Meeting of 18th April 2011. Later in 2015, the Government of Rwanda established the Prime Minister's Instructions determining procedure for eradication of asbestos materials in Rwanda.

1.3.2 Policy framework

National policy on injection safety, Prevention of transmission of hospital infections and healthcare and Healthcare waste management (2009)

The overall objective of this policy is to ensure that no person is infected as a result of healthcare she/he has received. It aims at putting in place mechanisms, systems, and practices to prevent transmission of infection through injections and other medical procedures and ensuring that medical waste is disposed of in a safe manner that does not have any risk to Health personnel, patients, and the community. The mission of this policy is to improve the health status of the Rwandan population, by protecting it from any disease transmitted by injections, other medical procedures, and medical waste, thereby making the population more productive.

Rwanda E-Waste Policy (2015)

The E-Waste Policy under the Ministry of ICT & Innovation, stresses that the utilization, purchase and import of electrical and electronic equipment is expected to grow substantially in the years to come, and a conventional estimate would be a growth rate of 20 per cent annually. The increased usage of electrical and electronic equipment would subsequently generate increased volumes of e-waste. Moreover, the lack of many infrastructures to handle e-waste in Rwanda has

motivated institutions and private persons to store outdated equipment, which also need to be managed in an environmentally safe manner. It should be highlighted that currently the electronic and electrical waste are being recycled in Rwanda by Enviroserve Rwanda Green Park.

National Guidelines on Health-Care Waste Management (2016)

The guidelines provide a minimum standard for safeguarding public health and the environment through efficient management of health-care waste. All types of healthcare wastes are considered by these guidelines, and each health facility is recommended to be responsible for managing its waste from the point of generation to the final disposal. These guidelines are recommended to all stakeholders in the health sector and in particular all those involved in delivery of health-care services in Rwanda.

1.3.3 Conventions and Protocols

Minamata Convention on Mercury

Rwanda has accessed to the Minamata Convention on Mercury and Mercury Compounds by the Presidential Order N°130/01 of 24/02/2017. In 2017, the Republic of Rwanda submitted notification of its consent to be legally bound by the Minamata Convention. The country's obligations are defined by the provisions of both the Convention and the country's domestic legal framework. The objective of the convention is the protection of human and environment from anthropogenic emissions and releases of mercury and mercury compounds.

Basel Convention on the Transboundary Movement of Hazardous Wastes and their Disposal

The Basel Convention on the Control of Transboundary Movements of Hazardous wastes and their disposal. It has been approved by the Presidential Order n° 29/01 of 24 August 2003 approving the membership of Rwanda includes hazardous wastes that are explosive, flammable, poisonous, infectious, corrosive, toxic, or eco-toxic. The convention covers and identify waste categories/characteristics and identifies specific waste classified as hazardous or non-hazardous.

Bamako Convention

The Bamako Convention, adopted under the auspices of the Organization of Africa Unity (OAU), prohibits hazardous waste imports into Africa. It therefor concerned with the Ban import into Africa and control of trans-boundary movement of hazardous wastes within Africa. The convention was negotiated by twelve nations of the OAU at Bamako, Mali in January 1991, and came into force in 1998.

The Stockholm Convention on Persistent Organic Pollutants (POPS)

Under the Stockholm Convention on Persistent Organic Pollutants, countries commit to eliminate or restrict the production and use of persistent organic pollutants. With over 150 signatories, the Treaty came into force on May 17, 2004.

Chapter 2: Inventory of mercury and mercury-contaminated wastes in Rwanda

2.1 Introduction

Mercury is a naturally occurring chemical element found in rock in the earth's crust, including in deposits of coal. On the periodic table, it has the symbol "Hg", and its atomic number is 80. It exists in several forms such as elemental (metallic) mercury, inorganic mercury compounds, methylmercury, and other organic compounds. Mercury is used in many industries such to produce chlorine gas and caustic soda, and in thermometers, barometers, batteries, and electrical and electronic equipment.

Even though it is used in many industries, mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages. High levels of methylmercury in the bloodstream of babies developing in the womb and young children may harm their developing nervous systems, affecting their ability to think and learn. In this regard, the Minamata Convention was adopted in 2013. This convention is an international treaty designed to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.

2.2 Methodology

2.2.1 Document review and key informant interviews

In this inventory, an extensive document review was conducted in line with chemicals and hazardous waste management by institutions and their needs. Documents include previous inventories, previous studies/publications on the subject of chemicals and hazardous waste management in Rwanda, and the Conventions such as Stockholm, Rotterdam, Basel and Minamata which were reviewed throughout the assignment.

The second dimension of the data collection process was through in-depth interviews of key informants that have knowledge of either chemicals management and/or hazardous waste management in their institutions. Accordingly, an interview schedule was developed for the purpose of obtaining data during the face-to face interview. The target respondents were Chief Executive Officers (CEOs) of Lead Agencies, heads of the chemicals and/or waste management departments of the institutions, representatives of non-state actor institutions, officers from policy development in Government, regulatory agencies, and technical support institutions.

2.2.2 Aim of the survey

This task was fundamental to understand the status of mercury and mercury-contaminated wastes in Rwanda and to locate mercury waste hotspots. The key institutions which were contacted during the inventory for Mercury and mercury-contaminated wastes are provided in **Table 2.1**. The specific activities which were conducted under this task are as follows:

- Conducting in-desk data collection – from secondary sources (e.g., reports from hospitals, previous inventories), regarding mercury and mercury-contaminated wastes in Rwanda;
- Check the status and current quantity of previously inventoried mercury stockpiles in Rwanda;
- Site visits for spot checks and contaminated waste sites, this focused on Kigali districts and selected six secondary cities in Rwanda which are Muhanga, Huye, Rusizi, Rubavu, Musanze, and Nyagatare. The site visit included other highlighted sites through key informant interviews mainly targeting hotspots areas;
- Collect data from public and private institutions (e.g., MINICOM, RRA, MINAGRI, RBC, REB, REMA, PSF, MoE.) in order to get a comprehensive list of other institutions or sectors generating or managing a large quantity of chemical and hazardous wastes in Rwanda were consulted.

Table 2. 1: Type of waste and consulted institutions during the inventory for mercury and mercury-contaminated wastes.

Waste Stream	Type of waste	Consulted Institutions
Mercury and mercury compounds	Skin lightening lotions, medical and laboratory devices with mercury, laboratory chemicals, and topical antiseptics	Rwanda FDA, MINICOM, REMA, Rwanda Forensic Institute, National Reference Laboratory.
	Light and lamps with mercury	Rwanda Energy Group (REG), Enviroserve Rwanda, REMA.
	Medical devices with Hg	Hospitals (referral and districts), Ministry of health (MoH), Depot Karisimbi Ltd, RMS Ltd, REMA.
	Other devices with mercury	Rwanda Meteo, Universities and Higher learning institutions, Enviroserve, REB, REMA.
	Pesticides and biocides	RAB, MINAGRI, PSF (industries), REMA.
	Wastes Management and sorting	Landfills and dumpsites in Kigali and Six secondary cities.

2.3 Mercury and mercury contaminated wastes inventory results

2.3.1 Mercury stockpiles in Rwanda

The e-waste recycling facility in Rwanda, Enviroserve, collected 3,611 tons in 2020 and 2021 of e-waste[2]. Using the emission factor of 0.22 g/kg of e-waste, the country could release 794.42 kg of mercury as stockpile from e-waste[3].

It was noted during the inventory that Rwanda has successfully phased out the use of mercury containing thermometers in the medical industry. Consultations with officials in the medical sector revealed that there are remaining stocks of disused clinical thermometers containing mercury.

The estimated quantities in stock were reported to be approximately 4,000 boxes with 10 units each. Using the emission factor of 1 g/unit, it is estimated that 40 kg of mercury are stockpiled in the form of clinical thermometers[4].

Furthermore, a total of 250 ambient air monitoring thermometers have been identified as stockpiles in various laboratories across the country, with less than 50 currently in use. Using the emission factor of 3.5 g/unit**,** it was estimated that 0.875 kg of mercury is stockpiled in the form of ambient air thermometers[5].

The mercury inventory in Rwanda revealed that a total of 19,558.85 kg/year of mercury could be emitted or released from the 10 source categories as detailed in the **Table 2.2** below[6].

[2]Enviroserve (2021) Electronic Waste Management: https://enviroserve.rw/; accessed in April 2023
[3]Ari, V. (2016) A review of technology of metal recovery from electronic waste. *E-Waste in transition—From pollution toresource*
[4]UNEP (2019) Mercury Inventory Toolkit for the identification and quantification of mercury releases and emissions. United Nations Environment Programme (UNEP), Geneva
[5] EPA (2022) Mercury thermometers. U.S. Environmental Protection Agency (EPA), Washington DC. https://www.epa.gov/mercury/mercurythermometers accessed April 2023
[6]See: REMA, 2023. Rwanda Minamata Initial Assessment Report

Table 2. 2: *Summary of mercury releases by sector in Rwanda*

SN	Mercury source category	Total release by source category (kg)	Percentage total releases (%)
1	Extraction and use of fuels/energy source	83.42	0.43
2	Primary (virgin) metal production	14,659.32	74.95
3	Production of other minerals and materials with mercury impurities	52.92	0.27
4	Intentional use of mercury in industrial processes		0
5	Consumer products with intentional use of mercury (whole life cycle)	2,389.23	12.22
6	Other intentional product/process use	353.19	1.81
7	Production of recycled metal		0
8	Waste incineration and burning	1,478.51	7.56
9	Waste deposition/landfilling and wastewater treatment	2,467.61	2.74
10	Crematoria and cemeteries	6.49	0.03

Source: REMA, 2023.

The total amount of mercury emissions and releases is distributed as follows; 2,396.58 kg are emitted to air, 544.01 kg are released to water, 13,480.66 kg are released to land, 600.41 kg are partitioned to by-products and impurities, while 2,415.00 kg are released to general waste and 122.19 kg are released into sector specific treatment or disposal.

The main potential source of mercury releases and emissions in Rwanda appears to be the extractive industrial sector (Primary metal production), which is consistent with findings from other countries in the region. Primary metal production accounts for 75.0 % of total mercury emissions and releases in Rwanda[7].

Identification and Quantification of Mercury Releases was done using the UNEP Toolkit. The Toolkit was used to guide the development of the inventory and in particular to identify sources and quantify consumption, emissions, and releases of mercury from these sources.

The inventory was developed using the level 2 and the quantities of mercury releases and emissions in Rwanda was computed based on mass balance approach as provided for by the toolkit. National, regional, and international information sources were used to collect mercury related data for the identified sources of mercury, completed by field visits to verify and assess processes and technologies that are currently applied in Rwanda[8].

2.4. Mercury waste management analysis in Rwanda

Referring to the data from MINICOM, the imports of items containing mercury have been reduced (**Figure 2.1.**). **Table 2.3.** shows more details on the import of mercury and mercury-containing items from 2011 to 2022. Particularly, it was found that the imports of items containing mercury have been reduced from 11,897 kg in 2011 to 156 kg in 2022. However, the cumulative import of items containing mercury in the past 10 years equals to 84,775 kg according to records from MINICOM. This shows the significant reduction of mercury and mercury-contaminated wastes in the future. The importers of those items include logistic companies, construction companies, trading companies, power plants, individuals, etc.

[7]See: REMA, 2023. Rwanda Minamata Initial Assessment Report

[8]UN Environment (2019). Toolkit for Identification and Quantification of Mercury Sources, Guideline for Inventory Level 1, Version 2.1, UNEnvironment Chemicals and Health Branch, Geneva, Switzerland

Table 2. 3: Imports of mercury and items containing mercury in Rwanda

Year	Mercury (kg)	Compounds -inorganic and organic of mercury excluding amalgams (kg)	Mercury or Sodium Vapor Lamps (kg)	Other inorganic or organic compounds not chemically defined (kg)
2011	0	11897	1352	0
2012	2	115	2884	50
2013	0	0	958	4305
2014	0	125	45891	9025
2015	0	1000	23491.52	566
2016	1200	375	2229.18	15
2017	0	525	1392	570
2018	830	75	971	650
2019	1385	0	202	86
2020	145	0	3221	0
2021	1	0	602.58	0
2022	0	0	155.95	1

Source: MINICOM, 2023.

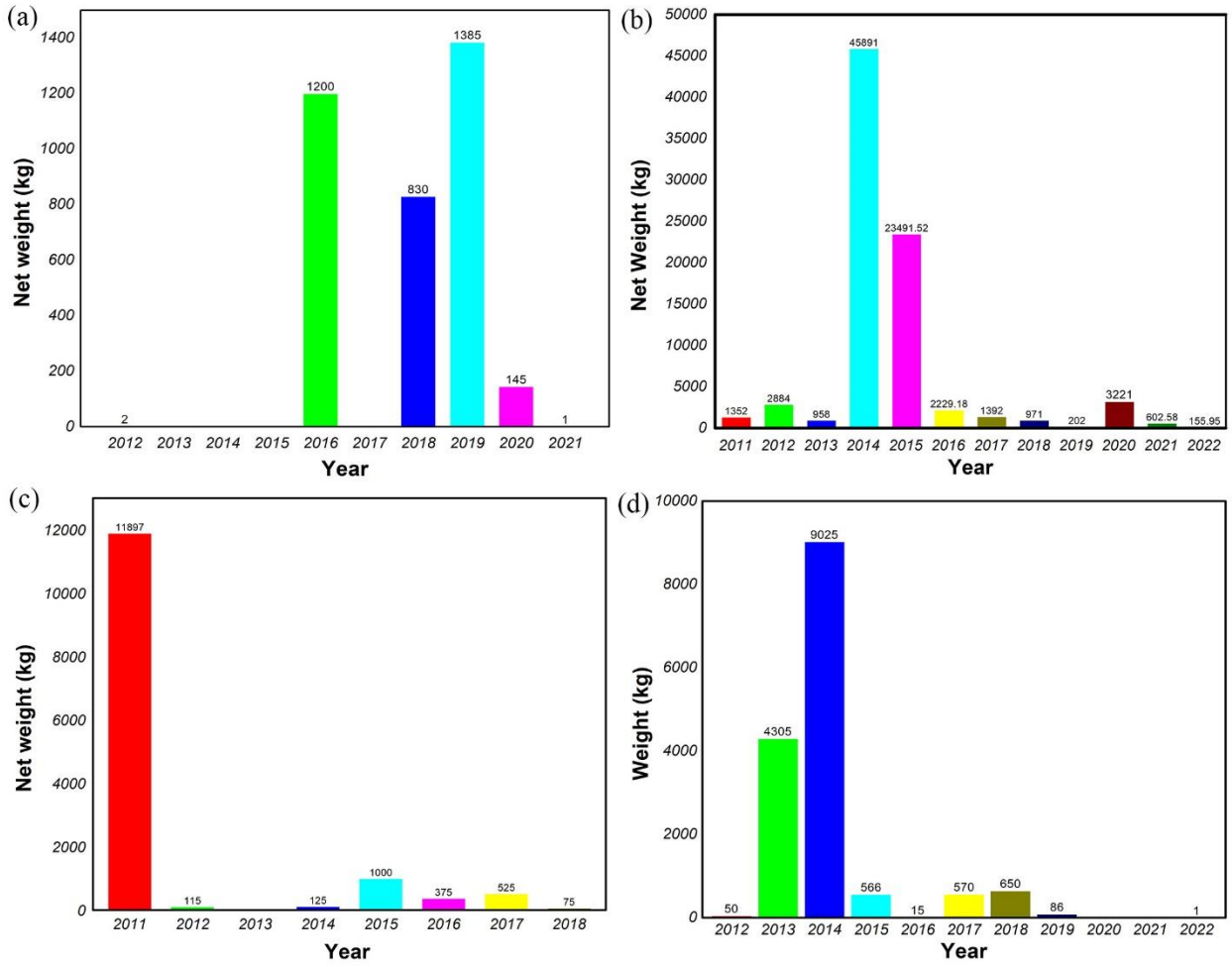


Figure 2. 1: *Imports of mercury and items containing mercury in Rwanda: (a) Mercury; (b) Mercury or sodium vapour lamps; (c) Compounds_inorganic or organic of mercury excluding amalgams; and (d) Other inorganic or organic compound_ Not chemically defined.*

This survey found that there is a gap in the management of waste containing mercury. There is a phase out of the items containing mercury, but the challenge is the disposal of those items. Thermometers and barometers containing mercury are kept in stores of different institutions waiting for finding the solution for their disposal. The wastes contaminated with mercury found during this study are solid wastes (the parts or whole discarded instruments, mercury compounds kept in their containers, etc.) containing pure mercury or other mercury compounds.

At Rwanda Meteorology Agency, there is a plan to replace the thermometers and barometers containing mercury with the ones free of mercury. The unused and new mercury-containing barometers and thermometers are kept in the store waiting for disposal (**Figure 2.2. a, b**). They

keep those items in their protective boxes to prevent them from breaking and spread mercury. Even though precautions are taken, those items may be broken and spread the mercury in the environment.

Enviroserve Rwanda has a store of around 1.5 tons of mercury wastes from electronic and electrical wastes (**Figure 2.2. c, d**). Most mercury and mercury compounds are kept in their original containers (e.g., lamps, thermometers, etc.) to avoid the spread of mercury and the contamination of other wastes.

At Rwanda Medical Supply ltd. there is around **150 kg** of thermometers containing mercury. Some of these thermometers were collected from the health sector institutions and others are new. As there is a phase out of thermometers containing mercury, these thermometers are waiting for final disposal.

The inventory done in secondary schools showed that there is around **1.10 kg** of the compound containing mercury used for experiments. Those compounds include Mercury oxide **(100 g)** at Kagarama Secondary School, Mercury (II) sulfide **(500 g)** at E.S. Kaduha, and Mercury (I) nitrate **(500 g)** at Indatwa Inkesha School G.S.O.B.

Figure 2. 2: *Mercury wastes: (a, b) Thermometers and barometers at Rwanda Meteorology Agency; (c-e) Enviroserve Rwanda (July 2023).*

2.5 Proper disposal of mercury

Disposal operations are those operations which do not lead to the possibility of resource recovery, recycling, reclamation, direct re-use, or alternative uses. The Basel Technical Guidelines

address disposal operations as an inherent part of disposal as noted in Annex IV, Section A and suggest permitting the following operations for mercury wastes[9]:

- D5 – Specially-engineered landfill
- D9 – Physico-chemical treatment
- D12 – Permanent storage
- D13 – Blending or mixing prior to submission to D5, D9, D12, D14 or D15
- D14 – Repackaging prior to submission to D5, D9, D12, D13 or D15
- D15 – Storage pending any of the operations D5, D9, D12, D13 or D14

2.5.1. Physico-chemical Treatment (Stabilization/Solidification)

Mercury wastes can be chemically stabilized and/or physically solidified using commercially available technologies. In many cases, a combination of both is used.

In stabilization processes, mercury is brought into reaction with chemical agents that convert it into a substance that is thermodynamically more stable, less soluble, and less volatile, making it less mobile and thereby reducing release and exposure potential.

In solidification processes mercury wastes are embedded in a solid and stable matrix. **Micro-encapsulation** means mixing the waste with the encasing material. **Macro-encapsulation** means pouring the encasing material over and around the waste mass, thus enclosing it in a solid block.

a. Challenges Related to Physico-chemical Treatment

- Increased storage/disposal costs due to additional treatment and waste volume should be considered
- Measures to prevent decomposition of stabilized mercury wastes in the long term should be identified
- Completeness of the reaction between mercury and treatment chemicals should be established
- Further research and steps towards large-scale commercialization needed.

b. Opportunities Related to Physico-chemical Treatment

- Reduces vapors pressure, solubility, and mobility; enhances physical strength.

[9] UNEP (2015), Practical sourcebook on mercury waste storage and disposal.

• Enhances safeguards against illegal use.

• Stabilized/solidified mercury wastes are relatively easy and safe to handle.

• Allows safe storage and disposal in Specifically Engineered Landfill SELs or permanent storage underground.

2.5.2. Specially Engineered Landfill

A specially engineered landfill (SEL) is an environmentally sound system for solid waste disposal and is a site where solid waste is capped and isolated from each other and from the environment.

a. Challenges Related to Specially Engineered Landfills

• Long-term stability of treated mercury wastes in SELs should be examined and methods to evaluate such long-term stability should be established.

• SELs where treated mercury wastes are disposed of should be continuously managed and monitored to prevent mercury releases to the environment.

b. Opportunities related to Specially Engineered Landfills

• Well established concept in many countries; experience with other hazardous wastes.

• Relatively low investment costs.

• Mercury wastes are isolated for a defined period of time.

• SELs could be a solution to countries that do not have natural underground facilities/options.

2.5.3. Permanent Storage (Underground Facilities)

Mercury wastes can be permanently stored in deep geological cavities (e.g., in an underground mine). The intent is to permanently isolate mercury wastes from the biosphere by including it as completely and permanently as possible in a suitable host rock via several natural and artificial barriers. A detailed case-by-case evaluation of the suitability of any such facility is critical to its effectiveness.

Mercury wastes, after having been solidified or stabilized, where appropriate, which meet the acceptance criteria for permanent storage (disposal operation D12) may be permanently stored in special containers in designated areas in an underground storage facility such as in salt rock.

2.6 Summary

According to the WHO, inhaling mercury vapor can have harmful effects on the nervous, digestive, and immune systems, lungs, kidneys, and skin, and can be fatal. Air, water, and soil are also affected by mercury pollution. On the other side, from the recent data from the Minamata Initial Assessment report by REMA in 2023, it is reported that 19,558.85 kilograms of mercury are released each year into the air, water, and soil, with harmful effects on the environment and human health. This shortcoming is attributed to the artisanal and small-scale gold mining sector, as well as the health, information, and communication technology, transport, water, and informal economy sectors, which have been identified as priority sectors for mercury use in Rwanda. These include activities such as the production of cement, pulp and paper, lime and light aggregates, chemicals and laboratory equipment, monometers and gauges, waste incineration and burning, the production of recycled materials, waste dumping and landfilling, wastewater treatment and dental amalgams. From these perspectives, Rwanda is stepping up the fight against mercury pollution by reducing and, if possible, eliminating the use of mercury in key industrial sectors identified.

2.7 Recommendation

The recommendations are:

- Construction of interim storage facilities for mercury wastes accessible to anyone who generates the wastes containing mercury.
- Construction of final disposal facilities for waste containing mercury.
- Sensitization of mercury and wastes containing mercury management and their impact on human health.
- Facilitate and support the investors whose activities include recycling or disposing of wastes containing mercury.
- Education on waste sorting and management.
- Use alternative means to replace mercury. For example, where mercury is used as a catalyst, use alternative catalyst.

Chapter 3: Inventory of persistent organic pollutants (POPs) in Rwanda

3.1 Introduction

According to the United Nations Environment Programme (UNEP), Persistent Organic Pollutants (POPs) are a set of toxic chemicals that are persistent in the environment and able to last for several years before breaking down (UNEP/GPA 2006a).

They are toxic chemicals that negatively affect human health and the environment. POPs are persistent in the environment with the ability to accumulate high concentrations in fatty tissues and are bio-magnified through the food-chain. As they can be transported by wind and water, most POPs generated in one country can affect people and wildlife far from where they are used and released.

POPs include a range of substances such as:

(i) Intentionally produced chemicals currently or once used in agriculture, disease control, manufacturing, or industrial processes. Examples include PCBs, which have been useful in a variety of industrial applications (e.g., in electrical transformers and large capacitors, as hydraulic and heat exchange fluids, and as additives to paints and lubricants) and Dichlorodiphenyltrichloroethane (DDT), which is still used in some parts of the world as biocide.

(ii) Unintentionally produced chemicals, such as dioxins, resulting from some industrial processes and from combustion (for example, municipal and medical waste incineration and backyard burning of trash).

In 1995, the UNEP expanded its research and investigation on POPs with an initial focus on what became known as the “Dirty Dozen” (Annex 2). From that time, additional substances such as

carcinogenic polycyclic aromatic hydrocarbons (PAHs) and certain brominated flame-retardants, as well as organometallic compounds such as tributyltin (TBT) have been added to the list of Persistent Organic Pollutants.

3.2 Methodology

3.2.1 Document review and key informant interviews

In this inventory, an extensive document review was conducted in line with chemicals and hazardous waste management by institutions and their needs. Documents include previous inventories, previous studies/publications on the subject of chemicals and hazardous waste management in Rwanda, and the Conventions such as Stockholm, Rotterdam, Basel and Minamata which were reviewed throughout the assignment.

The second dimension of the data collection process was through in-depth interviews of key informants that have knowledge of either chemicals management and/or hazardous waste management in their institutions. Accordingly, an interview schedule was developed for the purpose of obtaining data during the face-to face interview. The target respondents were Chief Executive Officers (CEOs) of Lead Agencies, heads of the chemicals and/or waste management departments of the institutions, representatives of non-state actor institutions, officers from policy development in Government, regulatory agencies, and technical support institutions.

3.2.2 Aim of the survey

This task was important to understand the status of PCBs in Rwanda, including their quantification and analysis of transformer oil for all suspected transformers to contain PCBs. The scope therefore focused on tracing the fate of previously inventoried PCBs in 2013 and to locate PCBs hotspots in Rwanda. The specific activities conducted under this task are as follows:

- Conducting in-desk data collection – from secondary sources (e.g., previous inventories, reports were collected from REMA), regarding PCBs and their management in Rwanda;
- Identify and evaluate the status and current quantity of previously inventoried PCBs in Rwanda (e.g., record what happened after the inventory);
- Conduct the inventory of transformers imported from 2013 to date and assess if there is any transformer filled with Askarel/ PCBs imported since that time. This assessment followed the REMA guideline [10] for PCBs inventory and the datasheet in **Annex 9** was used to collect relevant information at REG/EDCL;
- Conduct the lab analysis with rapid test kits for the suspected new transformers (the analysis excluded the already tested transformers in the previous inventory).

3.3 POPs inventory results

3.3.1 PCBs inventory results

The initial inventory was conducted in 2005 and covered each of the four provinces of the country and Kigali, the capital. It focused mainly on transformers. A total of 986 transformers were inspected out of 1,012 existing transformers by that time. From that inventory, it was concluded that around 154 tons of fluids contained PCBs and 353 tons of solid wastes were contaminated with PCBs[11].

Based on the updated PCBs inventory that was conducted in 2013, a total number of 2,349 transformers were inspected in 23 of the 30 Districts in Rwanda. Many sites surveyed contained transformers manufactured after 1986; where 2,051 manufactured after 1986 and 229 before 1986, all of which have not been tested for PCBs. In the absence of contrary information (such as analytical data or a confirmed age for the equipment), all units manufactured before 1986 have been assumed to contain PCBs, until analytical tests are done. The **Table 3.1** below illustrates the results of inventory conducted in 2013[12].

[10] REMA, 2013: Guide/ Manual for PCBs inventory guidance in Rwanda in 2013
[11] REMA, 2015.Polychlorinated Biphenyls (PCBs) disposal and Management Plan in Rwanda
[12] REMA, 2015.Polychlorinated Biphenyls (PCBs) disposal and Management Plan in Rwanda

Table 3. 1: *Adapted to situation of the updated inventory in 2013*

Branch	Inventoried equipment	Equipment supposed with PCB	Quantity of PCBs		
			Liquid	Waste	Total
Remera	118	20	118.893	20.419	139.402
Kacyiru	96	15	102.376	2.0439	104.42
Kanombe	97	15	95.175	6.5405	101.716
Gikondo	102	11	132.816	9.973	142.789
Muhima	119	11	178.448	12.445	190.893
Nyarugenge	75	18	34.935	59.715	94.65
Nyamirambo	39	3	30.937	13.914	44.851
Ngoma	252	5	144.979	32.31	177.289
Nyagatre	335	7	44.081	76.081	120.162
Bugesera	79	2	39.202	14.999	54.201
Rwamagana	106	1	37.725	13.914	51.639
Nyamagabe	127	1	56.25	20.634	76.884
Huye	88	11	57.837	20.439	78.276
Nyanza	45	6	3.619	6.5405	10.16
Ruhango	48	3	24.064	9.973	34.037
Muhanga	72	2	49.149	12.445	61.594
Karongi	58	18	150.46	59.715	210.175
Ngororero	60	9	33.46	13.914	47.374
Rubavu	85	26	76.45	32.31	108.355
Rusizi	102	18	182.638	76.081	258.719
Musanze	108	17	151.901	75.245	227.146
Rulindo	86	6	33.46	13.914	47.374
Gicumbi	46	4	43.807	20.634	64.441
Total	**2344**	**229**	**1,780.907**	**665.64**	**2,446.547**

Source: REMA, 2015

The updated inventory has contributed to better identification of the national stock of PCB-containing transformers in terms of levels of PCB concentration but also enabled to establish a plan for a gradual phase-out of in-service transformers and decommissioning of out-of-service transformers. The national technical capacity for elaboration of PCB management strategies and action plans has been enhanced as well. The information on the level of PCB-contamination of transformers in the 2016 survey was obtained through field testing by rapid analytical methods. The testing by the quantitative method confirmed contamination by PCBs in 100 transformers. That included 23 phased-out transformers stored at the Gikondo storage facility and 77 transformers in operation mostly owned by REG.

i. PCBs inventory current situation in 2023

In August 2018, the Government of Rwanda through the Rwanda Environment Management Authority (REMA) started the incineration of Polychlorinated Biphenyls (PCBs) oil from transformers.[13] The incineration took place at the cement kilns of CIMERWA, a Rwandan cement manufacturer located in Rusizi District, Western Province. The incineration initiative has been funded by the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP) through the 'Management and Disposal of Polychlorinated Biphenyls (PCBs) in Rwanda' project. This project was managed by REMA in partnership with the Energy Utility and Corporation Ltd (EUCL). It was planned to incinerate approximately 50 metric tons of PCBs contaminated oils which were collected from 96 transformers. However, 5.2 extra tons were incinerated hence incineration of 55.2 tons of PCB-oil was completed under this project[14].

To date, the data from REG shows that there are only 4 transformers containing PCBs still in use. There are 2 transformers at Mironko Plastic Industries and one transformer at Hotel des Mille Collines in Kigali city, and one transformer at Ruhengeri Hospital in Musanze District. Other transformers contaminated with PCBs are stored at the warehouse of REG located in Jabana, Kigali City **(Table 3.2)**. Among those 21 transformers stored in Jabana, only 2 still contain PCB oils **(Figure. 3.1 (a, b))** as they were phased out after the "Management and Disposal of PCBs in

[13] REMA, 2018. Rwanda incinerates harmful oils used in transformers: www.rema.gov.gov.rw (Accessed on July 26th, 2023).
[14] GEF, 2018. Management and disposal of PCBs in Rwanda, Terminal Evaluation Report.

Rwanda" project was ended. The other 19 are empty as their oils were incinerated at CIMERWA. **(Figure 3.2).** Thus, there are around 1.066 tons of PCB oil and 12.759 tons of PCB contaminated wastes (10.759 tons of the transformers which still contain or contained PCBs before (**Figure 3.3)** and around 2 tons of other PCB – contaminated wastes (Figure 3.4). The estimated amount of PCB waste was obtained after consulting REG, field visits and testing the oils of the transformers by the consultants.

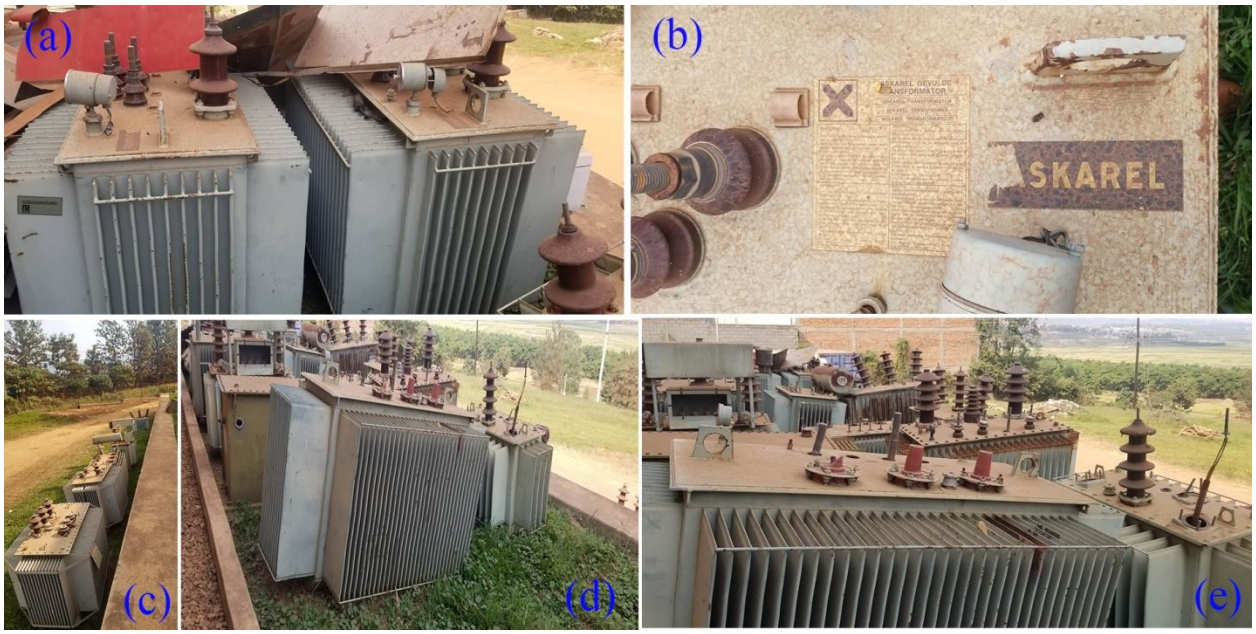


Figure 3. 1: *Current storage of transformers contaminated by PCB at REG storage in Jabana. (a) and (b)Transformers containing PCB oil; (c-e) Storage situation.*

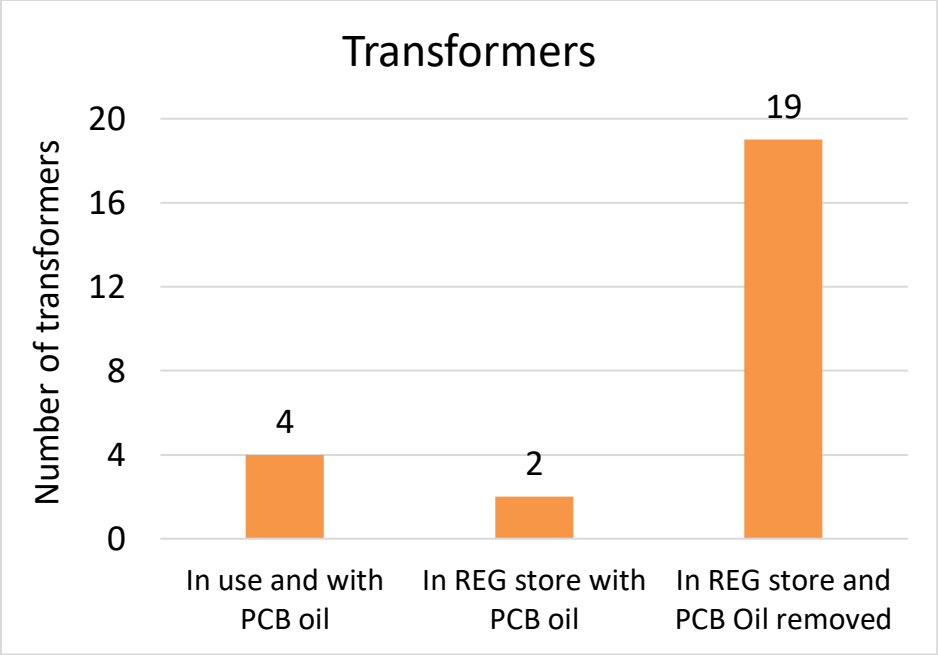


Figure 3. 2: Number of transformers with PCB oils in Rwanda, 2023

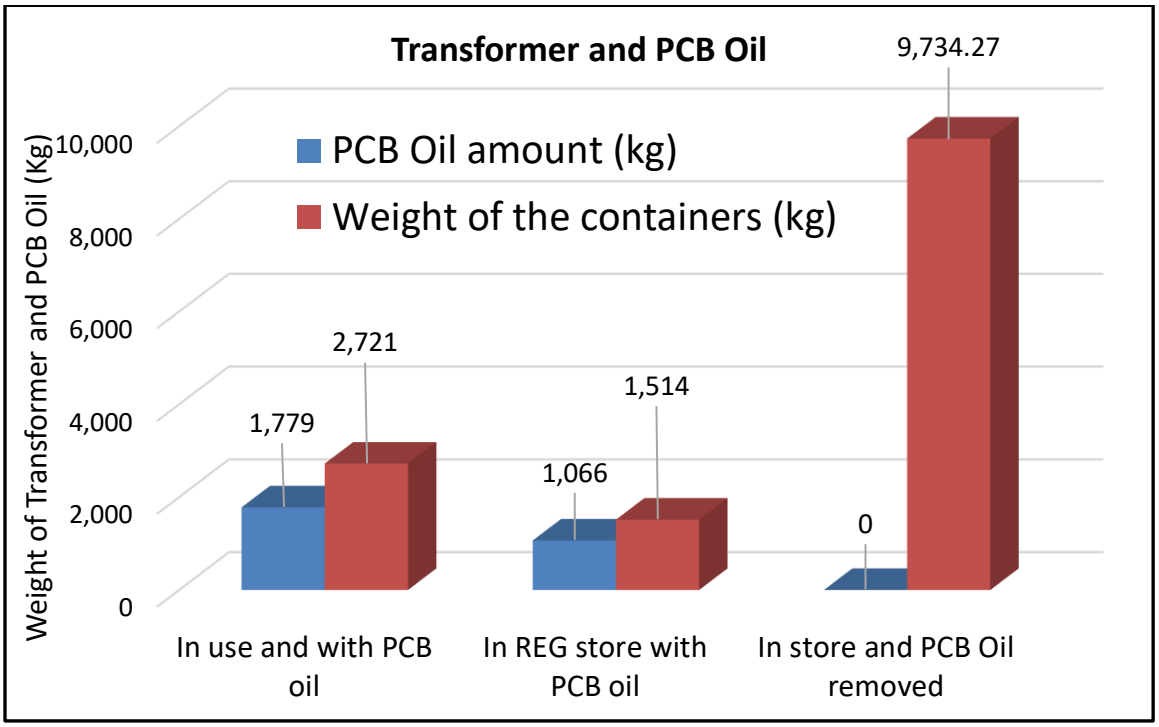


Figure 3. 3: Weight of Transformer and PCB Oil in Rwanda 2023

Table 3. 2: *PCB oil and PCB contaminated transformers in Rwanda, July 2023.*

Transformers	Number of transformers	PCB Oil amount (kg)	Weight of the containers (kg)	Transformer total weight (kg)
In use with PCB oil	4	1,779	2,721	**4,500**
In REG store with PCB oil	2	1,066	1,514	**2,580**
In REG store with PCB oil removed	19	*	9,734.27	**9,734.27**
Total	**25**	**2845**	**13969.27**	**16814.27**

* *As the transformers were not washed to remove the contamination from PCB oil, the amount of the oil is unknown. But those transformers are considered as PCB contaminated wastes.*

ii. PCBs current disposal status and associated risks

Currently, transformers containing or contaminated by PCB oil are stored outside in the garden **(Figure 3.1 (c-e))** and some of them are open. This facilitates the spread of PCB oils in the environment. There is also a container in which the other wastes contaminated by PCBs are stored **(Figure 3.4).** In addition to that, till now, REG faces the challenges of final disposal of these PCB contaminated wastes. They need guidelines and financial support. In addition, quicker disposal is needed to avoid the exposure of PCBs as the risk of pollution of the ecosystem, human health, water, soil, and air is very high.

Figure 3. 4: Wastes contaminated by PCBs (other than transformers) at REG storage at Jabana interim storage.

The risk on the soil and water is very high as the leak of these oils may lead to their penetration in the soil to reach the ground water. PCBs do not readily break down once in the environment and they can remain for long periods cycling between air, water and soil.[15] PCBs can accumulate in the leaves and above-ground parts of plants and food crops. They are also taken up into the bodies of small organisms and fish. As a result, people who consume fish may be exposed to PCBs that have bioaccumulated in the fish they are ingesting. This shows how the impact of the PCBs contaminated wastes stored in Jabana may have the huge negative impact on the ecosystem and human health.

iii. PCB testing in transformers

During this study, we tested the oils taken from 6 transformers located in Kigali City, Musanze District, and Rubavu District. The purpose was to confirm the results found in the inventory done in 2013 on the transformers owned by REG. In addition, after consulting REG, we were informed that there are private companies producing electricity and sell it to REG[16]. We found that their transformers were not included in the inventory of 2013.

a. Materials and methods

The transformer oils were tested using CLOR-N-OIL 50 PCB screening kit manufactured by Dexsil Corporation and supplied by ETI Environmental Technology International Ltd. These kits work on the principle of chlorine determination. Since PCBs are chlorine-based materials, the test kits are able to detect them. These kits are able to detect the PCB oils with the concentration higher than 50 ppm.

The oils were taken from some transformers owned by REG which the inventory of 2013 showed that they contain PCBs (2 transformers located at REG storage in Jabana and 1 located at Ruhengeri Hospital) and other 3 transformers from private power plants **(Table 3.3)**. Those power plants are Gisenyi (started the activities in 1957), Gihira (started the activities in 1984) and Mutobo (started the activities in 2009). From each transformer we took one sample, and one test

[15] https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls (Visited on October 31st, 2023).
[16] https://www.reg.rw/what-we-do/generation/power-plant/ (Visited on September 21, 2023).

was performed for each sample. Due to financial and time constraints, we were not able to test transformers from all private power plants.

Table 3. 3: PCB testing in Transformers from private power plants in Rwanda.

District	Power plant	On grid/off grid	Installed capacity/MW	Owner	Age
Musanze	Mutobo	On grid	0.2	REPRO LTD/ IPP	2009
Rubavu	Gihira	On grid	1.8	RMT/PPP	1984
	Gisenyi	On grid	1,7	Prime Energy/PPP	1957

b. Results

The samples from the transformers of REG showed that the oils of one transformer at REG storage in Jabana and the one at Ruhengeri Hospital contain more than 50 ppm of PCBs. The other transformer at REG storage in Jabana contains pure Askarel. These are the transformers out of service.

The samples taken from transformers which are still used in the grid system were also tested (**Figure 3.5**). The sample from the transformer located at Ruhengeri hospital showed that the oil contains more than 50 ppm PCBs **(Table 3.4)**. Other samples showed that the other transformers contain less than 50 ppm PCBs, meaning that the PCB content may be 0 ppm.

Figure 3. 5: PCB determination in oils which are in service (the above part of the figure is the reference from the manufacturer of the test kits).

Table 3. 4: Results of PCB testing in transformers

District	Power plant	On grid/off grid	Manufactured year	Results
Musanze	Mutobo	On grid	2016	Less than 50 ppm PCBs
	Ruhengeri Hospital		1983	Higher than 50 ppm PCBs
Rubavu	Gihira	On grid	1985	Less than 50 ppm PCBs
	Gisenyi	On grid	2017	Less than 50 ppm PCBs

Source: (REG, 2023, the results were obtained by conducting tests during this survey)

3.3.2 POPs Pesticides Inventory Results

Pesticide is any substance, or mixture of substances of chemical or biological ingredients intended for repelling, destroying, or controlling any pest, or regulating plant growth. A number of pesticides have also been shown to cause adverse effects on non-target organisms, amongst those are POPs man-made hazardous chemicals that threaten human health and the planet's ecosystems potentially causing biodiversity loss. The Stockholm Convention obliges Parties to eliminate the production and use of pesticides listed in its *Annex A* and to restrict the production use of the pesticides listed in *Annex B*[17].

There are 17 POPs used as pesticides which are listed in Annex A**:**

- **Aldrin** to kill termites, grasshoppers, corn rootworm, and other insect pests;
- **Chlordane** to control termites;
- **Chlordecone** as agricultural pesticide;
- **Dicofol** to control mites on a variety of field crops, fruits, vegetables, ornamentals, cotton, tea, acaricide for cotton, citrus and apple crops;
- **Dieldrin** to control termites and textile pests;
- **Endrin** insecticide sprayed on the leaves of crops such as cotton and grains, also used to control rodents such as mice and voles, Heptachlor to kill soil insects and termites;
- **HCB** widely used to control wheat bunt;
- **Alpha-HCH** and **Beta-HCH** insecticide;
- **Lindane** broad-spectrum insecticide for seed and soil treatment;
- **Mirex** to combat fire ants;
- **PeCB** fungicide, PCP herbicide, insecticide, fungicide, algaecide;
- **Endosulfan** to control crop pests, tsetse flies and ectoparasites of cattle, used also as wood preservative.
- **Toxaphene** insecticide used on cotton, cereal grains, fruits, nuts, and vegetables are also used to control ticks and mites in livestock.

[17] Pesticide POPs | UNEP - UN Environment Programme (www.unep.org, visited on August, 20th 2023).

Most of the pesticides used in Rwanda are imported from different countries. However, the country has established a list of allowed and forbidden importation that is published and regularly updated. In 1990s, the first ministerial directives were made public to prohibit the importation and the use of POPs pesticides used in Rwanda such as DDT, Aldrin, Dieldrine and Endrin. These pesticides were replaced by the organophosphorous compounds and synthesized pyrethrinoïds[18]. In 2007, the first National Implementation Plan (NIP) has taken account twelve chemical substances regulated by the Stockholm Convention on Persistent Organic Pollutants (POPs), namely: Aldrine, Endrine, DDT, Dieldrine, Chlordane, Mirex , Toxaphene , Heptachlor, Hexachlorobenzene, Polychloro Biphenyls, Polychloro dibenzo-p-Dioxine, Polychloro Dibenzofuran); the first nine on the list being pesticides. From 2007 to 2012, nine new chemical substances have been added on the list of POP pesticides: Lindane (γ-HCH), Chordecone, α-Hexachlorocyclohexane (α-HCH), β-Hexachlorocyclohexane (β-HCH), Endosulfan, and Pentachlorobenzene.[19]

The inventory study done in 2015 shows that the importation of products used in agricultures containing POPs was banned. The POPs containing biocides were temporarily disposed in Nyanza (Kigali City) and are still there. At Nyanza former public wastes sites there are 3,028 kg of solid POP wastes, including lindane and endosulfan stored in plastic drums.[20] The present study found that there is a need of proper management of that interim storage facility because it seems to be abandoned and relocating the place is very difficult. Also, the plants and trees grown there may damage the storage and cause the leakage of those wastes.

Table 3. 5: Obsolete POP Pesticides interim storage and weight in Rwanda, July 2023

S/N	POP Pesticides (Obsolete)	Location of interim storage	Amount (kg)	Geographical location
1	Lindane +Thiram (Fernasan) 45 % WP	Nyanza former public wastes landfill	1,280	Elevation: 1684m; E: 00511175; N: 04778661
2	Endosulfan 3% Dust	Nyanza former public wastes landfill	1,748	

Source (REMA, 2015)

[18] REMA, 2016. Update national implementation plan of Stockholm Convention on persistent organic pollutants.
[19] REMA, 2016. Update national implementation plan of Stockholm Convention on persistent organic pollutants.
[20] REMA, 2015. Update national implementation plan of Stockholm Convention on persistent organic pollutants.

3.3.3 PBDEs inventory Results

Polybrominated Diphenyl Ethers (PBDEs) include the commercial versions of pentabromodiphenyl ether (c-pentaBDE), octabromodiphenyl ether (c-octaBDE), and decabromodiphenyl ether (c-decaBDE). PBDEs are used as flame retardants in a number of applications, including plastic cabinets for televisions, personal computers, and small appliances; wire insulation, and automobiles[21]. PBDEs are found in vehicles manufactured before 2004.[22] These chemicals can get into the air, water, and soil during their manufacture. They can also leak from products that contain them or escape when the products that contain them break down.[23] They do not dissolve easily in water; they stick to particles and settle to the bottom of rivers or lakes. Some PBDEs can build up in certain fish and mammals when they eat contaminated food or water.

People can be exposed to PBDEs and PBBs by eating contaminated foods, especially those with a high fat content, such as fatty fish. Another source of exposure results from breathing contaminated air or swallowing contaminated dust. Working in industries that make these chemicals or that make, repair, or recycle products containing these chemicals flame retardants can result in exposure.[22]

In Rwanda, the main source of PBDEs wastes is electric and electronic equipment. To get the exact total amount of PBDEs wastes in Rwanda is difficult because of the informal sector involvement in refurbishing and recycling e-waste; informal recycling of plastic wastes; and insufficient record of PBDEs wastes in public and private organizations. The records of Enviroserve Rwanda shows that they have collected around **200 tons** of PBDEs wastes from E-wastes. At Enviroserve Rwanda, they separate PBDEs from other wastes, wash and crush them to be sold to companies for recycling **(Figure. 3.7)**.

[21] EPA: www.epa.gov (visited on August 28, 2023).
[22] REMA, 2015. Update national implementation plan of Stockholm Convention on persistent organic pollutants.
[23] CDC: www.cdc.gov (visited on August 28, 2023).

Figure 3. 6: Treated PBDEs wastes at Enviroserve Rwanda waiting for recycling (July 2023).

3.4 Proper disposal of POPs

According to UNEP guidelines, the disposal of POP wastes can be done in two steps: the pre-treatment and disposal of POP wastes.[24]

3.4.1. Pre-treatment

a) Adsorption and absorption

The word "*Sorption*" is the general term for both absorption and adsorption processes. Sorption is a pre-treatment method in which solids are used for removing substances from liquids or gases. The *adsorption* involves the separation of a substance (liquid, oil, gas) from one phase and its accumulation at the surface of another (e.g., activated carbon, zeolite, silica, etc.). On the other hand, *absorption* is the process whereby a material transferred from one phase to another interpenetrates the second phase, e.g., when contaminants are transferred from liquid phase onto granular activated carbon (GAC). GAC is widely applied in the removal of organic contaminants in wastewaters because of its effectiveness, versatility and relatively low-cost. Both adsorption and absorption processes can be used to extract contaminants from aqueous wastes and from gas streams. The concentrate and the absorbent or absorbent may require treatment prior to disposal.

[24] UNEP (2019), General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants.

b) Blending

The blending of waste is the process to create a homogeneous feedstock prior to waste treatment and most of the time it may be appropriate in order to enable treatment or to optimize treatment efficiency. However, the blending of wastes with POP content above a defined low POP content with other materials for the purpose of generating a mixture with a POP content at or below the defined low POP content is not environmentally sound.

c) Desorption

Desorption includes chemical desorption and thermal desorption. Thermal desorption (e.g., through vacuum thermal recycling or the use of a toroidal bed reactor or a liquid waste pre-heater) is a technology that utilizes heat to increase the volatility of contaminants such that they can be removed (separated) from a solid matrix (typically soil, sludge, or filter cake). Direct fired and indirect fired desorbers exist. Thermal desorption processes are also categorized into high temperature thermal desorption (HTTD) and low-temperature thermal desorption (LTTD) processes. In HTTD, wastes are heated between 320 ℃ and 550 ℃ whereas in LTTD between 90 ℃ and 350 ℃. LTTD, also known as low-temperature thermal volatilization, thermal stripping and soil roasting is used for volatile and semi-volatile compounds and elements (most commonly light petroleum hydrocarbons) from contaminated media (most commonly excavated soils). Such processes have been used for the decontamination of non-porous surfaces of electrical equipment, such as transformer carcasses that formerly contained PCB-containing dielectric fluids, or fluorescent lamps that contained mercury. Thermal desorption of POP wastes may result in the unintentional formation of POPs which may require additional treatment of treated waste or off-gas released.

d) Dewatering

Dewatering is a pre-treatment process in which water is partially removed from the waste to be treated. Dewatering can be employed for disposal technologies that are not suitable for aqueous wastes. For example, water will react explosively with molten salts or sodium. Depending on the nature of the contaminant, the resulting vapors may require condensation or scrubbing and further treatment.

e) Dismantling/disassembling

Dismantling or disassembling is a pre-treatment in which equipment, components or assemblies are taken apart to separate materials to increase options for reuse, refurbishment, recycling, recovery, and final disposal.

f) Dissolution

It is a pre-treatment process by which a waste (liquid, solid or gas) is dissolved into a solvent.

g) Distillation

It is a process which separates a solvent from a mixture by applying thermal energy and vaporizing components and then condensing that vapor in a subsequent stage. Through this process, the solvent is separated, thereby allowing for subsequent recovery of the solvent and the reduction of the volume of waste destined for final disposal using other processes.

h) Drying

Drying is a pre-treatment that removes water or a solvent by evaporation from a solid, semi-solid or liquid waste. In general, a gas stream, e.g., air, applies the heat by convection and carries away the vapor as humidity. Vacuum drying can also be used when heat is supplied by conduction or radiation (or microwaves), while the vapor produced can be removed with a vacuum system.

i) Other pre-treatment processes

There are other pre-treatment processes for POP wastes such as Mechanical separation, Membrane filtration, Mixing, Oil-water separation, pH adjustment, Sedimentation, Size reduction, Solvent washing, Stabilization and solidification, Vaporization, and Volume reduction.

3.4.2. Destruction and irreversible transformation methods

The following disposal operations, should be permitted for the purpose of destruction and irreversible transformation of the POP wastes when applied in such a way as to ensure that the remaining wastes and releases do not exhibit the characteristics of POPs:

(a) D9: Physico-chemical treatment;

(b) D10: Incineration on land;

(c) R1: Use as a fuel (other than in direct incineration) or other means to generate energy; and

(d) R4: Recycling/reclamation of metals and metal compounds.

POPs that are isolated from a waste stream during pre-treatment should subsequently be disposed of in accordance with operations D9 and D10.

Available information on the technologies, especially for more recent ones, is constantly evolving. Each facility operator may determine if an appropriate level of destruction and irreversible transformation will be achieved using a particular technology in given conditions. Those technologies are summarized are Alkali metal reduction, Advanced solid waste incineration, Base catalyzed decomposition, Catalytic hydrodechlorination, Cement kiln co-incineration, Gas phase chemical reduction, Hazardous waste incineration, Plasma arc, Plasma melting decomposition method, Supercritical water oxidation and subcritical water oxidation, and Thermal and metallurgical production of metals. Further details on the specificity of each technology can be found in the subsection IV.G.2 of the general technical guidelines (UNEP (2019), General technical guidelines on the environmentally sound management of wastes consisting of, containing, or contaminated with persistent organic pollutants).

3.4.3. Specially engineered landfill

Any landfilling should be carried out in a way that minimizes the potential of the POP content to enter the environment. This may be achieved through pre-treatment, e.g., a suitable solidification process.

A specially engineered landfill should comply with requirements regarding location, conditioning, management, control, closure, and preventive and protective measures to be taken against any threat to the environment in both the short and long term. In particular, measures should prevent the pollution of groundwater through leachate infiltration into the soil. Protection of soil, groundwater and surface water should be achieved through a combination of a geological barrier and a synthetic bottom line system during the operational phase and through a combination of a geological barrier and a top liner during the closure and post-closure phases. Measures should

be taken to prevent and reduce the production of gases and, as appropriate, introduce landfill gas collection and control systems.

Chemicals, including POPs, found in leachate, and discharged into the receiving environment can have an impact on the environment and human health. Landfill leachate on-site treatment technologies should be in place to reduce and prevent toxic leachate from entering the environment. Leachate can be treated through the use of physico-chemical and biological treatments or advanced treatment technologies such as active carbon filtration, reverse osmosis and nanofiltration, among others.

In addition, a uniform waste acceptance procedure based on a classification procedure for acceptable waste, including standardized concentration limit values, should be introduced. Moreover, monitoring procedures during the operation and post-closure phases of a landfill should be established in order to identify and prevent any possible adverse environmental effects of the landfill and take the appropriate corrective measures. A specific permit procedure should be introduced for the landfill. Permits should include specifications regarding the types and concentrations of wastes to be accepted, leachate and gas control systems, monitoring, on-site security, and closure and post-closure.

The following wastes containing or contaminated with POPs are not suitable for disposal in specially engineered landfills:

(a) Liquids and materials containing free liquids;

(b) Biodegradable organic wastes;

(c) Empty containers, unless they are crushed, shredded, or similarly reduced in volume; and

(d) Explosives, flammable solids, self-heating spontaneously combustible materials, water-reactive materials, pyrophoric solids, self-reactive wastes, oxidizers, organic peroxides, and corrosive and infectious wastes.

3.4.4. Permanent storage in underground mines and formations

Permanent storage in facilities located underground in geohydrologically isolated salt mines and hard rock formations is an option for separating hazardous wastes from the biosphere for

geological periods of time. A site-specific security assessment conducted in accordance with pertinent national legislation, such as the provisions contained in European Council Decision 2003/33/EC of 19 December 2002 (establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Council Directive 1999/31/EC), Annex, appendix A, should be performed for every planned underground storage facility.

Wastes should be disposed of in a manner that excludes any undesirable reaction between different wastes or between waste and storage linings, though, among other things, the storage of wastes in chemically and mechanically secure containers. The wastes that are liquid, gaseous, emit toxic gases or are explosive, flammable, or infectious should not be stored underground in mines. Operational permits should define waste types that should be generally excluded.

The following should be considered in the selection of permanent storage for disposal of POP wastes:

(a) Caverns or tunnels used for storage should be completely separated from active mining areas and areas that may be reopened for mining;

(b) Caverns or tunnels should be located in geological formations that are well below zones of available groundwater or in formations that are completely isolated by impermeable rock or clay layers from water-bearing zones;

(c) Caverns and tunnels should be located in geological formations that are extremely stable and not in areas subject to earthquakes.

3.4.5. Other disposal methods when the POP content is low

If wastes with a POP content below the low POP content referred to in subsection A of section III above are not disposed of using the methods described above, they should be disposed of in an environmentally sound manner in accordance with pertinent national legislation and international rules, standards, and guidelines, including specific technical guidelines developed under the Basel Convention.

Depending on, *inter alia*, the type of waste stream in question, the appropriate disposal method should be chosen to manage the waste in an environmentally sound manner. For example,

technical guidelines on the ESM of a number of waste streams have been developed under the Basel Convention and are available from www.basel.int .

3.6 Summary

POP pesticides and PCBs are the main POP wastes which are in Rwanda. A certain amount of those wastes was destroyed by incineration but there are others which need final disposal. Fortunately, the PCB and POP pesticides containing products are no longer imported to Rwanda. A quick intervention is needed to safely dispose of POP wastes which are in cities such as the ones located at Jabana REG workshop among others.

3.7 Recommendation

After field visit, the following recommendations are proposed:

- Construction of interim storage facilities for POP wastes and communicate their locations.
- Urgent disposal of POP wastes which are in cities as many people are exposed to them. E.g., the transformers containing PCBs in Jabana which are kept outside in the populated area of Kigali City should be disposed of as soon as possible to avoid the exposure of the population and the environment.
- Proper management of the available interim storage.
- Mark clearly the location of the interim storages of POP wastes.
- Plan the final disposal of POP wastes.

Chapter 4: Asbestos inventory in Rwanda

4.1 Introduction

Asbestos is a natural silicate mineral made up of strong fibers, durable and fire resistant, with a very thinness of 1/5,000 of human hair which has been mixed into many construction materials for a long period of time. With its utilization in construction materials and the long exposure, the inhalation of the asbestos fibers causes serious and severe diseases such as Asbestosis, Lung Cancer and Mesothelioma related to human lung and respiratory system. It is from 1980, that the information and knowledge about asbestos health risks and diseases were spread from international medical and scientific research. Since then, the use of asbestos fibers and different asbestos containing materials were banned in different countries.[25]

4.2 Methodology

4.2.1 Document review and key informant interviews

In this inventory, an extensive document review was conducted in line with asbestos hazardous waste management by institutions and their needs. Documents include previous inventories, previous studies/publications on the subject of asbestos hazardous waste management in Rwanda, and Asbestos Convention, 1986 which were reviewed throughout the assignment.

The second dimension of the data collection process was through in-depth interviews of key informants that have knowledge of either asbestos management and/or hazardous waste management in their institutions. Accordingly, an interview schedule was developed for the purpose of obtaining data during the face-to face interview. The target respondents were Chief Executive Officers (CEOs) of Lead Agencies, heads of the chemicals and/or waste management departments of the institutions, representatives of non-state actor institutions, officers from policy development in Government, regulatory agencies, and technical support institutions.

[25] LaDou J. *et al*. The case for a global ban on asbestos. Environ Health Prospect. 2010 Jul;118(7):897-901. doi: 10.1289/ehp.1002285. Epub 2010 Jun 8. PMID: 20601329; PMCID: PMC2920906.

4.2.2 Aim of the survey

This task contributed to understand the status of Asbestos removal and burial in Rwanda, to record as well as check the status of the burial sites. According to RHA, the target to remove Asbestos roof materials was at 1,308,259 m^2 and the performance rate in asbestos removal by 2022 is at 72.8 %. The key institutions to be contacted during the Asbestos inventory are provided in **Table 4.1**. The specific activities conducted under this task are as follows:

- Collect data on current quantity of buried and not yet buried asbestos in Rwanda, these data were collected from MINIFRA and RHA;
- Collect data on current stocks of asbestos and asbestos contaminated wastes prior and after their burial, these data were collected from MINIFRA and RHA;
- Map the current sites for asbestos sanitary burial and indicate the updated quantity/area of the buried asbestos;
- Conduct key informant interviews to assess the current condition of asbestos removal, removal process and safety, storage, and the types of materials removed;
- Conduct field visits to all sanitary burial sites of asbestos located in different districts of Rwanda investigate on the burial conditions/ status.

Table 4. 1: *Type of waste and consulted institutions during the Asbestos inventory in 2023*

Waste Stream	Type of waste	Consulted Institutions
Asbestos and asbestos containing waste	Asbestos Asbestos-contaminated waste including the bags used to transport asbestos, equipment, PPE and clothing that have been in contact with asbestos.	MININFRA Rwanda Housing Authority REMA

4.3 Asbestos inventory results

4.3.1. History on asbestos legal banning in Rwanda

In Rwanda, the first asbestos legal banning step was by the Prime Minister's Order N°27/03 of 23/10/2008 determining a list of prohibited drugs unless authorized or temporary permitted.

In 2009, the Government of Rwanda took the Resolution to eradicate all asbestos containing materials from buildings in order to protect the inhabitants from the health risks of suffering from asbestos related diseases.

Starting from 2011, Rwanda Housing Authority (RHA) with various stakeholders (government and private) is implementing the National Action Plan of Asbestos Eradication from buildings as established by the High-Level Consultative Meeting of 18th April 2011 chaired by the Right Honourable Prime Minister.

In 2015, the Government of Rwanda established the Prime Minister's Instructions N°002/03 of 05/05/2015 determining procedure for eradication of asbestos materials in Rwanda.

4.3.3. Asbestos removal journey in Rwanda

Training on asbestos safe removal was provided to different companies and notice calling for public institutions to integrate for asbestos removal in their budget was communicated to concerned institutions for consideration[26]

In 2014, fifteen asbestos burial sites were at the time operational and well managed in Rusizi, Karongi, Ngororero, Gisagara, Huye, Nyanza, Muhanga, Kamonyi, Bugesera, Kayonza, Ngoma, Nyagatare, Musanze, Rulindo and Gicumbi Districts. Repair works and electrical installations were completed in all asbestos burial sites. **(Figure 4.3).**

[26]Ministry of Infrastructure, 2015. Annual report 2014/2015.

To preserve eco-friendly green cities, since 2009, Rwanda has removed 1.2 million square meters of asbestos roofs out of 1.7 million square meters, an accomplishment rate of 72.8%. In 2022 RHA started the campaign to remove the remaining of 456,429.2 square meters of asbestos that are still on buildings[27].

4.3.2. Current situation in Rwanda

The data provided by RHA show that, since there are no recognized asbestos mines in Rwanda, all asbestos containing materials were introduced through importations since the colonial period up to 2000.

The test of the sample taken from a school in Nyarugenge District showed that the asbestos roofs available in Rwanda are a mixture of sand and cement for 60% and of asbestos fibers for 40%. These materials are found on old buildings such as health centres, hospitals, churches, schools, public offices, factories, and residential houses.

Up to 30th June 2023, RHA through the Asbestos Removal Project has managed to remove around 80.1% of the inventoried asbestos from buildings and disposed them into prepared asbestos burial sites. The total 1,356,173.2 m^2 of asbestos materials from roofs and ceilings of buildings countrywide out of 1,692,089.2 m^2 inventoried were disposed in burial sites.

Table 4. 2: List of Asbestos burial sites and their locations in Rwanda

Province	District	Number of Asbestos burial site	Location names	Observation
East	Rwamagana	1	Gahengeli, Rweri, Kamurindi	Operational
	Nyagatare	1	Nyagatare, Nyagatare, Mirima1	Operational
	Ngoma	1	Kibungo, Mahango, Kacyiru	Closed
	Kayonza	1	Mukarange, Nyagatovu, Gatagara	Closed
	Bugesera	1	Mayange, Mbyo, Kabyo	Closed

[27] KT press, 2022. Rwanda resumes battle against asbestos https://www.ktpress.rw/2022/04/rwanda-resumes-battle-against-asbestos/, accessed 22 April 2023.

North	Musanze	1	Kimonyi, Kivumu, Musezero	Operational
	Rulindo	1	Rusiga, Taba, Kingazi	Operational
	Gicumbi	1	Kaniga, Rukurura, Kabare	Operational
West	Rubavu	1	Nyakiliba, Nyakibande, Gikombe	Operational
	Ngororero	1	Hindiro, Gatare, Kigarama	Operational
	Karongi	1	Rubengera, Mataba, Ruvumbu	Operational
	Rusizi	1	Kamembe, Ruganda, Ruhimbi	Operational
South	Muhanga	1	Shyogwe, Mubuga, Matsinsi	Closed
	Kamonyi	2	Gacurabwenge, Gihinga, Nyarunyinya	One is Operational, the other is closed
	Nyanza	1	Mukingo, Mpanga, Remera	Operational
	Huye	2	Mbazi, Mwulire, Gitwa	One is Operational, the other is closed
	Gisagara	1	Ndora, Gisagara, Rugara	Operational
TOTAL		**19**		

Source: Rwanda Housing Authority, 2023

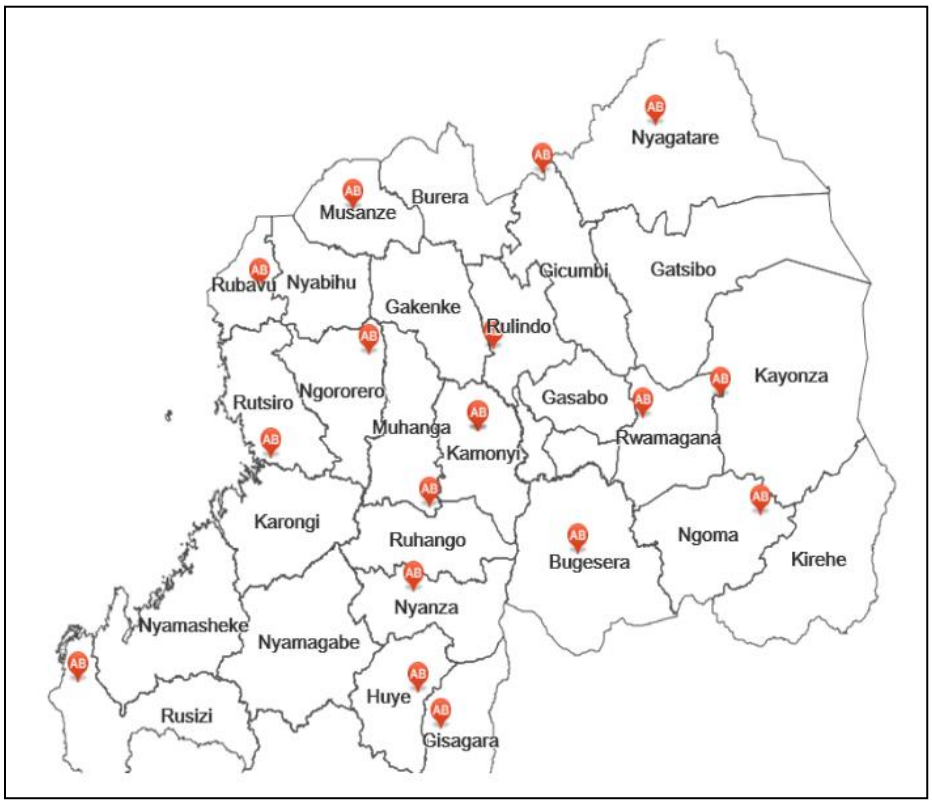


Figure 4. 1: *Location of the asbestos burial sites (Source: Rwanda Housing Authority, 2023)*

Table 4.2 shows more details on the removal of asbestos progress in Rwanda. Currently, 13 asbestos burial sites are used **(Figure 4.2 a, b)** and located in 13 districts:

In addition to the above-mentioned sites, there are also burial sites 6 asbestos burial sites which are closed **(Figure 4.2 c, d)**. Those sites are located in Ngoma, Kayonza, Bugesera, Muhanga, Kamonyi and Huye districts.

Figure 4. 2: *Burial sites of asbestos: Sites in use (a) Nyagatare and (b) Kamembe; Closed sites (c) Gacurabwenge and (d) Shyogwe. July 2023.*

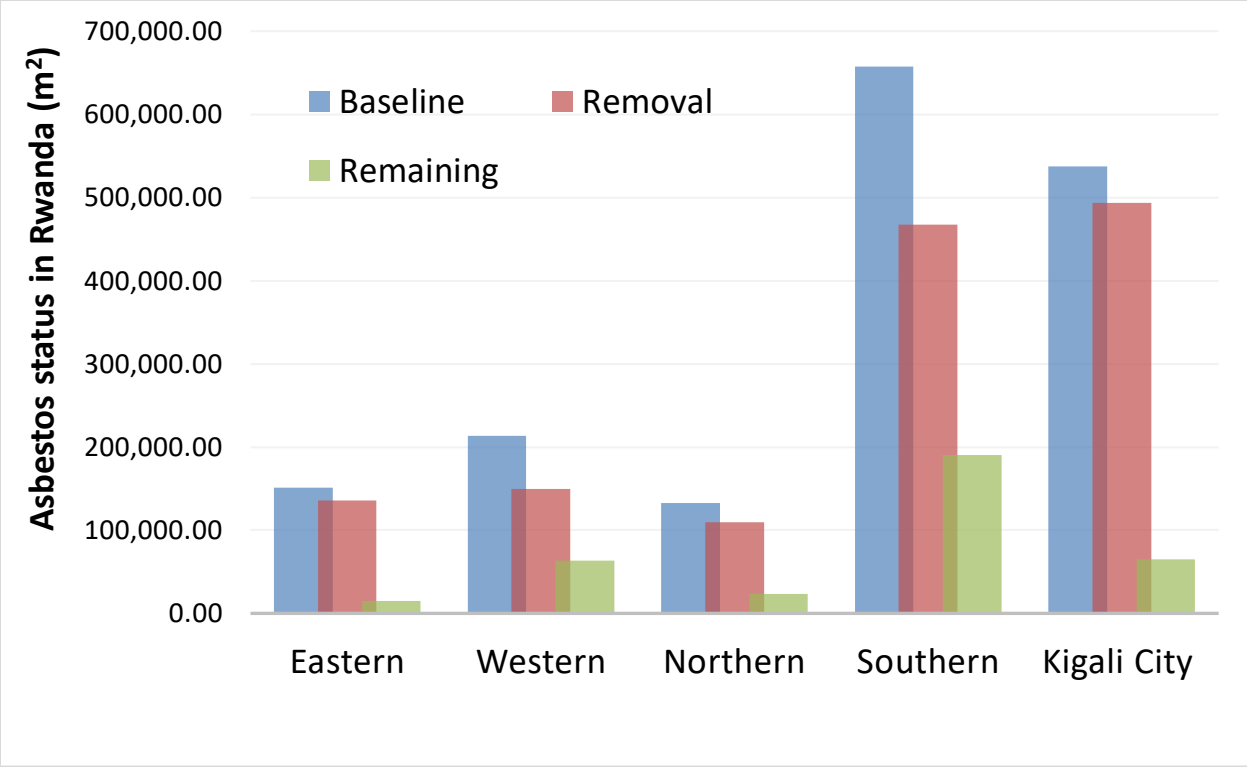


Figure 4. 3: *Asbestos status in different province of Rwanda in July 2023 by RHA*

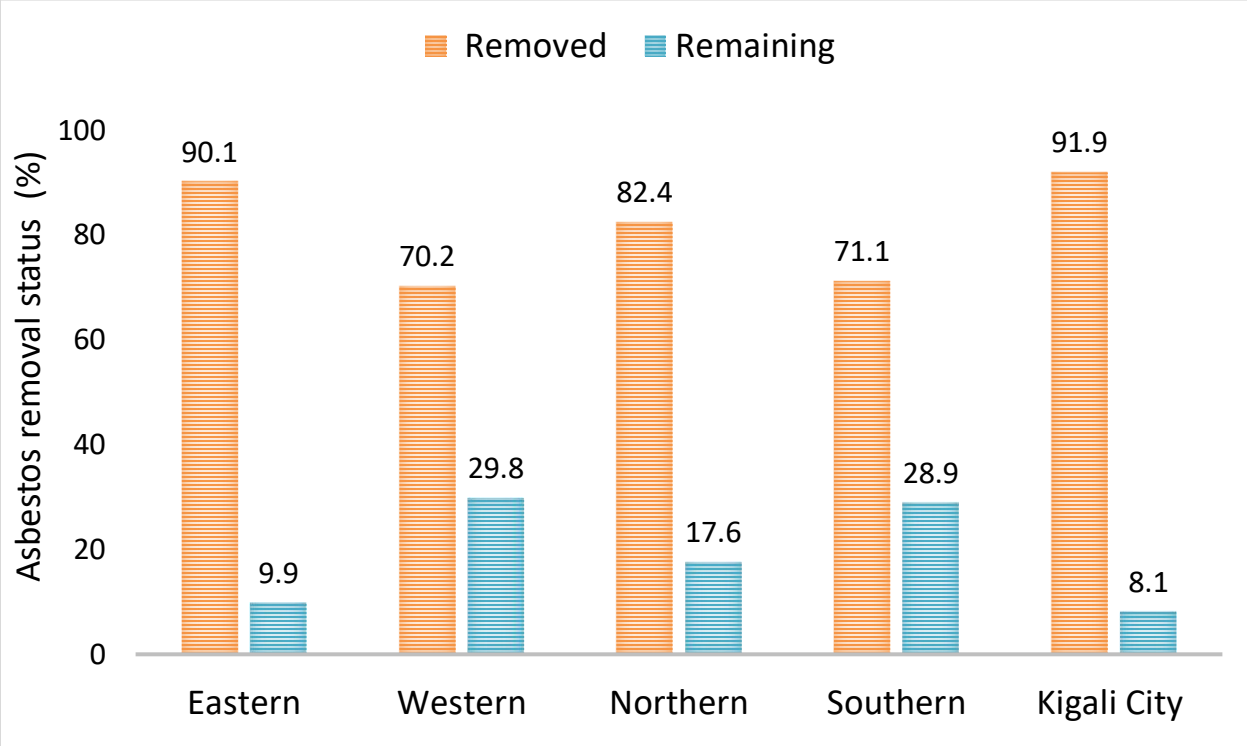


Figure 4. 4: *Asbestos removal status in different districts of Rwanda in July 2023, by RHA*

Table 4. 3: *Asbestos removal progress by June 30th, 2023.*

Province	Baseline (m^2)			Removal (m^2)		Remaining (m^2)		Total Removal (m^2)	% Removal
	Public	Private	Total baseline	Public	Private	Public	Private		
Eastern	73,982.0	76,833.0	150,815.0	70,055.4	65,772.8	3,926.6	11,060.2	135,828.2	90.1
Western	96,850.9	116,744.1	213,595.0	70,910.1	79,069.4	25,940.8	37,674.7	149,979.5	70.2
Northern	66,436.0	66,550.0	132,986.0	62,913.0	46,728.0	3,523.0	19,822.0	109,641.0	82.4
Southern	372,211.5	285,181.2	657,392.7	216,202.6	250,973.8	156,008.9	34,207.4	467,176.4	71.1
Kigali City	212,612.4	324,688.1	537,300.5	223,357.1	270,191.0	10,744.7	54,497.1	493,548.1	91.9
Total (m^2)	**822,092.8**	**869,996.4**	**1,692,089.2**	**643,438.2**	**712,735.0**	**178,654.6**	**157,261.4**	**1,356,173.2**	**80.1**

Source: Rwanda Housing Authority, 2023.

4.4 Challenges in Asbestos management in Rwanda

The complete eradication of the asbestos from buildings in Rwanda faces various challenges. The shortage of required budget funds for quick & total eradication is one of the factors slowing the removal and disposal of asbestos materials. Also, the mindsets to prioritize the asbestos eradication in institutional planning and budgeting lead to frequent extensions of eradication deadlines. Another challenge is the lack of willingness among some private building owners and the unauthorized removal of asbestos by some building owners. There are also the violations of the removal procedures by escaping the inspections. In addition to those challenges, the oldness of the asbestos materials in Rwanda generates more risks of fiber emissions.

Concerning the asbestos burial sites, it has been found that some closed sites are abandoned and to find some sites is difficult as there is no sign indicating them. This may lead to some consequences if the site is disturbed by other human activities or natural disasters as there is no warnings and information about the site.

4.5 Proper disposal of asbestos

UNEP has provided the guidelines for handling and disposal of asbestos[28]. From those practices, we summarized the Best Practices for temporary storage and final disposal of asbestos waste.

4.5.1. Temporary in-situ storage

Asbestos waste that has been segregated, or waste which is too contaminated to be segregated and therefore must be classified as asbestos waste, should be stored separately in secure, covered, labelled, containers until transportation to an appropriate site takes place. It is recommended that appropriate containers or skips are used to store known asbestos waste as these are the easiest to transfer to transport vehicles without exposing contaminated materials. These should be labelled correctly and covered to prevent access to contained materials or asbestos fiber release and should be locked when not in use to restrict access.

[28] UNEP, Asbestos handling, and disposal guidelines _ International Best Practices. https://wedocs.unep.org/20.500.11822/42291

Should large containers or skips not be available, then asbestos waste should be double-bagged and stored safely until transport can be arranged. The following provides guidance on how this can be undertaken:

- Waste must be packed in UN-approved packaging[29] with a hazard label and asbestos code information visible.
- Double-wrap and label asbestos waste. Standard practice is to use a red inner bag with asbestos warnings, and a clear outer bag with the CDG (Carriage of Dangerous Goods) label, if required.
- Avoid breaking up large pieces of asbestos waste. Instead, double wrap in suitable polythene sheeting (1000-gauge) and label accordingly.

In situations where the volume of asbestos or asbestos contaminated materials are too large for temporary in-situ storage, it may be feasible to store these materials as waste piles in a dedicated, secured location. However, in this case the surface should be covered in large tarpaulins (medium, minimum 80 gsm) or similar to minimize wind dispersion. Periodic downwind air monitoring may be necessary to confirm the absence of fiber release.

Warning signs should be placed around any asbestos waste sites at all locations at which the general public could access the site.

4.5.2. Final disposal of asbestos waste

Asbestos waste is classed as hazardous waste for the purposes of final disposal. Asbestos contaminated waste should be disposed of in a licensed disposal site wherever possible, in line with government regulation[30].

Asbestos waste can be disposed of in appropriate landfill facilities designated as non-hazardous, for example a construction and demolition (C&D) waste facility. In this case, asbestos waste should only be disposed of in cells that are specifically dedicated for the disposal of asbestos waste. Any interaction between asbestos waste and biodegradable waste should be prevented. Any cells used to dispose of asbestos waste must have clear signs at all access points as, once capped with earth, contents will not be clear.

[29] UN Class 9, UN2212 (Amphibole) or UN2590 (Chrysotile)
[30] HW Decree 5606, 2019, including Article 29

An alternative would be to use a dedicated C&D waste landfill facility for disposal of debris waste contaminated with asbestos. This facility would need to be designated as an asbestos landfill, with the requisite asbestos waste signage and restricted access, and would need to meet the requirements of government regulations, including Decree 5606, 2019.

There is no specific guidance on which materials the operators of landfills must use to cover asbestos wastes (landfill capping), only that 'appropriate material' should be used. The main requirement for material cover for asbestos is that it prevents dispersion of fibers. The type and depth of cover will depend on the surrounding landfill materials, taking into account the weather conditions the site will be subject to and other environmental conditions.

Asbestos and asbestos containing materials should be disposed of in a designated, engineered, hazardous waste landfill facility wherever possible. When this is not achievable, a dedicated C&D waste facility or separate cell in a non-hazardous, sanitary landfill can be used.

Landfill design should comply with The European Union Landfill Directive[31], specifically Annex 1 (attached to this document as Annex 12), as well as national standards, including anticipated national standards for landfill facilities.

In collaboration with the local government, locate a site where adequate cover material is available, access is good and controllable and where the waste cannot be exposed by water or wind erosion, slope failure, further disasters, or re-excavation. The location of the facility should be either natural or should be engineered to prevent any unacceptable discharges to ground and surface water and emissions over the entire life of the facility.

During and after the disposal of asbestos waste, make sure no visible *emissions* occur and cover waste with at least 15cm of compacted non-asbestos-containing material within 24 hours of disposal.

If no natural *barriers* exist around the site to deter access, install fencing, trenches, or other barriers to prevent unauthorized access to the designated area.

[31] The European Directive 1999/31/EC on landfill of waste.

Post *warning signs* at the entrance of the site and around the perimeter or, in the case of cells within a non-hazardous landfill facility, at access points and around relevant cells.

Final closure of an area containing asbestos waste requires at least an additional 75 cm of compacted non-asbestos material to provide a 1m final cover. This must be done within 90 days of the last deposition.

4.6 Summary

Since 2009, Rwanda has removed 1.2 million square meters of asbestos roofs out of 1.7 million square meters, an accomplishment rate of 72.8%. In 2022 RHA started the campaign to remove the remaining 456,429.2 square meters of asbestos that are still on buildings. Up to 30th June 2023, RHA through the Asbestos Removal Project has managed to remove around 80.1% of the inventoried asbestos from buildings and disposed them into prepared asbestos burial sites. A total of 1,356,173.2 m^2 of asbestos materials from roofs and ceilings of buildings countrywide out of 1,692,089.2 m^2 inventoried were disposed in burial sites.

Currently, 13 asbestos burial sites, located in 13 districts, are used and there is other 6 asbestos burial sites which are closed.

Training on asbestos safe removal was provided to different companies and notice calling for public institutions to integrate for asbestos removal in their budget was communicated to concerned institutions for consideration.

4.7 Recommendation

The main source of asbestos wastes is the construction sector. The following are the main recommendations proposed to speed up the total eradication of the asbestos from buildings in Rwanda:

1) The private and government sectors to consider the asbestos eradication as one of the priorities during planning and budgeting;
2) The private and government sectors should mobilize the budget funds from donors and stakeholders for complete eradication;

4) The RHA to continue trainings and capacity building for the benefit of more eradication partners to speed up total eradication;
5) The community sensitization on the Prime Minister Instructions N° 002/03 of 05/05/2015 to enhance legal compliance & regulate asbestos eradication in Rwanda;
6) Introduce the administrative fines to the noncompliance (Unauthorized removal, removal defectors, unwilling building owners);
7) Research and development with regard to strengthening the safe eradication.
8) Regarding the existing burial sites, it is recommended to monitor them by putting fences and signages where necessary.
9) Considering the provided guidelines for final disposal of asbestos and asbestos contaminated materials in this report, especially by landfill, it is recommended to engineer and prepare the existing temporary burial site for asbestos in Rwanda such that they can be considered as the final disposal for asbestos.

Chapter 5: Inventory of pharmaceutical and medical wastes in Rwanda

5.1 Introduction

The term "medical waste" is used in many countries, like the United States, and China, etc.[32], while the European Union and WHO refer to it as "healthcare waste[33]. Medical wastes also known as health care waste comprises with the following categories[34]:

(i) Pharmaceuticals - expired, unused, and contaminated: the drugs themselves (sometimes toxic and powerful chemicals) or their metabolites, vaccines, and sera;
(ii) Genotoxic waste - highly hazardous, mutagenic, teratogenic, or carcinogenic, such as cytotoxic drugs used in cancer treatment, and their metabolites;
(iii) Radioactive matter, such as glassware contaminated with radioactive diagnostic material or radiotherapeutic materials;
(iv) Wastes with high heavy metal content, such as broken mercury thermometers.

Medical waste covers all wastes produced in healthcare or diagnostic activities[35]. These waste are characterized as Infectious waste (waste suspected to contain pathogens), Pathological waste (waste consists of tissues, organs, body parts, blood, body fluids and other waste from surgery and autopsies on patients with infectious diseases); Sharps waste (items that could cause cuts or puncture wounds, including needles, blades, broken glass and pipettes); Pharmaceutical waste (includes expired, unused, spilt and contaminated pharmaceutical products, drugs, and vaccines

[32] Yoon CW, Kim MJ, Park YS, Jeon TW, Lee MY. A Review of Medical Waste Management Systems in the Republic of Korea for Hospital and Medical Waste Generated from the COVID-19 Pandemic. Sustain. 2022;14(6).
[33] Attrah M, Elmanadely A, Akter D, Rene ER. A Review on Medical Waste Management: Treatment, Recycling, and Disposal Options. 2022;
[34] See: Water Research Commission, 2006: Development of Guidelines and Recommendations towards the Classification, Rating and Disposal of Common Industrial Hazardous Waste Streams for the purposes of General Authorisation for Waste Disposal
[35] International committee of the Red Cross. Medical waste management. New Jersey health Care. 2011. 166 p.

that are no longer required), Radioactive waste (includes solids, liquid and gaseous material contaminated with radionuclide), chemical waste.

According to WHO estimates, in 2000, contaminated injections with contaminated syringes caused: 21 million hepatitis B virus (HBV) infections (32% of all new infections), two million hepatitis C virus (HCV) infections (40% of all new infections) and at least 260 000 HIV infections (5% of all new infections).

5.1.1 Medical waste management in Rwanda

Currently Rwanda has 8 Referral hospitals, 4 Provincial hospitals, 39 District hospitals, 503 health centres and 196 Private health facilities (Hospitals, Clinics and or Polyclinics) that are distributed in all 30 Districts of Rwanda. According to the Ministry of Health Third Strategic Plan 2012-2018 published in 2012, the estimated total quantity of Health Care Wastes generated in 35 Health Facilities within one year was 60,775,164 kg per year.

In 2014, the performance audit report of the auditor general on health care waste management conducted in referral hospitals revealed the gaps in proper medical waste management. The problem of the medical waste increases with the rapidly increasing population and urbanization. A large amount of medical waste is produced daily from all the hospitals, and the composition of medical wastes varies by the category of the medicine and properties of healthcare institutions.

5.2 Methodology

5.2.1 Document review and key informant interviews

In this inventory, an extensive document review was conducted in line with chemicals and hazardous waste management by institutions and their needs. Documents include previous inventories, previous studies/publications on the subject of chemicals and hazardous waste management in Rwanda, and the conventions such as Stockholm, Rotterdam, Basel and Minamata which were reviewed throughout the assignment.

The second dimension of the data collection process was through in-depth interviews of key informants that have knowledge of either chemicals management and/or hazardous waste management in their institutions. Accordingly, an interview schedule was developed for the purpose of obtaining data during the face-to face interview. The target respondents were Chief Executive Officers (CEOs) of Lead Agencies, heads of the chemicals and/or waste management departments of the institutions, representatives of non-state actor institutions, officers from policy development in Government, regulatory agencies and technical support institutions.

5.2.2 Aim of this inventory

The aim of this task was to estimate the quantity of Pharmaceutical and medical wastes generated in Rwanda and their characterisation. This task also described the current management approach for pharmaceutical and medical in Rwanda. Rwanda has several hospitals and health centres distributed in all 30 districts. Sampling in all districts and all hospitals and health centres is therefore out of the scope of this assignment. The key institutions consulted for the estimation of medical wastes are provided in **Table 5.1**. The specific activities to be conducted under this task are as follows:

- Estimate the quantity of pharmaceutical and medical wastes based upon daily waste per inpatient and waste per out-patient by referring to the total number of patients and their waste generation factor of 5.168 kg/day of medical waste generated by inpatients and outpatients[36];
- Conduct the characterisation of pharmaceutical and medical wastes based upon the above-mentioned approach from the Ministry of Health (2017);
- Collect data from the MoH, RBC, RMS Ltd, BUFMAR on the current stocks and status for the management of pharmaceutical and medical wastes.
- Conduct key informant interviews in Kigali and six secondary cities and with stakeholders highlighted in **Table 5.1** with the aim to locate and estimate the

[36] Ministry of Health, 2017. Medical Waste Management Plan (MWMP), Kigali, Rwanda

stockpiles/ hotspots of these waste as well as assess the current conditions of pharmaceutical and medical wastes management;

Table 5. 1: *Type of waste and consulted institutions for Pharmaceutical and medical wastes inventory in 2023.*

Waste Stream	Type of waste	Consulted Institutions
Pharmaceutical and Biomedical wastes	Infectious Wastes, Sharps Wastes, No Infectious Wastes, Pharmaceutical Wastes, Radioactive Wastes, Genotoxic/ Cytotoxic, Chemical Wastes, Non-hazardous general Wastes, Liquid Wastes (m^3)	An assessment of medical waste quantities and types generated by health facilities was conducted in 54 health facilities; comprising 4 Teaching hospitals, 7 Level two Teaching hospitals,1 referral hospital, 4 provincial hospitals and 35 district hospitals and 3 private hospitals.

5.3 Pharmaceutical and medical wastes inventory results

This survey focused on the entire waste stream from the point of generation to final disposal at designated areas as well as the established policy and procedures used to support healthcare waste management in health facilities.[37], [38], [39] All public hospitals were selected as they treat more patients and as a result generate more waste compared to private health facilities and health centres. Three private hospitals that treat more patients were also selected. Due to resource and time constraints, we could not have reached the health centres and all private health facilities in Rwanda. The aim of this task was to estimate the quantity of medical wastes generated in Rwanda and their characterization **(Figure 5.1)**.

[37] Ministry of Health. National Standards Operating Procedures on HCWM. 2016. 1–142 p.
[38] MOH. National Health Care Waste Management Guidelines. 2016.
[39] Rwanda Utillities Regulatory Authori. Regulations governing liquid waste collection and transportation. 2016. 1–16 p.

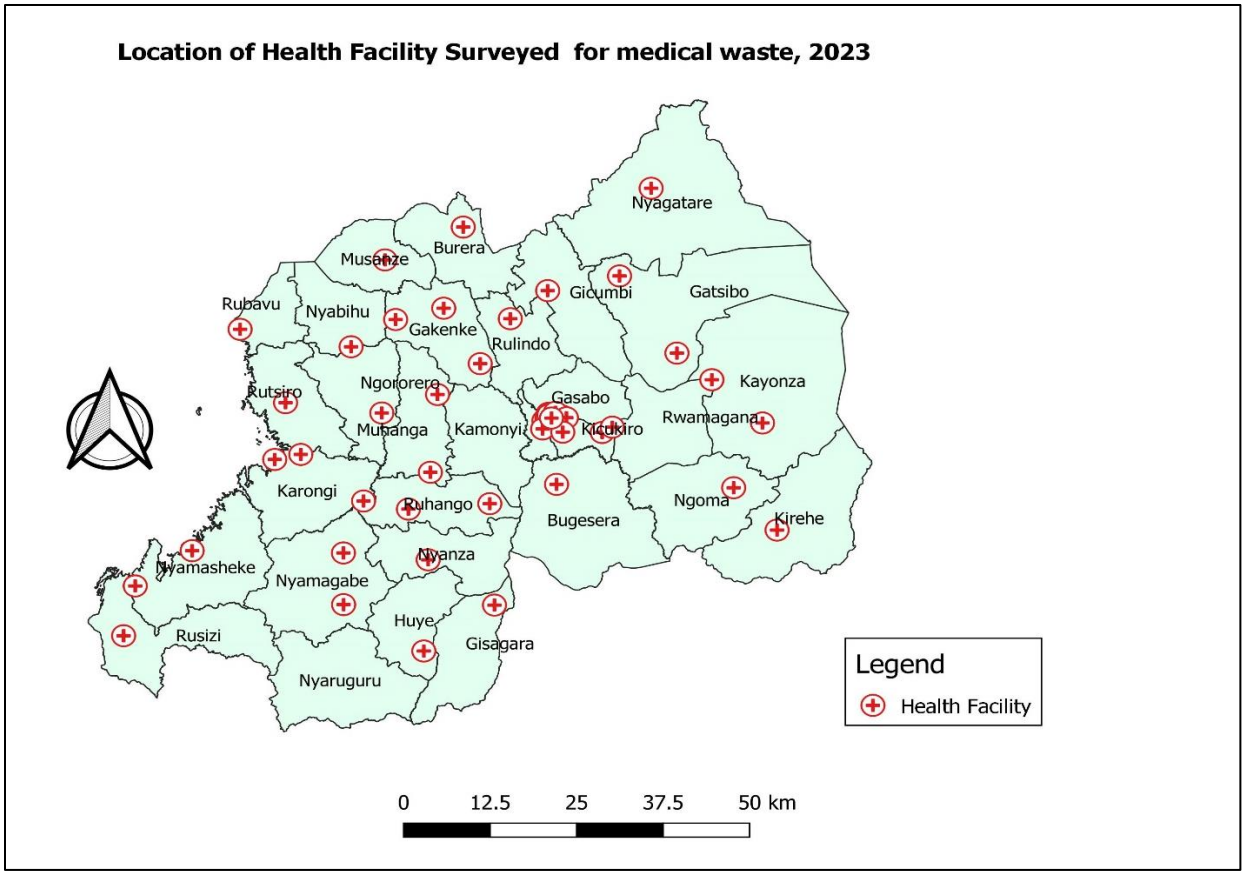


Figure 5. 1: *Location of healthcare facilities surveyed places for medical wastes generation in Rwanda, July 2023.*

5.3.1 Estimation of medical waste generation in Rwanda, 2023

An assessment of medical waste quantities and types generated by health facilities was conducted in 54 health facilities; comprising 4 Teaching hospitals, 7 Level two Teaching hospitals,1 referral hospital, 4 provincial hospitals and 35 district hospitals and 3 private hospitals. These hospitals had a total number of 686,215 inpatients and 1,793,310 outpatients (HMIS, July 2022 to June 2023).

Based on the research conducted by MoH, 2017 whereby the investigators estimated the quantity of medical wastes based upon daily waste per inpatient and out-patient by referring to the total number of patients and their waste generation factor of 5.168 kg/day of medical waste

generated by inpatients and outpatients[40]; the total estimated medical waste generated was **12,814,185.2kg/year** ((686,215+1,793,310) *5.168)).

In this survey, through the hospital self-administrated questionnaire, medical waste data were also collected based on the quantification of a daily medical waste generated and recorded in the hospitals waste register to determine the national volume of medical waste, brought to light an estimated average of **10,514994 kg per a year.**

The difference in the estimated medical waste generated between the two studies can indeed be attributed to several factors, including changes in technology use rather than paper based, and medical record-keeping practices in healthcare facilities. The second study appears to have used the current data collected from the filed based on a daily record from waste registers. This method is likely to provide a more accurate and up-to-date estimate of medical waste generation. The two studies also might have been conducted at different times. Over the five years, there could have been changes in healthcare practices, trainings, healthcare policies, and waste management methods that could also contribute to variations in medical waste generation estimates.

As revealed in a **Figure 5.2** below, the most (56%) medical waste generated and recoded in health facility was liquid waste.

[40] Rwanda Ministry of Health (MOH). Medical waste management plan. 2017. 1–51 p.

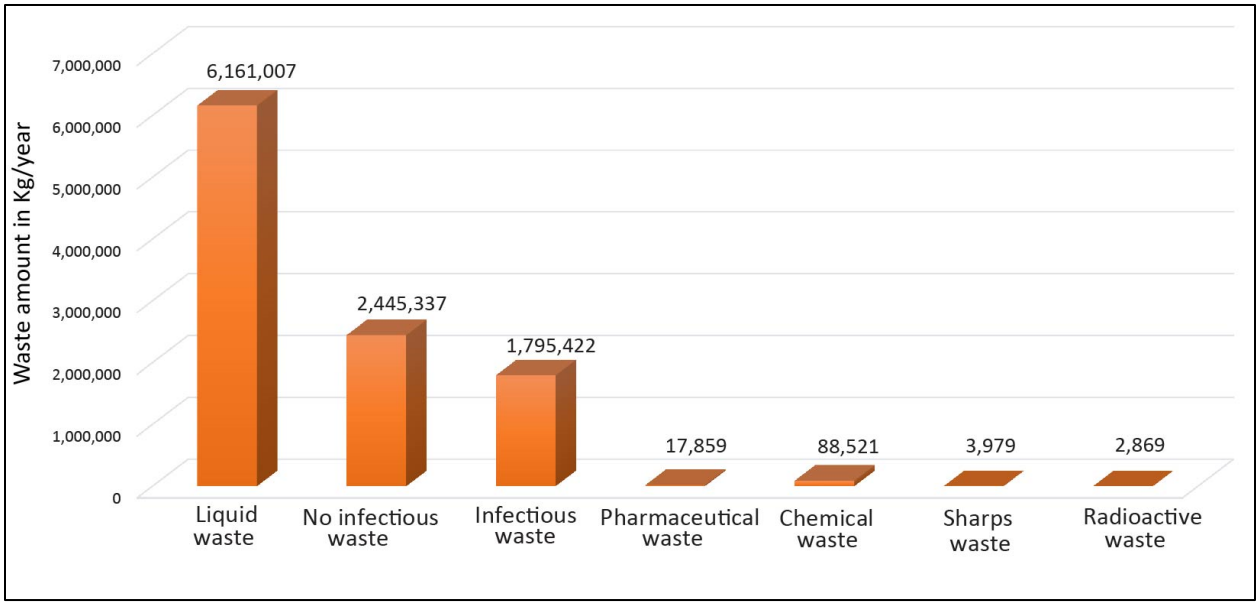


Figure 5. 2: *Distribution of medical waste generated by the health facilities in a year, 2023.*

Table 5. 2: *Characterization and quantity of medical care wastes generated in 54 health facilities within one year, 2023*

S/N	Description	Total quantity in kg or l per year	Percentage (%)
1	Liquid waste	6,161,007	58.59259
2	No infectious waste	2,445,337	23.25571
3	Infectious waste	1,795,422	17.07487
4	Pharmaceutical waste	17,859	0.169843
5	Chemical waste	8,8521	0.841855
6	Sharps waste	3,979	0.037841
7	Radioactive waste	2,869	0.027285
Total		**10,514,994**	**100**

Source: Primary data collection, 2023

5.3.2 Characterization and disposal of medical waste

Medical waste as infectious waste, sharps waste, pharmaceutical waste, chemical waste, non-infectious waste, and liquid waste shall be characterized as the follow in **Table 5.3**.[4]

Table 5. 3: *Medical wastes classification, characterization, and disposal.*

Type of waste	Characteristic	Best Treatment and disposal
Infectious waste	Material suspected to contain pathogens (bacteria, viruses, parasites or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts.	Incineration
Sharps waste	Items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpels and other blades, knives, infusion sets, saws, broken glass and pipettes.	Incineration
Pharmaceutical waste	Are waste including expired, unused, spilt and contaminated pharmaceutical products, such drugs, vaccines and sera (serum) that are no longer required.	Incineration
Chemical waste	Are waste consists of discarded solid, liquid and gaseous chemicals; for example, from diagnostic and experimental work and from cleaning and disinfecting procedures.	Incineration Decontamination
Non-infectious waste	Waste that has not been in contact with infectious agents, hazardous chemicals or radioactive substances and does not pose a sharps hazard. It is generated from offices, kitchens, and packaging material from store	Incineration, composting

Type of waste	Characteristic	Best Treatment and disposal
Liquid waste	Waste materials that appear in the form of liquid matter, including septic, or grey water used in a health facility	Wastewater treatment plant

5.3.3 Current management approach for medical waste in Rwanda

Medical wastes management are important processes to ensure the safe handling to proper disposal of healthcare-related waste. Out of the health facilities visited, the majority 96.3% treated waste onsite, 92.6% of waste was handled with the proper personal protective equipment (PPE), of 48.1% of the hospitals visited had waste treatment plant. Proper management of medical waste is crucial to prevent the spread of diseases, protect the environment, and maintain public health and safety **(Figure 5.3** and **Figure 5.4)**.

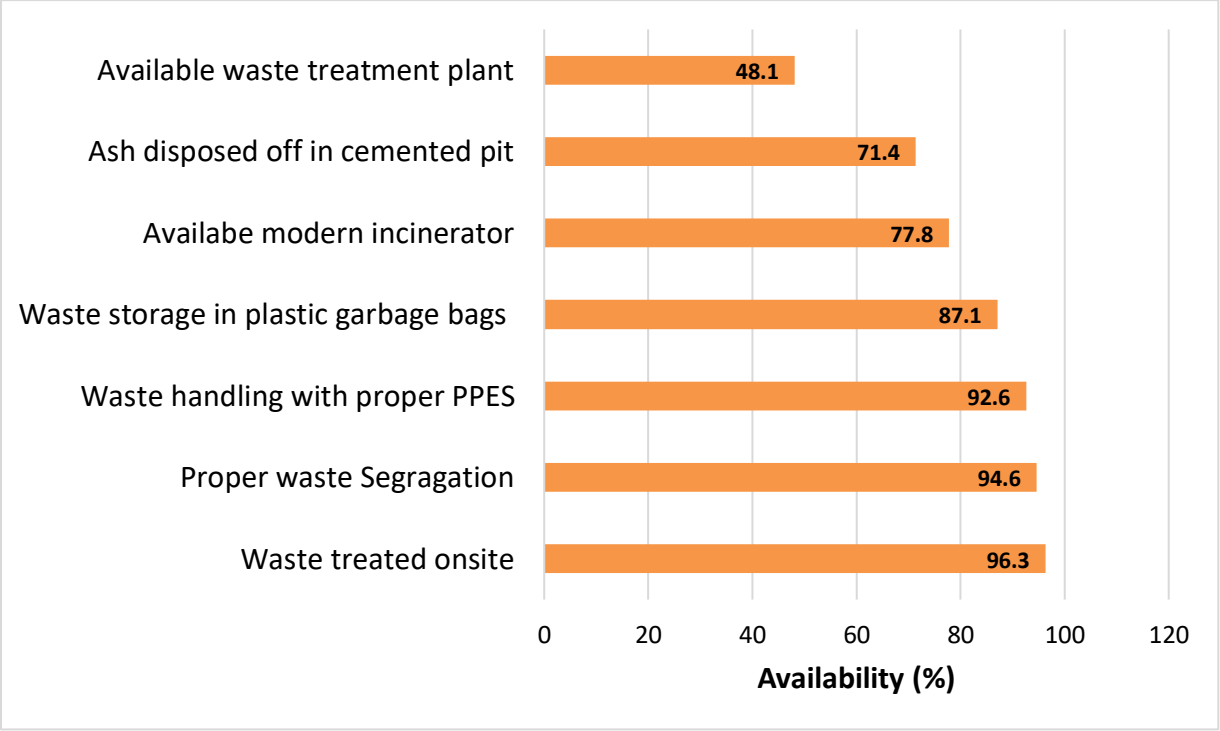


Figure 5. 3: *Distribution of medical waste management in Rwanda, 2023.(source: Primary data collection)*

Figure 5. 4: *Different medical waste disposal approaches in Rwanda, July 2023*

From **Figure 5.4**: **(A)** Plastic bags were fitted inside of pedal dustbins Bins are labelled according to policy and procedure of hospital waste management. Safety containers not filled over ¾. **(B)** Waste was stored in a secure place before being incinerated. Waste is segregated at the point of generation. **(C)** SterilWave 250 incinerators were the most used in the Rwanda Hospitals. **(D)** Out of all 54 health facilities surveyed; there were no accumulated medical waste founds. **(E)** Residual from Incinerator SterileWave 2050. **(F)** Stored incinerated residual from SterileWave 2050.

5.3.4 Challenges facing the medical waste management in Rwanda

- Financial constraints in waste management (replacement of damaged spare parts of incinerator, high cost of plastic bags and availability of waste dustbins)
- Lack of wastewater treatments plants due to old infrastructure system
- Management of the residues from Sterilwave 250 incinerators.

- The international biohazard symbol for infectious waste was missing on the red bags and containers for infectious waste used by all the hospitals.

5.3.5. Risk assessment for the management of residues from Sterilwave 250 Incinerators

SterilWave 250 Incinerator as it uses microwave technology, and does not need a steam generator, so there is no risk from excess pressure and no liquid effluent is produced. With its automated grinding and microwave sterilisation process contained in a single vessel, the Sterilwave can produce bacterial inactivation. It reduces weight by 25% and volume of waste by 80% means waste can be treated immediately where it is produced. The end product is unrecognizable, inert, dry, and stable waste. These waste residues are similar to municipal wastes and can then be fed into standard urban waste systems. The dry ground-up waste can also be used as secondary fuel. No environmental impact on-site treatment, and no liquid effluent produced. The SterilWave 250 Incinerator offers a range of benefits, including safety improvements, environmental advantages, and the potential for resource recovery through the use of waste as secondary fuel. These features make it a promising solution for efficient and eco-friendly waste management, particularly in settings where immediate on-site treatment is essential.

5.4 Summary

The quantification of medical waste generated in hospitals was conducted. The most three types of waste generated was liquid waste, non-infectious waste and infectious waste. Most of the waste generated are treated onsite as results of available modern incinerator technology. This chapter highlighted that the 54 health facilities consulted health facilities had a total number of 686,215 inpatients and 1,793,310 outpatients. Based on the quantification of daily medical waste generated and recorded in health facilities waste registers, an estimated national average of 10,515 ton per a year of medical waste was registered. About 82% of these medical wastes comprises liquid waste and non-infectious waste, while the remaining 18% comprises infectious waste, pharmaceutical waste, chemical waste, sharps waste and radioactive waste. SterilWave 250 incinerators are the most used for the treatment of such hazardous waste in Rwanda

Hospitals. Worth noting is that the staff compliance for handling waste with using the personal protectives equipment and waste segregation at the point waste generation was at the higher level. This should be reflected to the strong monitoring and follow up system adopted by the Ministry of health through the provision and equipped modern incinerators in the most of public health facilities with the capacity to incinerate all types of medical waste, accreditation standards for improving the quality of care and working in safe environment for staff and patient and using the qualified and trained personnel in waste management. However, practices adopted by some health facilities were deficient due to financial constraints and new technologies such as the use of new incinerators, and installation of wastewater treatment plant.

5.5 Recommendation

The recommendations proposed in this report shall be adopted by all healthcare facilities in Rwanda in improving upon current healthcare waste management practices throughout the country; therefore, the MOH should address the issues with regards to healthcare waste management activities that include:

- Providing adequate funding in medical waste management specifically for replacing or repair the damaged incinerator spare parts,
- Ensure the available and the use of plastics bags in the health facilities,
- Continuous training of healthcare providers in medical waste management including waste segregation,
- It is recommended for each health facility to have a proper wastewater treatment mechanism to treat liquid waste contaminated with medical waste before it can be released to the environment.
- The district hospital shall dispose of the waste residues from Sterilwave 250 incinerators in a district municipal landfill.
- The MoH shall conduct a risk assessment on residues generated by Sterilwave 250 prior to final disposal at the municipal landfill.

Chapter 6: Inventory of chemical wastes and hazardous chemical wastes in Rwanda

6.1 Introduction

This category includes any type of waste that is composed of noxious, potentially hazardous chemicals or reagents. Harmful chemicals and solvents that are the by-products of large-scale laboratories and manufacturing plants serve as the most common examples of industrial chemical waste. Chemical waste is categorized as 'hazardous' owing to their chemical reactivity, toxicity, explosiveness, corrosiveness, radioactivity, or other characteristics, that constitute a risk to human health or the environment[41]. This section focuses on the chemical wastes from schools, higher learning institutions, testing and research institutions, research institutions, agriculture sector and industries.

6.2 Methodology

6.2.1 Document review and key informant interviews

In this inventory, an extensive document review was conducted in line with chemicals and hazardous waste management by institutions and their needs. Documents include previous inventories, previous studies/publications on the subject of chemicals and hazardous waste management in Rwanda, and the conventions such as Stockholm, Rotterdam, Basel and Minamata which were reviewed throughout the assignment.

The second dimension of the data collection process was through in-depth interviews of key informants that have knowledge of either chemicals management and/or hazardous waste management in their institutions. Accordingly, an interview schedule was developed for the purpose of obtaining data during the face-to face interview. The target respondents were Chief Executive Officers (CEOs) of Lead Agencies, heads of the chemicals and/or waste management

[41]Handbook on chemicals and hazardous waste management and handling in India

departments of the institutions, representatives of non-state actor institutions, officers from policy development in Government, regulatory agencies, and technical support institutions.

6.2.2 Aim of this inventory

The aim of this task was to estimate the quantity of chemical wastes generated from Rwanda and to describe their current management. In this study, chemical wastes included wastes from expired, damaged and obsolete chemicals and hazardous contaminated wastes. It also included expired or seized low standard fertilizers, biocides, etc. The key institutions contacted for the estimate of chemical wastes are provided in **Table 6.1**. The specific activities to be conducted under this task are as follows:

- Estimation of the quantity of chemical wastes based on recorded sheet of expired, deteriorated or poor-quality chemical products, i.e., the estimate indicated the type of waste and quantity;
- Collection of data on imported chemical products and derive the quantity released as chemical waste;
- Continuing in-desk data collection from secondary sources and key informants' interviews to locate area with high concentrations concerning the different chemical wastes;
- Site visits of pollution hotspots and characterisation of types of chemical wastes in the area;

Table 6. 1: Type of waste and consulted institutions for chemical wastes inventory, 2023.

Waste Stream	Type of waste	Consulted institutions
Chemical wastes	Expired, damaged, or used chemicals	Universities, higher learning institutions, secondary schools, hospitals, NIRDA, REB, REMA, MINICOM, R-FDA, RSB, RMS, BUFMAR, Africhem Ltd, RFI, MEDIASOL.

6.2.3 Other chemical and hazardous wastes

The aim of this task was to estimate the quantity and characterisation of other chemical and hazardous wastes generated in Rwanda and to describe their current management. This inventory focused on the two main hazardous garage wastes, i.e., used tyres and used motor oil, as well as all types of electrical and electronic equipment that enters the waste stream. This part included also expired or seized low standard pesticides, fertilizers, biocides. The main institutions contacted for the estimate of used tyres and used motor oil, as well as all types of electrical and electronic equipment are provided in **Table 6.2**. The specific activities to be conducted under this task are as follows:

- Collect data on imported lubricants, vehicles in service until 2022 and derive the quantity of lubricant wastes and tyres wastes and with future projections;
- Review the data already archived on lubricants and tyres wastes;
- Lubricants consumed in Rwanda excluded export and the collected lubricants was used to estimate the quantity of lubricants used in (a) motor oil and (b) greases;
- Conduct a random surveying on Rwanda leading companies in selling lubricants oil, grease and tyres with the aim to understand the fate of lubricants and tyres once used by vehicles;

- With key informant interviews, locate the area with high concentrations of lubricants and tyre wastes;
- Collect data on imports and local production of electronic equipment's;
- Collect data on E-waste recycling rate and derive the estimate of E-waste in Rwanda based on previous studies such as the Ministry of Trade and Industry (2015)[42] and the International Communication Union (ITU, 2022)[43] ;
- Conduct site visits and key informants' meetings with waste management companies, recycles/ refurbishes and E-waste collectors with the aim to locate and understand the fate of E-waste in Rwanda;
- Collect data on imports of pesticides, fertilizers and biocides;
- Collect data on quantity of expired or seized low standard pesticides, fertilizers, biocides through consultation with relevant stakeholders;
- Document and locate the expired or seized low standard pesticides, fertilizers and biocides.

Table 6. 2: *Type of waste and consulted institutions for Other chemical and hazardous wastes inventory, 2023.*

Waste Stream	Type of waste	Consulted Institutions
Other chemical and hazardous wastes	Used motor oils, tires and other garage wastes	RRA, MINICOM, PSF, garages, REMA, Civil aviation authority, waste collection and management companies (COPED, Depot pharmaceutique Kalisimbi).
	E-wastes	Enviroserve Rwanda, Electronic refurbishing sector, PSF, REMA, Waste collection and management

[42] Ministry of Trade and Industry (2015) E-waste inventory study in Rwanda. Ministry of Trade and Industry.
[43] ITU. 2022. Ramping up e-waste awareness in Rwanda. Available at: https://www.itu.int/hub/2022/06/e-waste-awareness-in-rwanda/

Waste Stream	Type of waste	Consulted Institutions
		companies (COPED, Depot pharmaceutique Kalisimbi).
	Pesticides and biocides	RAB, MINAGRI, REMA and One Acre Fund. MINAGRI and PSF helped to get information on other institutions (public and private institutions) which may have these wastes in their stores.
	Expired or damaged fertilizers	RAB, MINAGRI, One Acre Fund, Waste collection and management companies (COPED, Depot Karisimbi).

6.3 Chemical wastes and hazardous chemical wastes inventory results

6.3.1 Various chemical wastes

This section focuses on the chemical wastes from schools, higher learning institutions, research institutions, agriculture sector and industries.

i. Chemical wastes from secondary schools

Schools are sources of chemical wastes mostly from the laboratories. The students do experiments in science courses which need the use of chemical reagents. Some of those reagents become damaged or expired, leading to the increase of chemical wastes. In this study, the consultants visited REB and different schools in all districts where data from 197 secondary schools have been collected and reported. The inventory results are presented in **Figure 6.1,** and they show that there are so much chemical wastes from those schools. Specifically, in all

consulted secondary schools, it was found that there is a **total of 26.98 tons** of expired chemicals which need to be disposed **(Figure 6.3,** and **Annex 11)**.

Apart from the damaged and used chemicals, there is a challenge in planning leading to the accumulation of expired chemicals. For example, the centres for national exams receive many chemicals to use in the practice of those exams. After the exams, the remaining chemicals stay at those schools and sometimes they are not needed by those schools. Also, there are some schools receiving chemicals from REB and most of the time they receive the ones they do not need. This leads to the accumulation and expiration of chemicals in those schools **(Figure 6.1 a)**. Many of the visited schools expressed their concern about the management of the chemical wastes.

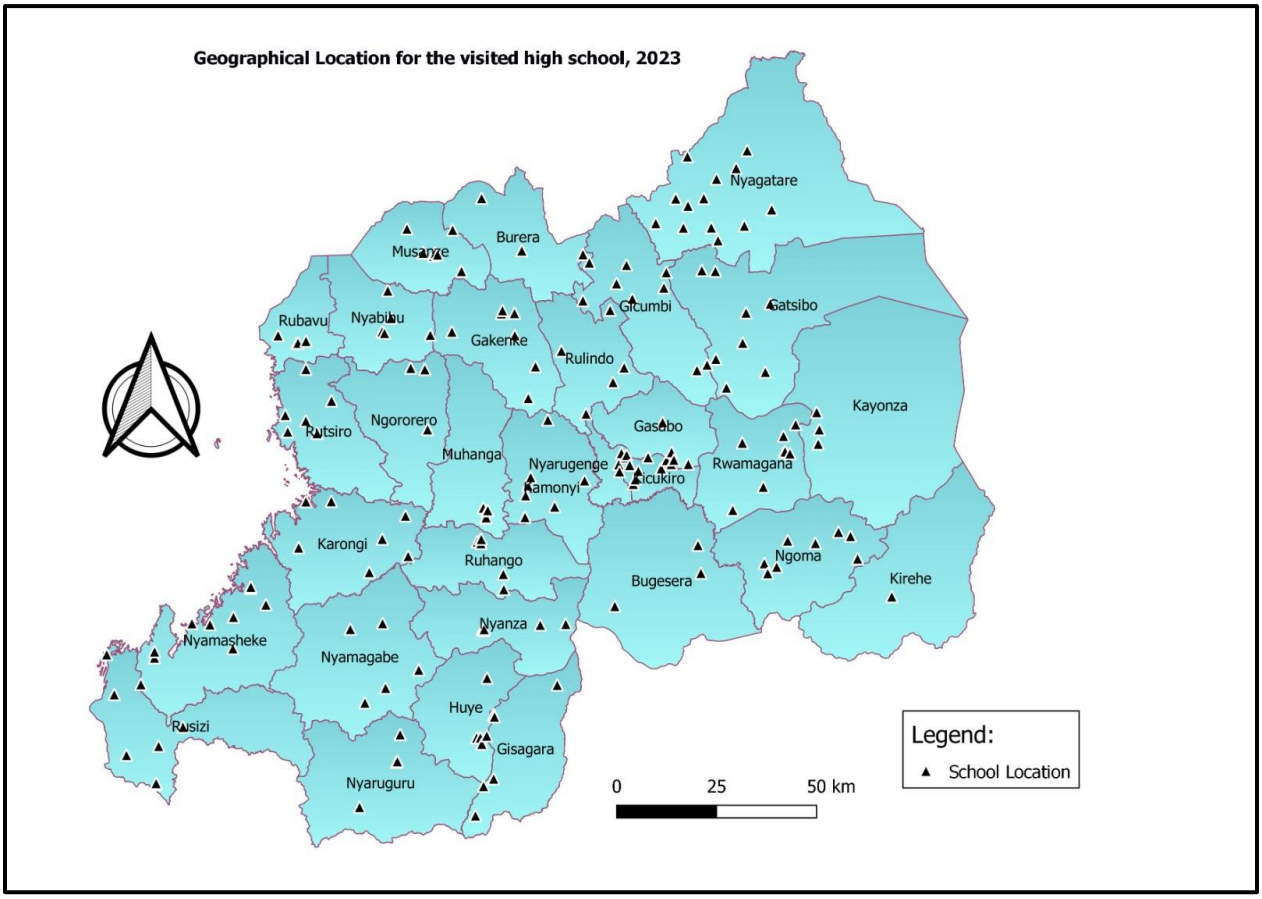


Figure 6. 1: *Geographical location for the consulted secondary school for chemical waste inventory in Rwanda, August 2023*

The common issue is the lack of safe places for the disposal of those chemical wastes and some schools lack staff with waste management skills. Most of the schools keep those wastes in shelves with chemicals **(Figure 6.2b)**. As the quantity of the chemical increases, some schools dump them or throw them in septic tanks. Referring to the questionnaire results, the leaders of schools or laboratory technicians wish the presence of disposal places for chemical wastes at least in every district so that every time they have chemical wastes, they can bring them there.

During the survey, we found that their schools disposing chemical wastes in cemented pits and others having agreements with Hospitals having incinerators of the destruction of those chemical wastes.

Figure 6. 2: *Expired chemicals in a secondary school (July 2023)*

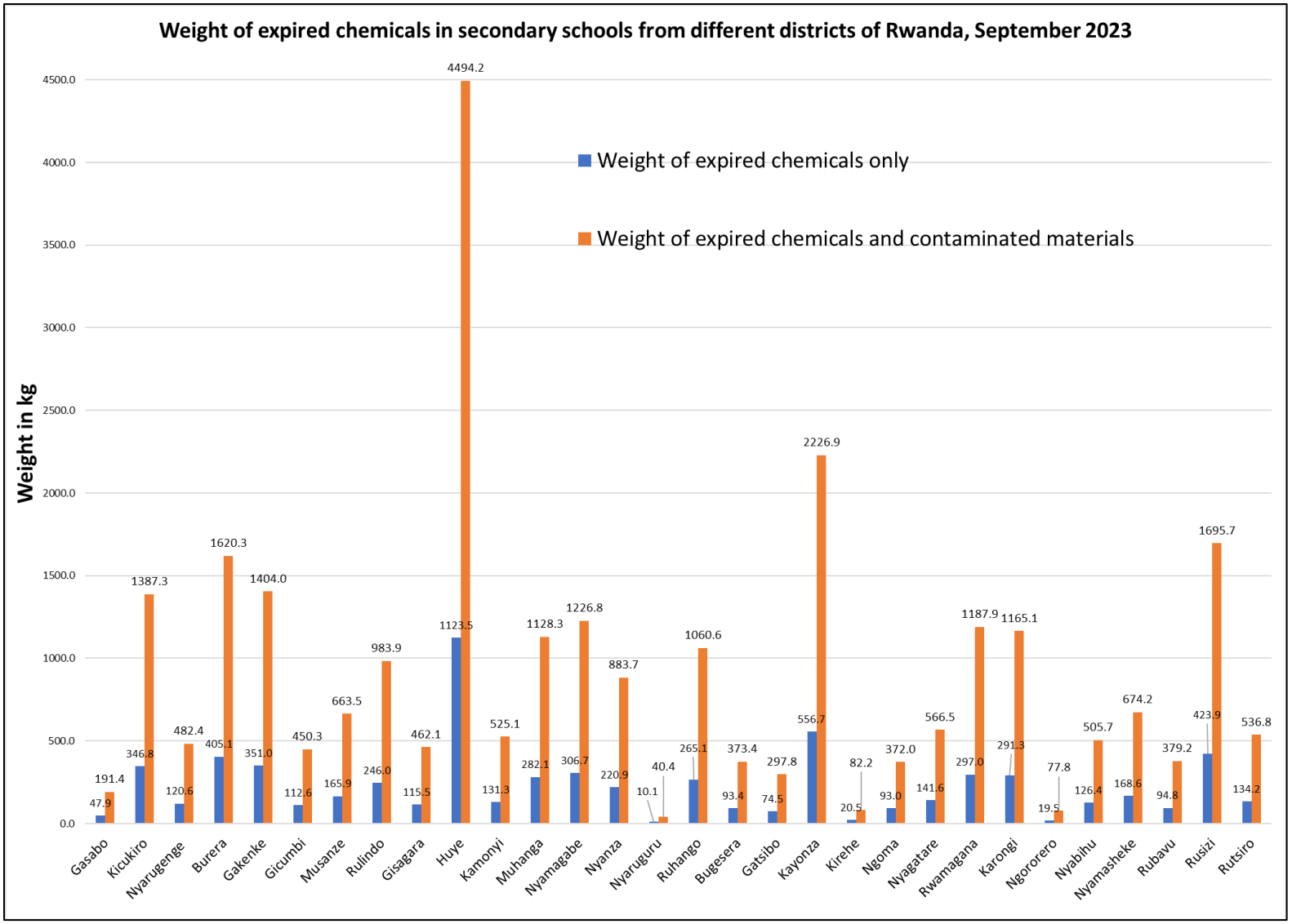


Figure 6. 3: Quantity of Expired Chemicals in Secondary School in different districts of Rwanda, September 2023.

a) Challenges of chemicals in wastes in secondary schools in Rwanda

From the visited secondary schools, the following challenges were remarked:

- The quantity of expired chemicals is increasingly accumulating in secondary schools.
- The visited schools don't have proper storage for expired chemicals.
- There is no plan and no budget for the secondary school to dispose expired chemicals in proper manner.
- Secondary schools in Rwanda don't have skilled lab technicians,
- Some schools have/get chemicals even if there is no chemistry laboratory and these chemicals end up being expired (eg. GS St Vincent Pallotti/Gikondo)
- Most of these expired chemicals have been staying in their stock for a long time (eg. from 2015 to date)

b) Recommendations regarding chemical wastes in secondary schools in Rwanda

From the visited secondary schools, the following recommendations are given:

- We recommend for considering disposing the expired chemicals in secondary schools, and this may seem to be challenging by considering the location of each school, we recommend preparing a collection site at each district in Rwanda for chemical waste temporary storage while waiting for disposal.
- There is a need to revise the existing procedure of how these secondary schools obtain the chemicals, where we propose for considering having a contractual framework instead,
- We recommend the policy maker, especially REB, to put in place a channel where each school can report on time the quantity of expired chemicals, we propose quarterly reporting.
- Each school should have an action plan, regarding the requisition and usage of chemicals depending on the number of programme and students.

- It is recommended for each secondary school to have a proper wastewater treatment mechanism to treat liquid waste contaminated with hazardous chemicals before they can be released into the environment.

ii. Chemical wastes from higher learning institutions

Higher learning institutions, especially the ones teaching sciences, are the generators of much chemical wastes. In these institutions there are technicians with the skills of chemical wastes management. In some institutions, the used disposable PPEs and containers containing residues of handled hazardous wastes are separately put in their specific bins (each lab has at least 3 bins to put different type of wastes). Some chemical wastes are diluted or neutralized following the recommended standard procedures, then disposed in the specific pits **(Figure 6.4)** and each pit is used for a specific chemical waste. But sometimes there is a gap in the management of expired or obsolete chemicals. **Table 6.3** shows the amount of the chemical wastes generated by the visited institution up to date. To solve that problem, some institutions have agreements with institutions or companies which incinerate those wastes. For example, Depot Karisimbi took the chemical wastes from UR-CST for incineration **(Figure 6.5)**, while the UR-CAVM/Busogo and INES Ruhengeri send the chemical wastes to Ruhengeri Hospital for incineration.

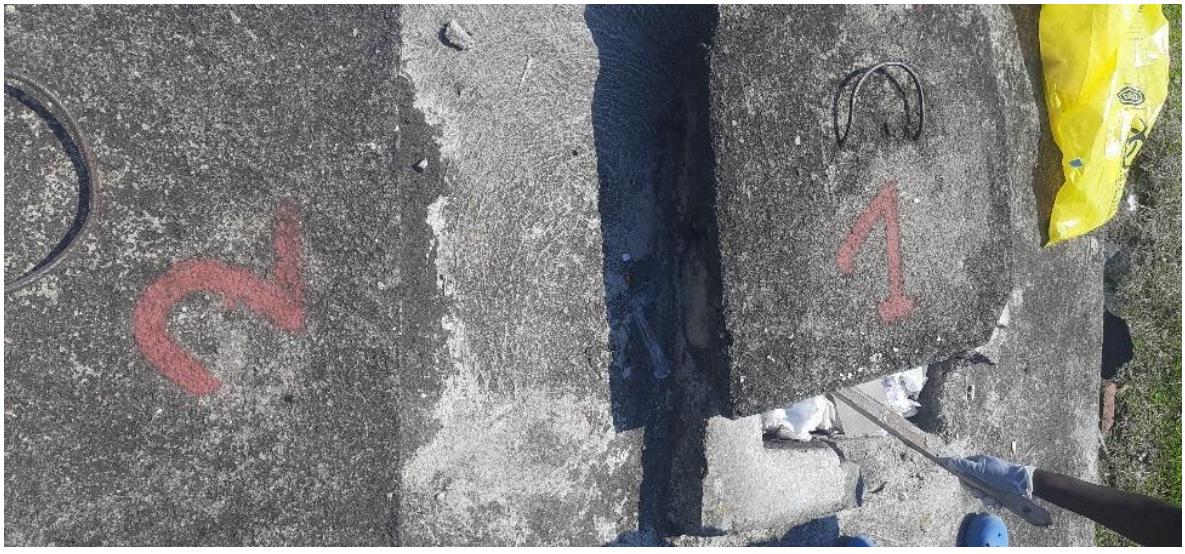


Figure 6. 4: *Pits for the disposal of diluted chemical wastes at INES Ruhengeri (July 2023)*

Figure 6. 5: *Expired chemical being collected from UR-CST by Depot pharmaceutique Kalisimbi for disposal by incineration in December 2022.*

Table 6. 3: *Chemical Waste generated in higher learning institutions in Rwanda, 2023.*

Institution		**Quantity of chemical wastes (Tons)**	**Comment**
University of Rwanda	College of Science and Technology (UR-CST)	1.56	The provided data is from the recent list of expired chemicals that the UR-CST has sent to Depot pharmaceutique Kalisimbi for disposal. The transported wastes for incineration weighted a total mass of 1,551.5 kg distributed as follow 815.5 kg of expired chemicals, 110 kg of broken glassware, and 420 kg empty containers of chemicals and 206 kg of single used Petri dishes from microbiology.
	College of Education	0.32022	This is the current situation at UR-CE regarding the list of expired chemicals in stock.
	College of Agriculture, Animal Science and Veterinary Medicine (UR-CAVM)		UR-CAVM/Busogo send the chemical wastes to Ruhengeri Hospital for incineration
	College of Medicine and Health Sciences	0.47	This is the weight of accumulated expired chemicals which need to be disposed of.
	CASS	2.5	At UR-CASS the is a lot of expired chemicals in their campus, where

Institution	Quantity of chemical wastes (Tons)	Comment
		there are two rooms full of expired chemicals which need to be disposed.
INES Ruhengeri	0.151	INES Ruhengeri sends the chemical wastes to Ruhengeri Hospital for incineration
ULK	0	They do not have any chemical waste
UNILAK	0.005	They have provided a list of 9 type of chemicals expired
University of Technology and Arts of Byumba	0.042	
Total	**5.05**	**Tons**

There are some institutions having in their stores the chemicals which expired many years ago and wondering how to dispose them. The example is the case of UR-Huye campus where there are two rooms full of expired chemicals **(Figure 6.6)**. The issue started when the UR was created, and the scientific faculties were relocated to other campuses. All the chemicals which were used by science faculties from the former NUR stayed in Huye and the new faculties of UR at Huye campus did not need to use those chemicals.

Figure 6. 6: *The expired chemicals at (A, B,C,D) UR-Huye Campus. (July 2023)*

iii. Chemical wastes from testing and research institutions

The testing and research institutions generate different types of wastes including chemical wastes. Most of the institutions we visited during this study, e.g.: Rwanda Forensic Institute (RFI), Rwanda Food and Drugs Food and Drugs Authority (RFDA), Rwanda Standards Board (RSB), Rwanda Medical Supply Limited (the former LABOPHAR), informed the consultants that they work with Depot Karisimbi for the disposal of those wastes which regularly collect these wastes for disposal. The accumulated chemical wastes equal to 0.82 tons which were at former LABOPHAR for many years were taken by Depot Karisimbi for disposal **(Figure 6.7)** in July 2023. Other institutions have a periodic removal of the generated chemical wastes for disposal helping to avoid the accumulation of those wastes (**Table 6.4**).

Figure 6. 7: *Expired chemicals at RMS - Huye (Former LABOPHAR): (a, b) in the store and (c) being packed for transport to the disposal destination (July 2023).*

Table 6. 4: Chemical Waste and hazardous wastes generated in testing/chemical store and research institutions, 2023.

S/N	Institution	Quantity in tons	Comment
1	RMS	0.82	Depot pharmaceutique Kalisimbi company is hired for disposal.
2	RSB	0.72	Depot pharmaceutique Kalisimbi company is hired for disposal. The rate of waste generation is estimated to be: 30 L /monthly and 30 Kg/monthly.
3	R-FDA		Depot pharmaceutique Kalisimbi company is hired for disposal.
4	Africhem Ltd	0.18	These are expired chemicals accumulated in their store by July 2023.
5	Mediasol	0.2	They are sent to Kanombe hospital for disposal by incineration.
6	BUFMAR	7.456	They are sent to Nyamata hospital for disposal by incineration.
7	RFI		Depot pharmaceutique Kalisimbi company is hired for disposal.
8	Agrotech & KIPHARMA	0.73	This 0.73 tons is made of: expired (0.34 tons), recalled& rejected (0.264 tons), damaged (0.15 tons), chemicals (0.21 tons), and samples (0.043 tons). These are expired chemicals accumulated in their store by July 2023
Total		**10.106**	**Tons**

iv. Chemical wastes from agriculture sector

The agriculture sector generates much chemical wastes. Those wastes originate from the expired and damaged fertilizers, pesticides, biocides and other chemicals used in research. The disposal of those chemical wastes is a burden to the institutions dealing with agriculture activities.

Most of the institutions reserve a room for the storage of the chemical wastes and some wastes are store in bags and kept on the floor **(Figure 6.8)**. The information obtained during the survey showed that there are some institutions with chemical wastes which stayed in their stores for more than ten 10 years. The results show that the measures for the disposal of chemical wastes from agriculture sector should be taken as the storage facilities are not enough and they are

hazardous. The inventory of expired chemicals in August 2023 showed that, there are around **472.335 tons** of expired fertilizers, pesticides and other biocides at different locations in Rwanda as it is shown in **Table 6.5**, which are waiting for final disposal.

Figure 6. 8: *Storage of chemical wastes. Photos taken at different RAB station and one NGO focusing on agriculture (July 2023, Source, RAB).*

Table 6. 5. The inventory of expired fertilizers in Rwanda. September 2023

S/N	Location	Quantity in tons of expired fertilizers and pesticides (Tons)
1	RAB (different stations)	**8.21**
2	One Acre fund (different stations)	**420.035**
3	Rwanda Fertilizers company Ltd	**4.3**
4	Solid waste temporarily stored in Nyanza-Kicukiro site	**25.79**
5	obsolete insecticide Pirimiphos methyl and obsolete fungicide Manconzeb located at Maheresho, Cell Ngambi, Sector Mbazi, Nyamagabe District	**14**
6	The metallic drum containing Methamidophos 50% EC at Rubungo RAB Station	**0.2**
4	**Total**	**472.335**

The metallic drum containing 200 Litres of the obsolete insecticide Methamidophos 50% EC mentioned in the national inventory of 2005 and that of 2015 in the Kabuye rice scheme, District

of Gasabo, was relocated and is stored at RAB - Rubungo Station. This organophosphate insecticide, highly toxic, is hermetically enclosed in a metallic drum to prevent risks of leak and spread in the environment while waiting its environmentally sound disposal **(Figure 6.9 a, b)**. Even though they tried to protect the drum from rain and sunlight, the CEBUDEMA consultants found that it has started to rust **(Figure 6.9 c, d)**.

Other POPs containing biocides were disposed in Nyanza (Kigali City) and Nyamagabe (Southern Province) and are still there. The interim disposal of these agrochemicals has been made in accordance with recommendations in the Environmental Management Tool Kit for Obsolete Pesticides (FAO Pesticide Disposal Series, Rome, 2009).[44]

In 2010, an average quantity of 14 tons of an obsolete insecticide Pirimiphos methyl and obsolete fungicide Manconzeb has been stored by World Vision under supervision of REMA in a pit digged in an afforestation located at Maheresho, Cell Ngambi, Sector Mbazi, Nyamagabe District.

[44] REMA, 2016: Updated national implementation plan of the Stockholm convention on persistent organic pollutants.

Table 6. 6: Composition and quantity of the solid waste temporarily stored in Nyanza-Kicukiro site. (Source REMA, 2016)

S/N	Name of active ingredient	Formulation	Quantity (kg)	Importation year
1	Pyrimiphos methyl	PP	11,931	1995
2	Thiophanate+Diazinon+Thiram	WP (**)	6,806	1990-1994
3	Mancozeb	WP	1,875	Not found
4	Benomyl	WP	1,900	1994-1995
5	Chlorothalonyl + copper oxychloride	WP	3,000	1994-1995
6	Other formulation	WP	283	NA
	TOTAL		**25,795**	

Figure 6. 9: *Current status of the metallic drum containing Methamidophos 50% EC at Rubungo RAB Station (July 2023).*

Table 6. 7: The inventory of expired fertilizers and pesticides at all Stations of RAB in Rwanda, *Source: RAB, (05-08-2023)*

S/N	Item description	Unit	Gakuta	Musanze	Ngoma	Ntendezi	Nyamagabe	Rwerere	Total in Kg
1	2.4D	L	-	-	-	-	-	2	**2**
2	Actellic	Kg	-	-	-	-	-	278	**278**
3	Alto	L	26	-	-	8.5	-	-	**34.5**
4	Avi-Klorpirifos	L	6	-	-	-	-	-	**6**
5	Basamide Liquide	L	-	-	-	-	-	1.45	**1.45**
6	Basamide Poudre	kg	-	-	-	-	-	6	**6**
7	Bayfidam	L	-	-	-	-	-	1	**1**
8	Beam	Kg	50	-	-	-	-	-	**50**
9	Benlate	Kg	4	-	-	15	8	29	**56**
10	Benomyl 50% wp	Kg	-	-	-	-	-	22	**22**
11	Bravocard	L	-	-	-	-	-	1	**1**
12	Carbendazim	L	-	-	93	-	-	-	**93**
13	Copper oxychloride	Kg	-	-	7	49	-	-	**56**
14	Cyper laser	L	12	-	-	-	-	-	**12**
15	Cypermethrin	L	-	29	-	-	-	-	**29**
16	Dacobre	Kg	-	-	-	-	-	77	**77**
17	DAP	Kg	4775	-	-	-	-	-	**4775**
18	Deltanex	L	-	-	-	-	-	0.2	**0.2**
19	Denacron (Pouder)	Kg	-	-	-	-	-	10	**10**
20	Detia	Kg	-	-	-	-	11	-	**11**
21	Dithane	Kg	-	-	-	-	-	145	**145**
22	Fungcure	Kg	50	-	-	-	-	-	**50**
23	Funguran	Kg	-	-	-	257	-	-	**257**
24	Gaucho	L	-	-	-	-	-	1	**1**
25	Imidacloprid	L	9	-	-	5	-	-	**14**
26	Lambda	L	-	-	1	-	-	-	**1**
27	Malathion	Kg					-		**0**

S/N	Item description	Unit	Gakuta	Musanze	Ngoma	Ntendezi	Nyamagabe	Rwerere	Total in Kg
28	Maullant	L	-	-	-	-	-	6.4	**6.4**
29	Mecotex	L	-	-	-	-	-	1.865	**1.865**
30	Propicanazole	L	-	-	-	-	-	0.2	**0.2**
31	Protect	L	-	-	-	-	-	2	**2**
32	Ridomil	Kg	194	-	-	28	70	30	**322**
33	Rizonil	Paquets	-	1448	-	-	-	-	**1448**
34	Rocket	L	7	-	1	5	-	0.351	**13.351**
35	Rogor	L	-	-	-	-	-	10	**10**
36	Safari Max	kg	-	-	-	8	-	4.088	**12.088**
37	Stimfol	L	-	-	-	-	-	6.5	**6.5**
38	Sulfate de mangnesium	Kg	-	-	-	-	-	-	**0**
39	Super scanner	Kg	88	-	13	2	17	-	**120**
40	Tebuconazole-Orius	L	63	84	-	-	1	12	**160**
41	Thiovit	Kg	18	31	-	19	-	-	**68**
42	Umeme 2.5EG	L	-	46	-	-	-	-	**46**
	Total in Kg		**5302**	**1638**	**115**	**396.5**	**107**	**647.054**	**8205.554**

Table 6. 8: The inventory of expired fertilizers and pesticides at all Warehouses of One Acre Fund, Source One Acre Fund (31-07-2023)

S/N	Item description	Warehouses						
		Karongi	Kayonza	Kigali	Musanze	Nyanza	Save	Grand total in Kg
1	DAP (18-46-0),5kg bag	-	-	-	-	-	4,270	4,270
2	DAP (18-46-0),10kg bag	-	-	-	-	-	7,110	7,110
3	DAP (18-46-0),25kg bag	-	-	-	-	-	2,620	2,620
4	DAP (18-46-0),50kg bag	-	-	-	50	-	204,350	204,400
5	Lime, Travertine, 25kg bag	-	-	-	-	-	1,400	1,400
6	Lime: travertine, 25kg bag	-	-	-	-	-	1,400	1,400
7	NPK (17-17-17), 5kg bag	-	-	-	-	-	8,565	8,565
8	NPK (17-17-17), 25kg bag	-	-	-	-	-	7,375	7,375
9	NPK (17-17-17), 50kg bag	150	-	-	200	100	156,250	156,700
10	Urea (46-0-0) 5kg bag	-	-	-	-	-	1,000	1,000
11	Urea (46-0-0) 10kg bag	-	-	-	-	-	250	250
12	Urea (46-0-0) 25kg bag	-	-	-	-	-	145	145
13	Urea (46-0-0) 50kg bag	-	-	-	-	-	25,300	25,300
Total in kg		**150**	**0**	**0**	**250**	**100**	**420035**	**420.035**

v. Chemical wastes and hazardous wastes from industries

The results of the survey in the industries showed that most of the visited industries produce fewer chemical wastes but a great number of hazardous wastes was observed in some industries as showed in **Annex 13**. Some chemical wastes generated are recycled and used as raw materials for other products **(Figure 6.10)**.

As the main purpose of the industries is business, they do their best to avoid the expiration of the raw materials. Concerning the chemical wastes which may originate from the chemical analysis for quality control, they are reduced by using the quality control kits which do not generate chemical wastes. Other industries like CIMERWA Plc. Incinerate some chemical wastes they generate.

However, this does not mean that the industries do not totally regenerate chemical wastes requiring the disposal. By referring to the data presented in Table of **Annex 13**, where 30 manufacturing industries which can be considered to be the potential source of chemical wastes in Rwanda were consulted, it is estimated that the industries can produce around **85.54 tons per year** of chemical and hazardous wastes which need to be disposed of appropriately.

Figure 6. 10: *Example of chemical wastes from different industries in Rwanda:* ***(A&B)*** *Hazardous wastes composed of broken glasses in a storeroom at SPERANZA GROUP LTD located in Kigali special economic zone.* ***(C&D)*** *Solid waste(boxes) and ash produced at Mount Meru Soyco Factory at Kayonza.* ***(E&F)*** *Separated hazardous wastes by GreenCare Rwanda Ltd at Huye. (July 2023)*

6.3.2 Polyethylene terephthalate (PET) hazardous wastes

Polyethylene terephthalate which is also abbreviated as PET / PETE is mainly used to manufacture the packaging material for food products such as fruit and drinks containers. For example, PET bottles are the single most used material by beverage companies for packaging juices, sodas and water. Pet bottles are non-degradable materials, which when burned releases toxic chemicals harmful to health, and if they are not well disposed of, they can become a threat to the

environment. Therefore, the Government of Rwanda has been encouraging everyone concerned in the country to be part of the campaign for phasing out of single-use plastics in the coming years. Since then, the use plastic straw has been restricted and reinforced in Rwanda. From this perspective, in 2019 there was born the idea to amend the law prohibiting polythene bags in 2008 and where the country adopted a law relating to the prohibition of manufacturing, importation, use and sale of plastic carry bags and single-use plastic items. The new law came with some leniency to allow a grace period for the traders who have a lot to do with the single use plastic. The law entered into force in August 2019. In addition, R-FDA has prohibited the packaging of alcoholic drinks in plastic bottles as they pose a threat to both consumers health and the environment. Nevertheless, despites all effort spared on phasing out single use plastics is still a challenge to address as one may need to find alternatives before completely phasing out all single use PET containers.

From this perspective, REMA in partnership with Enviroserve Rwanda Green Park have initiated a project for collecting PET wastes in in Kigali and secondary cities to support the private and public sector in decoupling hazardous waste generation and harmful releases from economic growth by enhancing the introduction of the 4Rs in priority industries and economic sectors. The projects began in 2nd Quarter of 2022-23 and the cumulative quantity of single use plastic waste collected is 584,302.8 Kg, among which 413,603.3 Kg have been collected in the during the third quarter from January to March 2023. The majority of SUP plastic waste was collected Of all the collected PET, 30% was in Kicukiro District, 24% Nyarugenge District and 19% in Gasabo District and while the rest were collected from the other districts and secondary cities such as 5% from Rwamagana, Kayonza and Nyagatare Districts, 3% from Bugesera Districts, 4% from Muhanga, Ruhango and Huye Districts, 5% from Musanze and Burera Districts, 4% from Rubavu and Nyabihu Districts, 3% from Rusizi and Nyamasheke Districts while 3% were collected from other Districts and cities countywide. In Total the project is planning to collect around 1,375 Tons of PET wastes and of efforts are being invested into penetrating and the interior of other districts to set up multiple collection points to collect the available plastic waste in each district to

maximize the plastic waste collection quantity **(Table 6.9)**. With the aim of this report, the collected PET wastes are waiting for proper disposal or recycling.

Table 6. 9: Quantity of PET wastes collected and to be collected in the period of 2022-2024

S/N	PET collection in the period of 2022-2024	Quantity in Tons	Percentage (%)
1	Total to be collected	1,375	100
2	Collected from Quarter 2 of year 2022-2023	170.7	12.4
3	Collected from Quarter 3 of year 2022-2023	413.6	30.1
4	Remaining to be collected before December 2024	790.7	57.5

6.3.3 Garage wastes

These wastes include used oil and other petroleum products such as engine oil, transmission fluid, lubricating oil, hydraulic oil, gear oil, grease, brake fluid, etc. It also includes used tyres and other wastes contaminated with hazardous chemicals. This inventory focused on the two main hazardous garage wastes, used tyres, and used motor oil.

A waste tyre is one which has been removed from a vehicle and cannot be put to immediate use. This applies to a tyre that has been stripped from its rim or a complete wheel. Once discarded it will remain waste until it is, either, repaired, retreated, recycled or recovered. Tyres are not degradable; they have a complex structure of the materials that consist of natural rubber, synthetic rubber, steel and fibre which cause it as difficult material to recycle. This presents the biggest challenge in terms of disposing of them without polluting the environment.

According to the estimated quantity of tires waste in **Tab 6.10**, by 2022 about 1,569 ton of used tires are disposed of from trucks and buses, 1,670 ton from cars, 1,093 ton from light duty trucks and 1,033 ton from motorcycles. In total, considering that each tire is used for two years period, around 5,364 ton of used tires were disposed of in 2022 in Rwanda.

Table 6. 10: Estimated quantity of tires waste

Year	Metric ton			
	Trucks and buses	Cars	Light duty trucks	Motorcycle
2010	581	575	533	270
2011	627	655	579	346
2012	685	777	634	425
2013	775	870	671	482
2014	809	949	718	526
2015	879	1,010	731	596
2016	994	1,111	769	658
2017	1,098	1,190	802	712
2018	1,196	1,273	833	787
2019	1,255	1,336	874	826
2020	1,255	1,336	874	826
2021	1,286	1,369	896	846
2022	1,569	1,670	1,093	1,033

Source: *Adapted from RoR, 2021*[45]*, Data from 2019-2022 are based on real GDP growth from the NISR,2023*[46]

From the 38 institutions visited to check the status of waste tires, only 52.63% of the institutions claimed to have the existing standards operating procedures (SOPs) for disposing of tyres wastes while 47.37% of the institutions noted that they do not have SOPs for disposing of tyres wastes.

Used motor oils are another class of garage waste produced in high amounts. The World demand for lubricant oil is about 41.35 million metric tons. The regional distribution indicates that Africa consumes only 2.068 million metric tons of the global lubricant consumption. Within Africa, South Africa Consumes about 0.305 million metric tons of the Africa quota while Kenya consumes about 0.007 million metric tons of lubricating oils. These lubricating oils become degraded after use due to presence of contaminants hence not fit for its intended use and require to be disposed of. Improper storage, handling, transportation, treatment, and disposal of the used oils results in negative environmental impacts and public health hazards.

According to the collected data in **Table 6.11**, by 2022 the imported liquid lubricants in Rwanda are estimated to 4,196,188 kg while the grease lubricants are estimated to 459,628 kg. It is clear from these data that the quantity of lubricants and greases are increasing gradually per year with for instance an increase of 27% of the imported lubricants in the last ten years. The huge import of lubricants in 2016 compared to the previous and following years can be explained by the decline in crude oil price experienced in 2016 as mentioned in historical annual data of oil prices[47].

[45] Republic of Rwanda (2021). National Greenhouse gas Inventory: Report to the United Nations Framework Convention on Climate Change. Republic of Rwanda, Kigali
[46] NISR, 2023. Gross Domestic Product - 2022
[47] https://www.macrotrends.net/1369/crude-oil-price-history-chart

Table 6. 11: Quantity of imported liquid and grease lubricants

	Quantity (kg)	
Year	**Liquid Lubricants**	**Grease Lubricants**
2010	2,367,959	136,247
2011	2,544,355	144,303
2012	3,305,031	189,820
2013	3,228,077	202,793
2014	3,420,676	195,738
2015	4,141,797	199,160
2016	7,472,244	388,966
2017	3,393,116	320,495
2018	3,356,115	367,611
2019	3,520,341	385,600
2020	3,223,637	353,100
2021	3,439,704	376,767
2022	4,196,188	459,628

***Source**: Adapted from REMA, 2019[48]; MINICOM, 2023, Data from 2019-2022 are based on real GDP growth from the NISR,2023[49]*

Among the 41 institutions that were visited to check the status of used lubricants, these institutions demonstrated various level in management of used moto oil as a hazardous waste. Based on the findings summarised in **Figure 6.11**, about 53.66% of the visited institutions have the existing standards operating procedures (SOP) for handling, storing and disposing of used moto oils while 46.34% of the institutions do not have existing SOPs for handling, storing, and disposing of used moto oils respectively. On the other side, 46.34% of the institutions highlighted that they have put in place measures to avoid the generation of those wastes while 53.66% of the institutions seem to have no measures put in place to avoid the generation of those wastes. In addition, 7.32% of the institutions have the treatment methods for used moto oils wastes while 92.38% of the institutions do not have treatment methods for used moto oil as a hazardous waste. As part of the existing disposing of mechanisms, only 36.59% of the institutions have disposing of mechanisms put in place while the remaining 63.41% of the institutions do not have disposing of mechanisms put in place for used moto oils.

[48] REMA,2019. Survey on burned and non-calcinated lime and a study that details the specific quantities of lubricants and solid wastes, Kigali, Rwanda.
[49] NISR, 2023. Gross Domestic Product - 2022

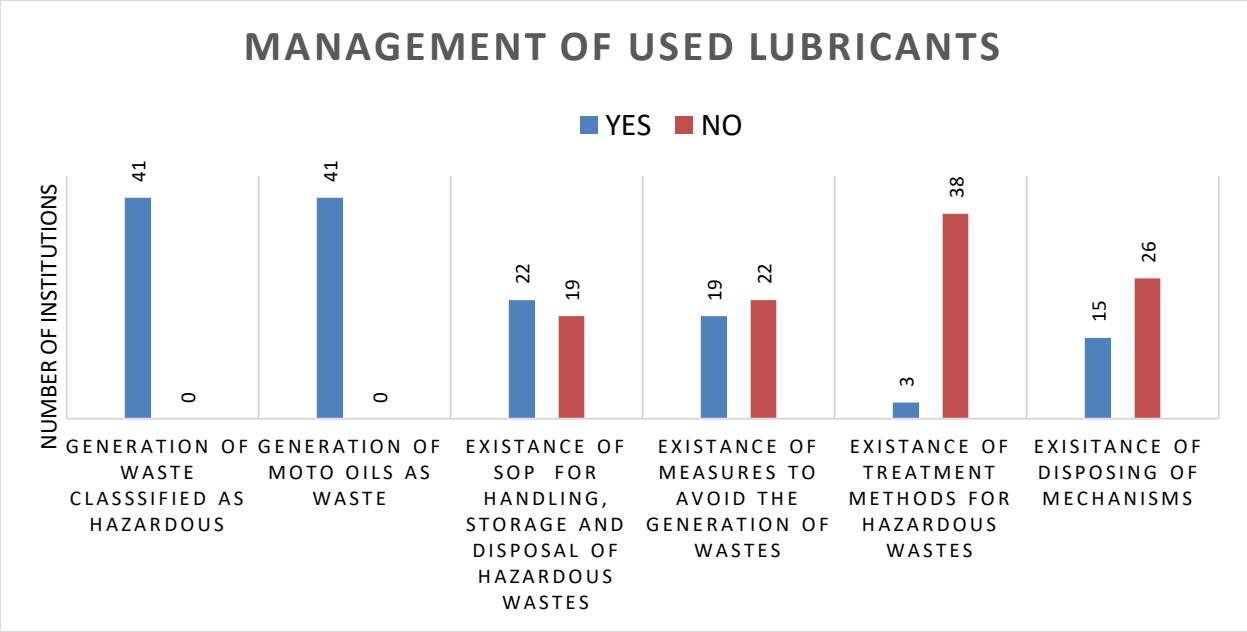


Figure 6. 11: Management status of used lubricants in visited garages

6.3.4 Electronic wastes

The category of electronic wastes (E-wastes) includes computers, cell phones, cathode ray tube (CRT), printed circuit boards, printer and toner cartridges, and electronic household appliances. E-waste is one of World wide's fastest rising pollution issues given the presence of a number of harmful substances which could adulterate the environment and people's life. According to Rwanda National E-Waste Management Policy, e-waste encompasses all discarded and disposed electrical and electronic equipment (EEE).

As per the Rwanda State of Environment and outlook Report of 2021, E-waste in Rwanda covers almost all types of electrical and electronic equipment that enters that waste stream. It also highlights that e-waste collection rate in Rwanda was 15.4% in 2018 increasing to 19.3% in 2019. Despite this collection rate of e-waste in Rwanda, imports of EEE into the country are expected to increase at the rate of 5.95% annually and annual e-waste generation may reach 70,000 tons of waste by 2050[50]. The total amount of electric and electronic equipment (EEE) placed on

[50] Rwanda State of Environment and outlook Report, 2021

Rwandan market, and corresponding estimates of Waste Electrical and Electronic Equipment (WEEE) generated, is shown in the **Figure 6.12**. The figure illustrates the estimates for 2009-2017 with consideration of all EEE products, excluding PV panels and off-Grid solar products. Those put into consideration include Cooling and Freezing appliances (C&F), lamps, Large Household Appliances (LHHA), Screens, Small Household Appliances (SHA), and Small IT.

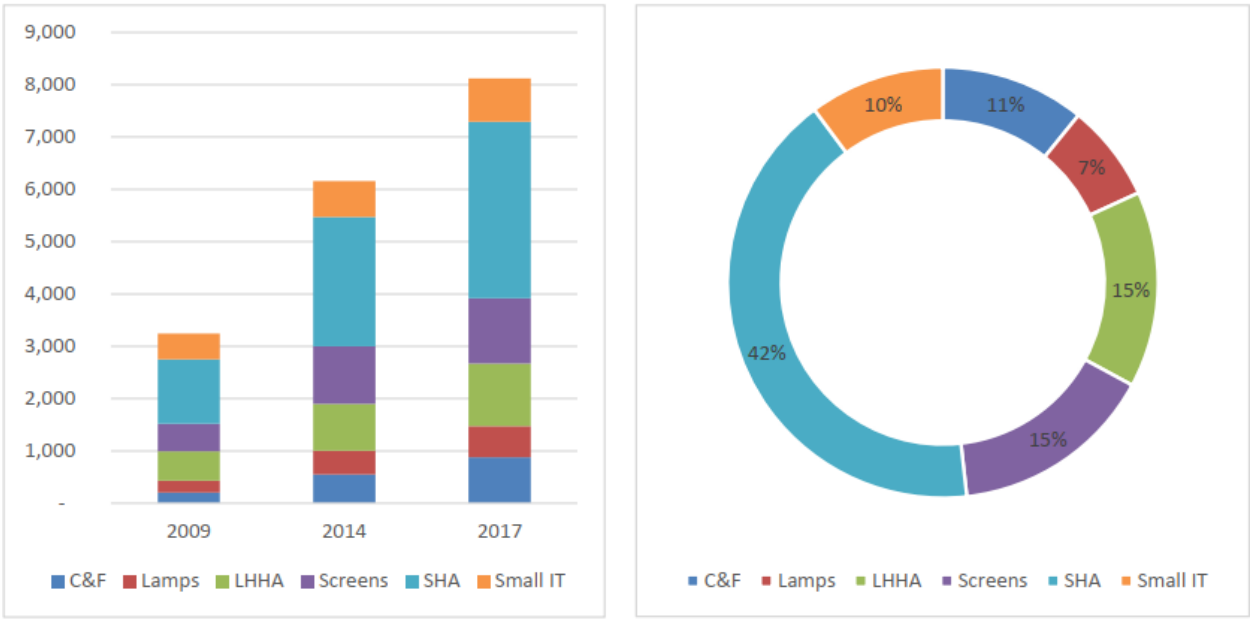


Figure 6. 12: *Evolution of E-waste generated in Rwanda (ton), excluding PV and off-grid solar products (left) and estimated breakdown of e-waste generated in 2017 per category (right),*[51]

Some of the major categories of electrical and electronic equipment observed in shops for Rwanda are Television and accessories (Include Television, DVD player, Decoder, Satellite dish, Receiver cables); Computer and accessories (Such as Laptops, Desktop computers, CD-R, CD-RW & DVD, computer speakers, Hard drives, USB sticks, CDMA sticks, Printers, Notebooks, Computer, keyboards & mouse); Mobile devices and accessories (For instance Mobile phones, Mobile chargers (separate), Mobile phone batteries, Headsets) and Other electronic items (Like Radios, Tape recorders, Stoves, Ironing machine, Power adaptor, Power dividers, Rechargeable batteries,

[51] Sustainable Management of E-waste in the off-grid renewable energy sector in Rwanda, 2017

Men and women beauty equipment, Power cables, Different types of lamps, Refrigerators, Air conditioner, Dry cell batteries, washing machines, coffee grinder, Juice maker, Kettles and Vacuum cleaners). Currently, there is a massively increasing number of EEE in institutions, families, and companies, etc. These lead to alarming rates of e-waste generation in Rwanda combined with strong demand from customers for the new smartphones.

The **Table 6.12** provides the major categories of electrical and electronic equipment found in Rwanda.

Table 6. 12: *E-waste categories and classification*

No	Categories	EEE
1	Large Household Appliances	Washing machines, dryers, refrigerators; and air conditioners.
2	Small Household Appliances	Vacuum cleaners, coffee machines, and iron toasters.
3	IT and telecommunication equipment	Personal computer (PC), laptops, mobile telephones, fax machines, copiers, and printers.
4	Consumer equipment	Radio sets, video recorders, TVs, video cameras, audio recorders and amplifiers, and musical instruments
5	Lighting equipment	Fluorescent lamps, high intensity or low sodium lamps, and metal halide lamps.
6	Electrical and electronic tools	Drills, saws machines, sewing machines, equipment for spraying, spreading, and dispersing.
7	Sports equipment, leisure, and Toys	Hand-help video game consoles, car racing sets or electric trains, Coin slot machines, Sports equipment with electronic and electrical components.
8	Medical instruments and equipment	Radiotherapy equipment, cardiology, dialysis, nuclear medicine, laboratory equipment for in-vitro diagnosis, analysers, and freezers.
9	Surveillance and Control	Smoke detector, thermostats, and heating regulators.

No	Categories	EEE
	equipment	
10	Automatic dispensers	Automatic dispensers for hot drinks, bottles or cans, and money.

Enviroserve Rwanda has collection centers different districts, and they plan to have those collection centers in every district by the end of October 2023. They do refurbish and recycle E-wastes reducing their impact on the environment. The wastes which they are not able to recycle are sorted and stored safely to be sent to Enviroserve Dubai as they have more advanced equipment for recycling and disposal of those wastes (**Figure 6.13)**. The information shown on their website (data till August 29, 2023) shows that they have collected **6,739 tons** of E-wastes, dismantled **5,916 tons** of E-wastes, and refurbished **10,709 computers**.

Figure 6. 13: *E-wastes resulting from dismantled EEE waiting to be sent abroad for recycling: (a) Lithium-ion batteries; and (b) Motherboards.*

6.4 Proper disposal of chemical and hazardous wastes

Chemical disposal refers to the safe and proper management of chemicals that are no longer needed or have become waste. The disposal process typically includes the identification and characterization of the chemicals, selection of appropriate disposal methods based on their properties, packaging and labelling of waste containers, transportation by licensed waste haulers, and disposal at authorized facilities such as incinerators, treatment plants, or landfills. Compliance with local, regional, and national regulations is crucial to ensure the responsible and environmentally sound disposal of chemicals. Proper chemical disposal plays a critical role in minimizing risks, promoting sustainability, and maintaining a safe working environment.

The chemical wastes may be disposed of in the following ways:

- **Chemical or physical treatment:** The purpose of treating hazardous waste is to convert it into non-hazardous material or to stabilize or encapsulate the waste in such a way that it will not leak or rep-resent a hazard when it is finally disposed of in the environment. Stabilization or encapsulating techniques are particularly necessary for inorganic wastes, in particular those containing toxic heavy metals.
- **Disposal of solid waste in a monitored landfill:** Solid inorganic chemical waste can usually be deposited in a specially monitored landfill. This procedure is however prohibited for reactive and flammable wastes. Such substances must therefore be disposed of in appropriate containers according to their chemical properties in order to minimize the risk of chemical reactions **(Annex 12)**.
- **Incineration:** Incineration is the controlled combustion process used to degrade organic substances. Particulate emissions, including heavy metals in the form of particles, are controlled by the use of bag filters (both wet and dry), high energy scrubbers or, less frequently, electrostatic precipitators. High temperature incineration of organic hazardous wastes in properly designed and operating facilities can be performed in a manner that complies with standards regulating the emission of gaseous pollutants.

Chapter 7: Inventory of perfluoroalkyl and polyfluoroalkyl substances in Rwanda

7.1 Background on PFAS

Per- and polyfluoroalkyl substances (PFAS) are a large group (>4000) of synthetic perfluorinated compounds ($C_nF_{2n+1}COOH$) widely used in many consumer products and industrial applications[52]. For instance, PFAS have been widely used as emulsifying agents in fluoropolymer manufacturing and as surfactants in paints, lubricants, photolithography, polishers, food packaging and fire-fighting foams.

Their characteristic structure consisting of several C–F bonds makes them highly stable and difficult to degrade by both environmental and metabolic processes, making them among the most environmentally persistent chemicals. The high thermal and chemical stability of PFAS make them persistent in the environment and nearly non-biodegradable, earning them the nickname "Forever Chemicals."

Despite the lack of a universal definition of PFAS, the U.S. Environmental Protection Agency (USEPA) defines PFAS as “chemicals with at least two adjacent carbon atoms, where one carbon is fully fluorinated and the other is at least partially fluorinated”.

Polyfluorinated alkylated substances (R-X) are compounds consisting of a hydrophobic alkyl chain, R, of varying length (typically C4 to C16) and a hydrophilic end group, X. The hydrophobic part may be fully [$R=F(CF_2)_n$-] or partially fluorinated. When fully fluorinated, the molecules are also called perfluorinated substances. Their general structure is given in **Figure 7.1**.

[52] ITRC. (2021). PFAS — Per- and Polyfluoroalkyl Substances (Accessed, April 2023). doi: https://pfas-1.itrcweb.org/1-introduction

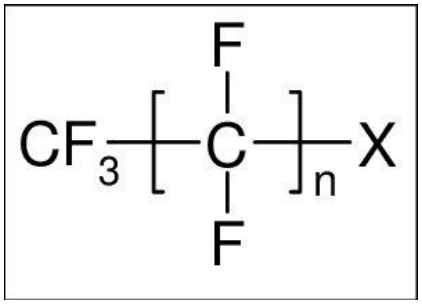


Figure 7. 1: *General structure of perfluorinated alkylated substances (PFAS)*

PFASs pose significant threats to the environment and human health because of their high stability, potential toxicity and persistence in the environment. Due to toxicity concerns, these compounds are now enlisted as "persistent organic pollutants" by the Stockholm Convention and European Commission.

Consequently, PFAS are currently under much attention by both international and national environmental protection agencies worldwide including REMA and other concerned government and non-government institutions in Rwanda. According to the growing number of literatures, it is noted that exposure to some PFAS can lead to the accumulation and remain in the body of the living organism for long period of time which may cause various adverse health and environmental effects.

Nevertheless, despite the imminent risks of PFAS on the environment and ecological system, their production, distribution, and application are not yet known in Rwanda. To this end, there is an urgent need to expand scientific foundation for understanding and managing the possible risks from PFAS exposure in Rwanda. Therefore, given the fact that PFAS is considered as an issue of high and growing concern for the public, REMA is committed to taking action to address public concerns of PFAS in Rwanda.

7.2 Objectives

The objectives of this document with regard to perfluoroalkylated substances are:

- To provide most recent information on PFAS status in Rwanda through the identification of their sector use and quantification;
- To describe their behaviours in the environment and ecosystem;
- Describe the best methods for detecting and analysing PFAS;
- Conduct institutional capacity in management of PFAS;
- Recommend future interventions to achieve reduction of PFAS generation and release in the environment.

7.3 Summary on PFAS

7.3.1 Common PFAS and their important subsets

PFAS is the collective name for a vast group of fluorinated compounds, including oligomers and polymers. The group comprises several hundred of compounds and can be divided into 23 categories (**Table 7.1**) [53]. Important subsets are the (per) fluorinated organic surfactants and the fluorinated organic polymers such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). Due to its surface-active properties, it is used in a wide variety of applications. PFOS can be formed by degradation from a large group of substances, referred to as PFOS-related substances, which may be simple salts of PFOS, *e.g.,* potassium, lithium, ammonium, or polymers that contain PFOS.

Perfluorooctanoic acid (PFOA) is a completely fluorinated organic acid that is produced synthetically as its salts. It can also appear as a result of degradation of some precursors e.g., fluorotelomer alcohols. PFOA is primarily used as an emulsifier in industrial applications, for

[53] NCEHS. (2001). National Centre for Ecotoxicology & Hazardous Substances, Review of occurrence and hazards of perfluoroalkylated substances in the UK, A nonconfidential overview, Environment Agency, Wallingford, United Kingdom.

example in the production of fluoropolymers. The typical structure has a linear chain of eight carbon atoms. The PFOA derivative that is most widely used and therefore of most concern is the ammonium salt (Ammonium pentadecafluorooctanoate: APFO).

Table 7. 1: *Categories of perfluoroalkylated substances*

Category	Substance type
1	Perfluoroalkyl sulfonates
2	Perfluoroalkyl sulfonyl derivatives
3	Perfluoroalkyl sulfonamides
4	Perfluoroalkyl sulfonamide alcohol derivatives
5	Perfluoroalkyl sulfonamide phosphate derivatives
6	Perfluoroalkyl sulfonamide glycine derivatives
7	Perfluoroalkyl sulfonamide polyethoxylate derivatives
8	Perfluoroalkyl sulfonamide aminopropyl derivatives
9	Perfluoroalkyl sulfonamide chromium complex derivatives
10	Perfluorocarboxylic acids
11	Fluorosulfonamides
12	Fluoroesters
13	Fluorothioethers
14	Fluorocarboxylates
15	Fluorourethanes
16	Fluoroalcohols
17	Fluoroacrylates
18	Fluorophosphates
19	Fluoroalcohol derivatives
20	Perfluorosulfonamide acrylate polymers
21	Fluoroacrylate polymers
22	Perfluoroalkyl and -alkoxy silanes

Category	Substance type
23	Perfluorophosphonics

Source: (NCEHS, 2001)

7.3.2 History and current uses of PFAS

Since the 1940s, PFAS constitute a large family of fluorinated chemicals, exceeding several thousand that might be in commercial use or the environment, that vary widely in their chemical and physical properties. PFAS are used around the globe in industrialized and urbanized areas. Fluoropolymer coatings can be in a variety of products. These include clothing, furniture, adhesives, food packaging, feat-resistant non-stick cooking surfaces, and the insulation of electrical wire.

Basically, PFAS have special physical and chemical properties, including chemical inertness, high thermal stability, low surface energy, hydrophobicity and oleophobicity which make them attractive to several applications and the most important fields of application are:

- Carpet protection,
- Paper and board protection,
- Textile protection,
- Leather protection,
- Fire-fighting foams,
- Specialty surfactants,
- Polymerisation aid.

Annex 2 provides a general (not exhaustive) introduction to some of the uses of PFAS chemistries that are, or have been, marketed or used. The specific applications for all PFAS are not well

documented in the public realm. For example, of the 2,000 PFAS identified in a 2015 study, only about half had an associated listed use[54].

7.3.3 Human and ecological health effects of PFAS

Because of their wide use, it is reported that PFAS can be detected in food, water, wastewater and human blood samples. PFAS enter the body through the gastrointestinal tract, respiratory system, and skin, making exposure to these compounds unavoidable. Moreover, PFAS can have long half-lives of up to 6 years in blood serum[55]. Exposure to even low concentrations of perfluorinated compounds can have an adverse effect on human health hence, the ability to detect them at low levels is crucial. Toxicological research has linked PFAS exposure with detrimental effects on organ systems, disruption of the development of the endocrine system, neurotoxicity and involvement in many diseases, including cancer. In contrast, the higher concentration of PFAS in aquatic organisms compared to the water they inhabit indicates their potential bioaccumulation[56].

Regarding the effect of PFAS on human and ecological health, the best studied PFAS are PFOS and PFOA, although considerable information is available for some other PFAS. Laboratory animal toxicology studies and human epidemiological studies suggest health effects that may occur as a result of long-term exposure to PFOA and PFOS at environmentally relevant levels. **Figure 7.2** summarizes current health effects information. Regarding ecotoxicity, studies published by ITRC[57] in 2022, demonstrate a wide range of effects concentrations across the various terrestrial and aquatic biota. In general, aquatic invertebrates appear to be more sensitive to PFOS and other PFAS than their terrestrial counterparts.

[54] Guidance on PFAS Exposure, Testing, and Clinical Follow-Up. (2022). In Guidance on PFAS Exposure, Testing, and Clinical Follow-Up. Washington (DC): National Academies Press (US) Copyright 2022 by the National Academy of Sciences.
[55] Zarębska, M., & Bajkacz, S. (2023). Poly– and perfluoroalkyl substances (PFAS) - recent advances in the aquatic environment analysis. TrAC Trends in Analytical Chemistry, 117062. doi:https://doi.org/10.1016/j.trac.2023.117062
[56] Rehman, A. U., Crimi, M., & Andreescu, S. (2023). Current and emerging analytical techniques for the determination of PFAS in environmental samples. Trends in Environmental Analytical Chemistry, 37, e00198. doi:https://doi.org/10.1016/j.teac.2023.e00198
[57] ITRC. (2022). PFAS — Per- and Polyfluoroalkyl Substances: Human and Ecological Health Effects of select PFAS (Accessed, April 2023). doi:https://pfas-1.itrcweb.org/7-human-and-ecological-health-effects-of-select-pfas/

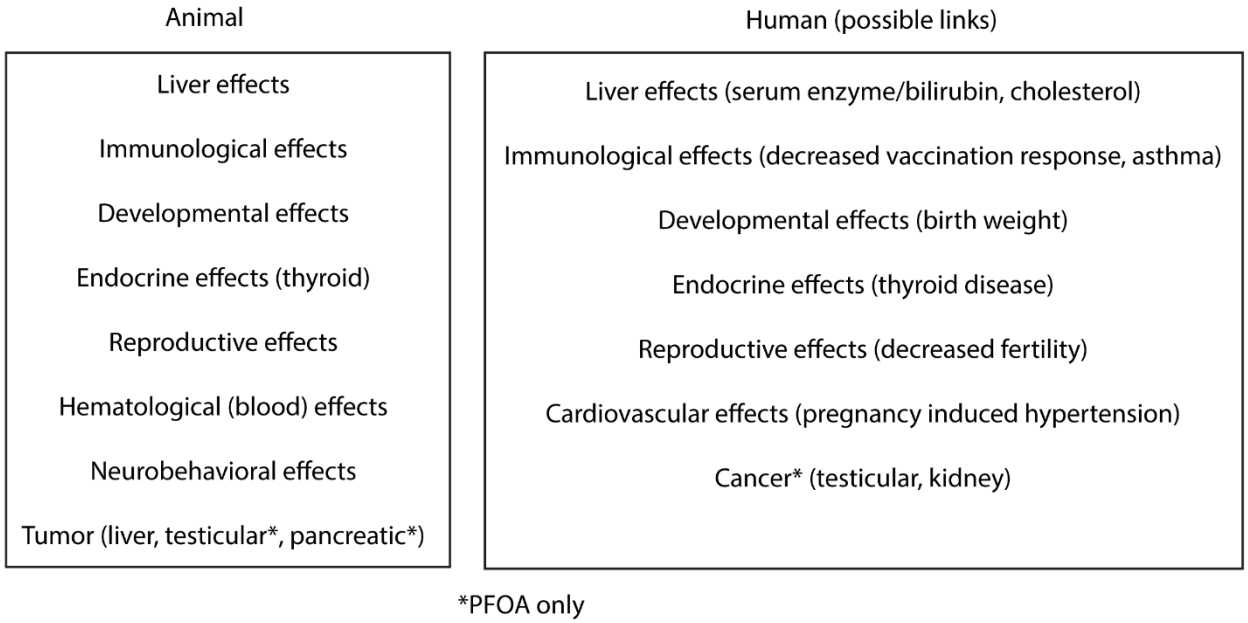


Figure 7. 2: *Some health effects of PFOA and/or PFOS identified from published studies (not exhaustive). Source: (ITRC, 2022)*.

7.3.4 Detection and analysis methods for PFAS

i. Screening methods for total PFAS

The Total Fluorine and Total Extractable Organic Fluorine (EOF) methods measure all forms of PFAS in the samples and do not identify individual PFAS[58],[59]. They are the effective screening tool to detect intentionally added PFAS, and results should prompt a discussion and, possibly, more thorough testing.

Among them, Total Extractable Organic Fluorine is the most recommended approach by great number renowned testing laboratories and research especially for solid samples due to the fact that this method first removes inorganic fluorine and then measures the concentration of organic fluorine, which is representative of total PFAS. This test is beneficial because it is relatively low-

[58] https://pfas.com/pfas-testing/total-pfas-test-methods/ (Accessed, July 2023).
[59] EPA. PFAS Analytical Methods Development and Sampling Research, https://www.epa.gov/water-research/pfas-analytical-methods-development-and-sampling-research (Accessed, July 2023).

cost and provides information about all PFAS, including those not captured in PFAS targeted/individual analysis tests.

Key features of Total Extractable Organic Fluorine for PFAS screening include:

- Fast and economical screening process to provide results promptly.
- Threshold level determination to prioritize samples for more comprehensive analysis.
- Current targeted PFAS test methods can analyse for roughly 40 compounds. That's less than 0.1% of the approximately 4,700 CAS-registered compounds classified as PFAS. Testing for total PFAS can provide a more complete picture of PFAS contamination to support remediation, destruction, and control efforts.

According to the literature, as PFAS chemicals contain organic fluorine, if the detected level of EOF is greater than the regulated limit of PFAS in your matrix (e.g., > 50 ppm, or >100 ppm for many consumer products), further analysis such as targeted PFAS testing may be recommended.[60]

ii. Targeted PFAS analysis methods

The targeted PFAS Analysis Methods can allow to determine the concentrations of specific PFAS Compounds. Currently available methods to individually detect PFAS include gas or liquid chromatography (GC or LC) tandem mass spectrometry (MS/MS), methods that are expensive, time consuming and require samples to be sent to a centralized laboratory for analysis.

Alternatively, high-performance liquid chromatography (HPLC) is also used, however, due to a lack of chromophores, PFOA is not easily amenable to traditional HPLC methodologies. Among the reported HPLC methods for PFOA determination, mass spectrometry (MS) detection is

[60] Susan D. Richardson et al., Improved total organic fluorine methods for more comprehensive measurement of PFAS in industrial wastewater, river water, and air. Water Research. May 2023, 119859

employed most frequently. While these methods are selective and sensitive, field analysis is limited due to lack of field-deployable techniques[61].

Detection of PFAS is challenging because these compounds lack chromophores or electroactive groups and thus are not optical or electrochemically active. Therefore, methods such as UV-Vis spectroscopy or electrochemistry cannot be directly applied to measure these compounds.

7.4 Methodology

7.4.1 PFAS site risk identification and assessment

- According to the literature, many different sources of PFAS contribute to contamination, with the most common being: Wastewater treatment plants, military and firefighting training areas, Industrial and consumer products discharges. Therefore, given the fact that there is currently a rapid growing in the sector of industrialization in Rwanda, we focused to the industrial and consumer products, and firefighting sectors to identify the major site risk assessment regarding PFAS in this report.

- The following risk site listed in **Table 7.2** were consulted and the interview questionnaire presented in **Annex 8** was used to collect key information data related to PFAS control and management:

[61] Rehman, A. U., Crimi, M., & Andreescu, S. (2023). Current and emerging analytical techniques for the determination of PFAS in environmental samples. Trends in Environmental Analytical Chemistry, 37, e00198. doi:https://doi.org/10.1016/j.teac.2023.e00198

Table 7. 2: *Identified sites for consultation regarding PFAS*

S/N	Site Category	Stakeholder Consulted
1	Fire Fighting Organs	Fire and Rescue Brigade in Rwanda National Police (RNP), Supplier of Fire extinguisher, MINICOM
2	Textile Industries	NIRDA, UTEXIRWA
3	Paint Industries	NIRDA, AMEKI COLOR, CROWN PAINTS LTD, AMACO PAINTS, IYAGA,
4	Electric cable manufacturer	Alfa Cables LTD
	Lubricant Manufacturer	Africa Lubricant Manufacturing Company Ltd
4	Agriculture Products (Biocides, Fertilizers, and insecticides)	RAB, RFDA, RSB,
5	Food packaging papers, Hygiene Paper Manufacturing Industries	SUPA, V-Plus Packaging Rwanda, Roba Industries Ltd
6	Mattress Industries	Rwandafoam, VIVA Products

7.4.2 Quantification and identification the suspected products to contain PFAS

- For each identified site for survey, this report has identified interim quantification of the type of fluorinated compounds.

- Consultation of chemical composition of the imported raw materials or finished product (e.g., material safety data sheet, product specification form, etc.)

- Next, the consultant team did the benchmarking to all the collected data to identify the types of surfactants/ water repellents reported to contain PFAS from the literature.

- The collected data from this quantification showing the current status regarding the suspected products to contain PFAS in Rwanda as well as related key informant interviews guided for the future plans for PFAS regulation policy and managements.

7.4.3 Sampling and analytical methods

a. Sample collection

- In total, 15 samples were collected from different places as follow **(Table 7.3)**:

Table 7. 3: *Samples for measuring Total Extractable Organic Fluoride to quantify PFAS*

S/N	Sample Name	Sample Description	Sample CODE
1	Recycled Toilet Paper (Clear)	Made in Rwanda by Roba Industries	TP01
2	Recycled Toilet Paper (SAFI)	Made in Rwanda by ALVYO Rwanda Ltd	TP02
3	Toilet Paper (Poshy)	Made in Kenya by Jubilee Tissue Industries	TP03
4	Table Napkins (SAFI)	Made in Rwanda by ALVYO Rwanda Ltd	TN01
5	TABLE NAPKINS (SUPA)	Made in Rwanda by SUPA	TN02
6	TABLE NAPKINS (Poshy)	Made in Kenya by Jubilee Tissue Industries	TN03
7	Ordinary Varnish (AMEKI)	Paint made in Rwanda by AMEKI COLOR	AM01
8	White Enamel (Irangi ryamavuta, Ameki)	Paint made in Rwanda by AMEKI COLOR	AM02
9	Whether guard (Ameki)	Paint made in Rwanda by AMEKI COLOR	AM03
10	Ordinary Varnish (RITVER)	Paint made in Italy by RITVER	RT01
11	White Enamel (Irangi ryamavuta, RITVER)	Paint made in Italy by RITVER	RT02
12	Whether guard (RITVER)	Paint made in Italy by RITVER	RT03
13	Wastewater	Wastewater from AMEKI COLOR taken on 14/07/2023	WW01
14	Pizza Container	Pizza Container made in Rwanda by V-Plus Packaging Rwanda	PC01
15	Mattress Foam	Mattress Foam made in Rwanda by VIVA Products (Matelas Dodoma)	MF01

- During Sampling, we considered randomly taking the samples from both the product made in Rwanda and made from abroad or the imported finished products for comparison purpose.
- Where possible, samples were collected directly from the factory, and if not, from the market.
- After Sample collection, each sample was stored in a sealed container with a label showing the type of sample, brand, location, date, and kept appropriately before being tested for total PFAS.

b. Target analytes

According to the literature, there are approximately 4,700 CAS-registered compounds classified as PFAS, however, the currently existing targeted tests for PFAS compounds can only cover roughly 40 PFAS compounds that is less than 0.1%. To achieve the objective of this study, the targeted testing methods for PFAS was ruled out and opted to the Total Extractable Organic Fluorine method which can target the total PFAS. Therefore, the targeting analyte was total PFAS but not the individual PFAS.

1.4.4 Analytical methods for PFAS

- The analytical methods for sample testing for PFAS used in this report is Total Extractable Organic Fluorine test. This used was chosen depending on the sample type by adopting the USEPA reported methods in **Appendix 3**[62] .

- The samples testing was conducted at the Chemistry Laboratory, College of Science and Technology from the University of Rwanda (UR-CST) in the July 2023.

- The following is the detailed method used for Total Extractable Organic Fluorine test using different samples:

[62] USEPA. (2023). PFAS Analytical Methods Development and Sampling Research (Accessed, April 2023). doi:https://www.epa.gov/water-research/pfas-analytical-methods-development-and-sampling-research#:~:text=Standard%20Analytical%20Methods%20%20%20%20Media%20,for%20non-drinking%20...%20%209%20more%20rows%20

Initially, 10 g of samples were cut into small pieces of about ½ inch square and placed in oven at 100^{o}C for 24 hours for moisture evaporation. Next, the dried samples were placed into an A 11.5 Spare grinding chamber until the metal section is about 3/4 full using the IKA A11 basic analytical mill for no longer than 60 Sec. The process was repeated until the milled sample is small enough to pass through a 425 µm sieve. Thereafter, 1 g of each homogenized sample was measured directly into 40-mL nickel crucibles. The samples were covered with 5 mL of 8 mol/L sodium hydroxide solution. The sample and sodium hydroxide solution were slowly shaken to make the mixture as homogenous as possible. The crucibles were placed on a hot plate for evaporation to dryness, covered and introduced into a muffle furnace for combustion. The temperature was set at 200^{o}C for approximately 16 h in an oven. The crucibles were then cooled to room temperature and 10–15 mL deionized water was added to the crucibles and kept on a hot plate in order to aid the dissolution of the fusion cake. After 2 h, the sample solutions were transferred to 50-mL plastic beakers. The sample solutions were neutralized using concentrated and then diluted hydrochloric acid. Concentrated hydrochloric acid was added dropwise until the pH decreased from 12.0–13.0 to 8.0–8.5 then to pH of 7.2–7.5 by adding diluted hydrochloric acid. The sample solutions were then diluted to 50 mL with deionized water. Finally, the obtained solution was tested by an ion-selective electrode meter (ISE) (HQ40D Digital multi meter) equipped with a fluoride-selective electrode (model 96-09, Orion) which was employed for the determination of fluoride in the samples and standard solutions.

The total extractable organic fluorine (TEOF) was calculated by using the following formula **(Equation 1)**:[63]

$$TEOF = [\mathrm{F}]\frac{\mathrm{Vf}}{\mathrm{V}i} \qquad Equation\ 1$$

Where [F] is the fluoride concentration (mg/L) analysed by fluoride-selective electrode,

[63] Susan D. Richardson et al., Improved total organic fluorine methods for more comprehensive measurement of PFAS in industrial wastewater, river water, and air. Water Research. Volume 235, 15 May 2023, 119859.

V_f is the final volume (mL) of the solution, and V_i (mL) is the volume of loaded sample.

7.5 Assessment results

7.5.1 PFAS inventory in Rwanda

By considering the published related report elsewhere about the common major sources of PFAS, and the inventory of PFOS in Rwanda conducted in 2015 by REMA, the following sectors have been identified as the possible major source PFAS in Rwanda:

- Paint Industries;
- Fire-Fighting Sectors;
- Textile and Mattress Industries;
- Lubricant/ Hydraulic Fluids Manufacturing Industries; and
- Sanitation and Cosmetics manufacturing Industries

While searching for the common PFAS containing ingredients from the desk review literature that can be used from the above-mentioned manufacturing sectors elsewhere, the following list of chemicals become the baseline for this study while conducting the PFAS inventory in Rwanda:

- Aqueous Film Forming Foam (AFFF) (Firefighting foam);
- Preparations and charges for fire-extinguishers; charged fire extinguishing grenades; Aqueous Film Forming Foam (AFFF);
- Polyvinylidene fluoride (PVDF);
- FEVE resin (Fluoroethylene Vinyl Ether) or Co-Polymer of Tetrafluoroethylene and Perfluoroalkyl Vinyl Ether Pellet;
- Fluorinated Surfactants;
- Fluoropolymers of vinyl chloride or of other halogenated olefins,
- Polytetrafluoroethylene (PTFE);
- Fluorinated Ethylene Propylene (FEP); and

- Ethylene Tetrafluoroethylene (ETFE);

Usually, the above listed chemicals can be used to function as levelling, wetting and anti-blocking agents in different industrial product manufacturing including, paint industries; firefighting sectors; textile and mattress industries; lubricant/ hydraulic fluids manufacturing industries; and sanitation and cosmetics manufacturing industries **(Table 7.4)**.

Table 7. 4: *List of imported items in Rwanda suspected of containing PFAS FROM 2010 to 2022 (Data obtained from MINICOM in July 2023).*

s/n	Type of Suspected PFAS containing items	Imported Quantity in Kg/Year												
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	Preparations and charges for fire-extinguishers; charged fire extinguishing grenades; Aqueous Film Forming Foam (AFFF)	6566	26152	36056	-	6564	32361	33912	17398	-	-	-	-	-
2	Polyvinylidene fluoride (PVDF)	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Fluoropolymers of vinyl chloride or of other halogenated olefins,	-	-	17078	-	-	-	-	56	-	-	-	25000	200
4	FEVE resin (Fluoroethylene Vinyl Ether) or Co-Polymer of Tetrafluoroethylene and Perfluoroalkyl Vinyl Ether Pellet	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Fluorinated Surfactants	-	-	-	-	-	-	-	-	-	-	-	-	-

s/n	Type of Suspected PFAS containing items	Imported Quantity in Kg/Year												
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
6	Polytetrafluoroethylene (PTFE)	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Fluorinated Ethylene Propylene (FEP)	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Ethylene Tetrafluoroethylene (ETFE)	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Lubricating preparations (including cutting-oil preparations, bolt or nut release preparation	7863	12777	6091	-	-	-	77667.13	68088.41		112789.59	1170264.29	-	380020.81

7.5.2 PFAS testing results and discussions

As mentioned on the methodolgy section of this chapter, the samples were randomly collected and brought in the laboroatory to quantify the quantity of fluorine via the total extractable organic fluorine test. For this test, the developed flowchart presented in **Figure 7.3** was followed to an overview related to the PFAS content in these samples.

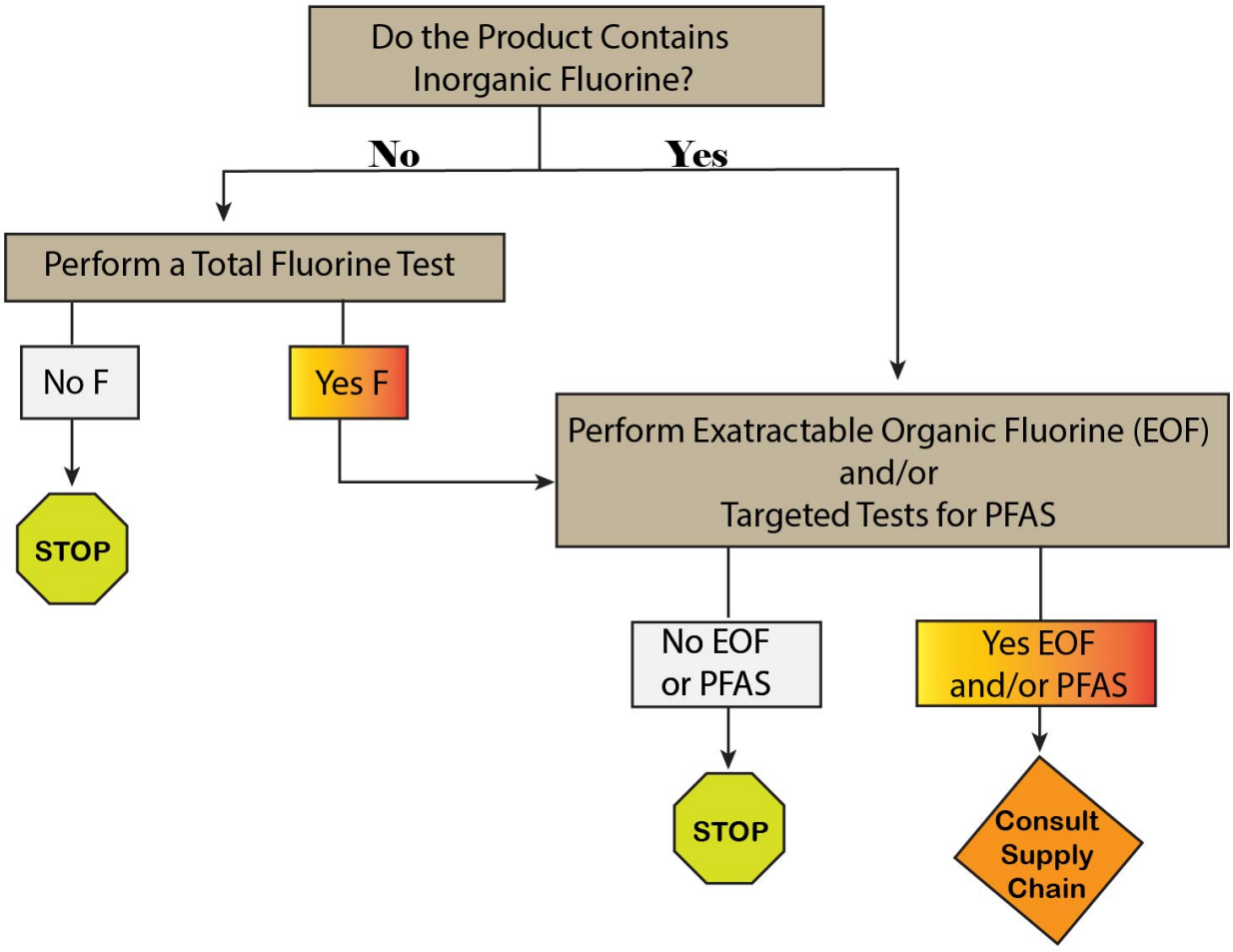


Figure 7. 3: *The flowchart for the methodology used for sample collecting and testing for PFAS analysis.*

The results presented in **Figure 7.4** showed that the toilet papers from the recycled materials with the sample code of TP01 and TP02 contain a comparatively high amount of organic fluorine that are 7 mg/L and 10.2 mg/L, respectively, compared to the toilet paper not produced from recycled materials as the results showed to contain 5.1 mg/L. Although the table napkins made

in Rwanda from the non-recycled materials with sample code of TN01, and TN02 showed to contain relatively low quantity of organic fluorine that is 4.525 mg/L and 3.65 mg/L, their counterpart not made in Rwanda with a sample code of TN03 showed the lowest organic fluorine of 1.77 mg/L. In addition, the tested pizza container (PC01) carton and mattress foam (MF01) showed to contain relatively low amount of organic fluorine that is 5.25 mg/L and 1.24 mg/L, respectively.

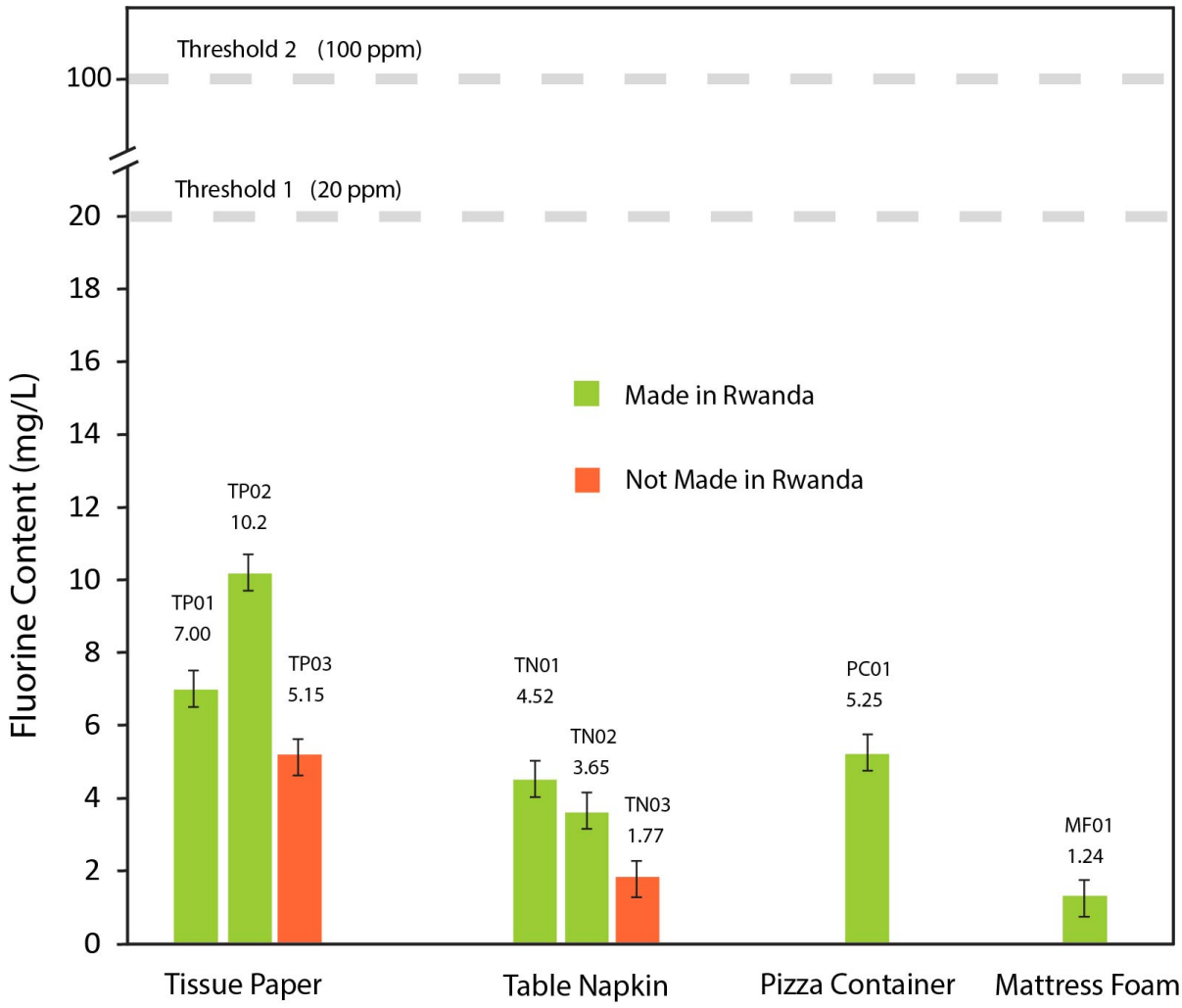


Figure 7. 4: *Results for total extractable organic fluorine test in hygienic and food contacting papers and mattress foam samples collected at different places in Rwanda, 2023.*

Beyond threshold 1, it may suggest that there is an intentionally addition of PFAS in the product. Beyond threshold 2, this may trigger an investigation to the supply chain.

In addition, we have considered testing the total extractable organic fluorine for different samples collected from paint industries in Rwanda. As it can be seen form **Figure 7.5**, the White Enamel and Ordinary Varnish paint samples made or not made in Rwanda showed comparable TEOF results which were quite below both threshold 1 and threshold 2. On the other hand, all weather guard paints and wastewater from paints industries showed the results which are above 20 ppm.

While trying to understand the significance of the obtained test results of total extractable organic fluorine test with the objective of quantification of PFAS content in the tested samples, we relied on the previously published related guidelines elsewhere. Apparently, Scientists and regulators are still debating what level of organic fluorine indicates intentional use. For example, California has banned intentionally added PFAS, starting in January 2023, paper food packaging must have less than 100 parts per million organic fluorine. On the other hand, Denmark has settled on 20 ppm as that threshold.[64], [65] According to the report published by the consumer report on March 2022, they have used 20 ppm organic fluorine as the threshold to measure intentionally versus unintentionally added PFAS in different food contacting materials such as containers.

Therefore, the obtained TEOF results for hygienic papers, pizza container and mattress foam, white enamel paint, and ordinary varnish samples are below 20 ppm, and this implied that there is no suspicion of intentionally adding PFAS in the tested products. However, it is recommended consider weather guards paints and wastewater from paint industries for further targeted PFAS testing. However, according to the literature where several states in the United States use 100 ppm as threshold to suggest an intentional addition or application of PFAS ingredients during the manufacturing, none of our tested sample reached or become closer to that level.

[64] Kevin Loria, Dangerous PFAS Chemicals Are in Your Food Packaging, March 2022. https://www.consumerreports.org/health/food-contaminants/dangerous-pfas-chemicals-are-in-your-food-packaging-a3786252074/#allResults

[65] USEPA. How EPA's Recommended Standards and Ecolabels Address Per- and Polyfluoroalkyl Substances (PFAS),

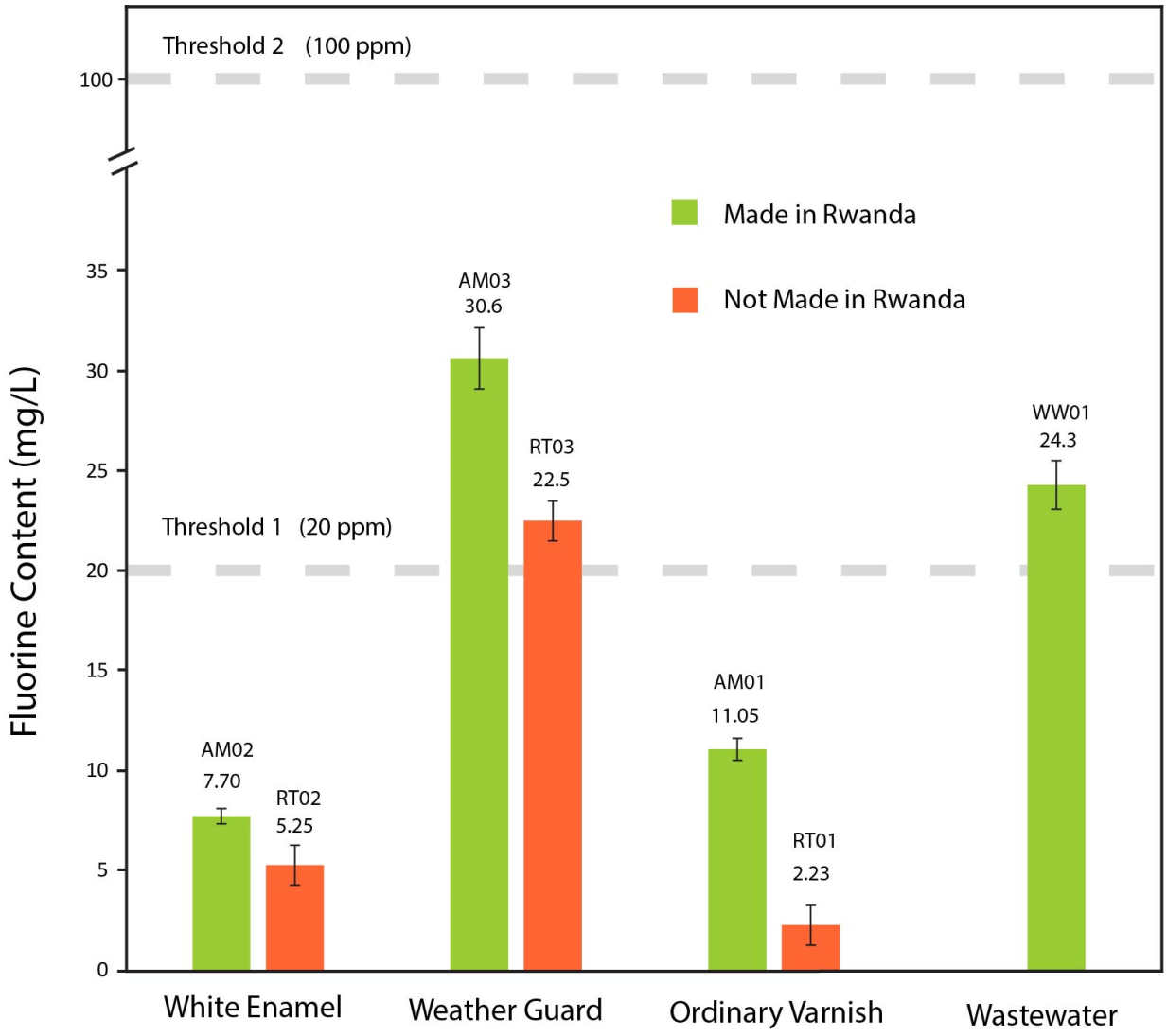


Figure 7. 5: *Results for total extractable organic fluorine test collected in different samples from paint industry at different places in Rwanda, July 2023.*

Beyond threshold 1, it may suggest that there is an intentionally addition of PFAS in the product. Beyond threshold 2, this may trigger an investigation to the supply chain.

7.5.3 Institutional capacity assessment

- To assess the institutional assessment capacity regarding the regulation and management of PFAS in Rwanda, this report has identified ten stakeholders among the key players by

considering both public and privet organizations and factories in Rwanda. Specifically, the following stakeholders have been consulted: RFDA, RFL, University of Rwanda, MINICOM, AMEKI Colour, Alfa Cables, Africa Lubricant Manufacturing Company Ltd, Viva Products Ltd, Crown Paints, and V-Plus Packaging Industries Ltd.

- In the questionnaire **(Annex 8)** used to collect the information related to the inventory PFAS in Rwanda, some questions such as: *(1) Is your Institution/Factory aware of contamination that can be caused by Per- and polyfluoroalkyl substances (PFAS) to its products or manufactured materials? And (2) Does your Institution/Factory plan to have the capacity to test PFAS contamination in the products or to manage/treat PFAS containing wastes?* Were used to assess the institutional capacity for the management of PFAS compounds.

- As presented in **Figure 7.5**, apart from the fire-fighting sectors in Rwanda, it was found that there is no organization or factory which is claiming to be in possession of fluorinated compounds. However, this was a little in discrepancy compared to the data of the fluorinated compounds that may have been imported in Rwanda from 2010 to 2022 as obtained from MINICOM **(Table 7.4)**. Moreover, 30% of the respondent showed that they are aware and usually avoid PFAS as contamination in their daily activities. This means, that the remaining 70% of the respondent don't know or did not hear about PFAS before. Noticeably, 100% of all the consulted stakeholders on this matter respondent that they don't have neither the testing capacity nor the treatment or management capacity for PFAS.

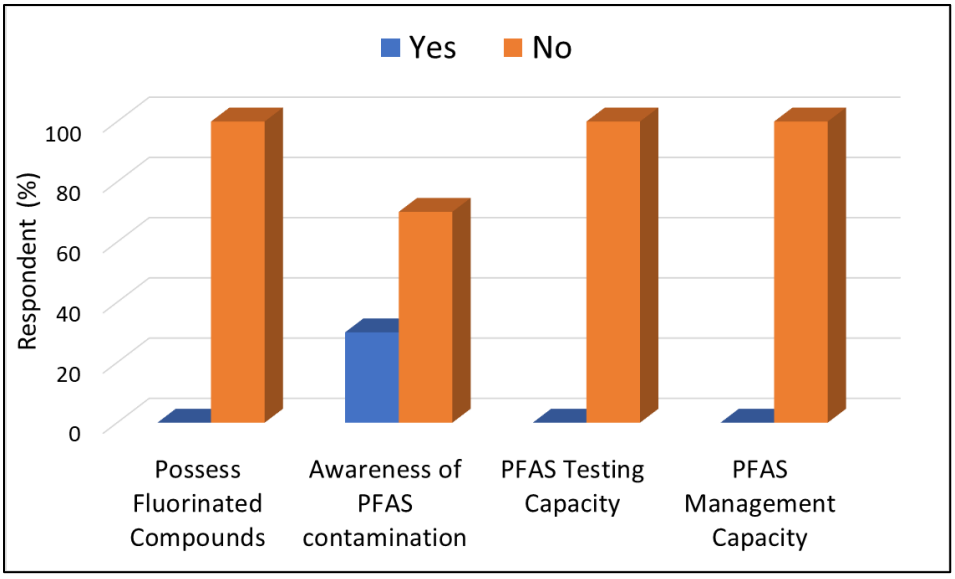


Figure 7. 6: *Institutional capacity for the management of PFAS compounds in Rwanda, 2023.*

7.5.4 PFAS waste disposal

- PFAS can enter the environment through production or waste streams and can be very persistent in the environment and the human body. By considering their natures, PFAS may be volatile, soluble, and may have high environmental mobility and persistence, PFAS have many and varied pathways into waste streams, presenting challenges for ultimate disposal. Therefore, determining the appropriate method for ultimate disposal of PFAS wastes is a complex issue to address.

- Although different PFAS waste disposal approach may be considered such as: landfills, and underground injection, the EPA recommend the incineration by high temperature chemical breakdown for the effective treatment and disposal of PFAS.[66]

- By considering for the PFAS by high temperature chemical breakdown *via* the incineration, it is worthy to consider that PFAS compounds are difficult to break down due to fluorine's electronegativity and the chemical stability of fluorinated compounds. And the incomplete

[66] US-EPA, Feb 2020, Per- and Polyfluoroalkyl Substances (PFAS): Incineration to Manage PFAS Waste Streams.

destruction of PFAS compounds can result in the formation of smaller PFAS products, or products of incomplete combustion (PICs), which may not have been researched and thus could be a potential chemical of concern.

- Although the required temperature for effectiveness of incineration to destroy PFAS compounds is still for debate, it was reported that the incineration of perfluorooctanoic acid found no detectable level of fluorotelomer-based polymers after 2 second residence time at 1000^{o}C. However, some type of PFAS such as CF_4 may require the temperature over 1400^{o}C before it can decompose by incineration.[67]

- Therefore, this report recommends disposing PFAS wastes by high temperature chemical breakdown *via* the incineration at a temperature which is not low than 1000^{o}C **(Table 7.5)**.

Table 7. 5: Recent guidance and literature basis for PFAS thermal destruction[68]

Sources	Temperature Noted
Pancras et al. (2016)	1000^{o}C-1200^{o}C
Kucharzyk et al. (2017)	1000^{o}C or greater
USEPA (2020)	1000^{o}C
UNEP (2019)	1100^{o}C
Ross et al. (2018)	1100^{o}C
ITRC (2020)	1000^{o}C or greater

7.6 Legal and conventions and protocols related on chemicals and hazardous waste including PFAS in Rwanda

This section describes laws, policies and institutional framework relevant to the PFAS. Both international and national regulations are described under this section. Rwanda is equipped with

[67] Grace K. Longendyke, Sebica Katel and Yuxin Wang, PFAS fate and destruction mechanisms during thermal treatment: a comprehensive review, Environ. Sci.: Processes Impacts, 2022,24, 196-208.
[68] Lloyd J.Winchell et al., Per- and polyfluoroalkyl substances thermal destruction at water resource recovery facilities: A state of the science review, Water Environ Res. 2021; 93: 826– 843.

institutions, laws, regulations, and policies enacted to protect environment. Rwanda has also adhered and ratified international treaties and conventions' aiming at the promotion and the protection of environment either, nationally or internationally. It is for a paramount to note that effective environmentally sound management of waste and implementation of waste management policy depends on the institutional capacity of national and subnational waste management related agencies. At continental and regional levels, our country has been fully participating in meetings and has adhere to the AU Agenda 2063 as well as to the EAC Vision 2050 as guiding documents for a sustainable development[69].

7.6.1 Legal framework

The Constitution of the Republic of Rwanda

The National Constitution of Rwanda of 2003 (amended in 2015) guarantees the right to a protected environment. Article 53 states that everyone has the duty to protect, safeguard and promote the environment that the State should ensure the protection of the environment, and do so by means of a law that determines the modalities for the protecting, conserving, and promoting the environment. In addition, its article 3 contains specific provisions regarding the waste management. Its article 22 on the right to live in clean and healthy environment; article 49 on the duty of each Rwandan to respect of the Constitution and other laws of the country.

Rwanda is part of the international arena, and this implicates Rwanda to share with the rest of world concerns including environmental protection and promotion. In that regard, the Constitution of the Republic of Rwanda, in its article 168 stipulates that "upon publication in the official gazette, international treaties and agreements which have been duly ratified or approved have the force of law as national legislation in accordance with the hierarchy of laws provided for under the first paragraph of article 95 of the Constitution."

Law No 48/2018 of 13/08/2018 on environment

[69] REMA, 2018. Short and Medium term hazardous, toxic, and radio-active wastes strategy and plan in Rwanda

The Law on environment N°48/2018 of 13/08/2018 highlights key principles for environment protection in its different chapters. In chapter 3, the conservation and protection of natural environment is emphasized on soil in article 8 for soil and subsoil conservation. Article 12 on water resources protection state that water resources must be protected from any source of pollution. Furthermore, in its chapter V on obligations of the state, decentralized entities and local communities with regard to the protection, conservation and promotion of environment; in its articles 30 says about the list of projects that must undergo an environmental impact assessment before they obtain authorization for their implementation is established by an Order of the Minister.

Law N° 63/2013 of 27/08/2013 determining the mission, organization and functioning of Rwanda Environment Management Authority (REMA)

The law establishing REMA, the authority in charge of supervising, monitoring, and ensuring that issues relating to environment are integrated in all national development program (art.3) with one of the main missions (art.3, 1º) to implement Government environmental policy. The laws highlight the prevention, protection, and promotion of the environment. For instance in its article 3, 2° REMA is responsible to advise the Government on policies, strategies and legislation related to the management of the environment as well as the implementation of environment related international conventions, whenever deemed necessary; 7° to participate in the preparation of activities strategies designed to prevent risks and other phenomena which may cause environmental degradation and propose remedial measures; and 8° to provide, where it is necessary, advice and technical support to individuals or entities engaged in natural resources management and environmental conservation.

7.6.2 Conventions and Protocols related to PFAS

Basel Convention on the Transboundary Movement of Hazardous Wastes and their Disposal

The Basel Convention on the Control of Transboundary Movements of Hazardous wastes and their disposal. It has been approved by the Presidential Order n° 29/01 of 24 August 2003 approving the membership of Rwanda includes hazardous wastes that are explosive, flammable, poisonous, infectious, corrosive, toxic, or eco-toxic. The convention covers and identify waste categories/characteristics and identifies specific waste classified as hazardous or non-hazardous.

Bamako Convention

The Bamako Convention, adopted under the auspices of the Organization of Africa Unity (OAU), prohibits hazardous waste imports into Africa. It therefor concerned with the Ban import into Africa and control of trans-boundary movement of hazardous wastes within Africa. The convention was negotiated by twelve nations of the OAU at Bamako, Mali in January 1991, and came into force in 1998.

The Stockholm Convention on Persistent Organic Pollutants (POPS)

Under the Stockholm Convention on Persistent Organic Pollutants, countries commit to eliminate or restrict the production and use of persistent organic pollutants. With over 150 signatories, the Treaty came into force on May 17, 2004. It is known that PFAS are among other POPs that are toxic, man-made, hazardous chemicals that have dangerous effects on the environment and our health. PFHxS, PFOA and PFOS are the three subgroups of PFASs currently listed under the Stockholm Convention as industrial POPs.

7.7 Analysis of PFAS waste management in Rwanda

To date, there is no particular measures for PFAS waste management in Rwanda. What has been observed during this survey, is that there is still remarkably little knowledge on PFAS consideration as hazardous chemical from the concerned both public and private institutions in Rwanda.

7.7 Summary

In summary, PFAS are potentially harmful chemicals that can be found in common, everyday products and most drinking water. They are known as “forever chemicals” because they do not break down over time, and health leaders across the country are concerned about the negative effects of long-term exposure. For instance, it is known that PFAS can build up in some people who are exposed to the chemicals over long periods of time. They can lead to health problems such as liver damage, thyroid disease, obesity, fertility issues and cancer. Since they don’t degrade easily, PFAS can accumulate in the food chain. The main way people are exposed is through eating and drinking contaminated food and water. Therefore, it is great importance to avail guidelines for proper management of PFAS applications in Rwanda.

7.8 Future Perspectives and Recommendations

Based on the findings of this report especially regarding the management of PFAS applications and wastes in Rwanda, the following recommendations are given:

- According to the recorded data concerning the public awareness on PFAS contamination or where the majority is not aware of it, it is recommended to increase a regular awareness for PFAS adverse effect and how it can be avoided in their daily activities.

- According to the obtained data from testing different samples for PFAS by Total Extractable Organic Fluorine (TEOF) it is recommended to consider additional samples especially from cosmetics, textile, drinking water, hygienic products, food contacting materials, firefighting forms, paints, non-stick cookware, leather, and lubricants industries as the can be identified to be the potential sources of PFAS that can be harmful to the environment and living organisms. Moreover, targeted PFAS testing is recommended as the PFAS screening methods such as TEOF is not enough to get more insight of PFAS Content in a sample.

- Regarding the PFAS testing, it has been found that the equipment to perform both targeted and non-targeted tests for PFAS are available in Rwanda especially at R-FDA, RSB, UR, and RFI, however, there is a need for investing in the human capacity building for PFAS testing and.

- Regarding PFAS management and regulation reinforcing in Rwanda, there is a need for the concerned institutions in Rwanda such as RSB, R-FDA, RICA to set the standards for guiding manufacturers about acceptable limit for PFAS content in their products.

- The government is recommended to control the entry and exist of fluorinated compounds especially these which can be used for manufacturing industries in Rwanda, however, some restriction to allow the entry and exit critical fluorinated products such as fluorinated medicines and other products which don't have an alternative replacement may be considered.

Chapter 8: Chemicals and hazardous wastes interim storage facilities management plan

8.1 Introduction

Chemicals and hazardous wastes pose serious negative impact on health and environment when inadequately handled. That is why establishing an interim storage management plan and assessing institutional capacity in Rwanda require urgent attention to reduce risks on health and environment.

The development of chemicals and hazardous wastes interim management plan took in consideration available data and recommended international practices, standards for managing hazardous waste as well as other guidelines developed by local institutions such as the guidelines from Rwanda Biomedical Centre[70].

On the other hand, the assessment of institutions capacity considered the existing public, regulatory, academia and private institutions with a consideration of their capacity needs and the existing infrastructures for chemicals and hazardous wastes management.

8.2 Chemical and hazardous wastes interim storage facilities management plan

Over the past two decades, Rwanda has embarked in a transformational journey, where the country has recorded transformation in all sectors of national life. This transformation brought agricultural and industrial development, infrastructure development and most important human resources development on one hand.

On the other hand, this observed development has generated an increased volume of solids and liquid waste which is causing a serious environmental pollution if not treated or handled with care and appropriately. Hazardous wastes are generated as product through daily lives activities. It is for an importance to understand that as more hazardous wastes are generated, their proper

[70] Rwanda Biomedical Centre (2018). Pharmaceutical Disposal Management Guidelines. Kigali, Rwanda

management practices should be put in place even though wastes management in Rwanda faces numerous challenges[71].

Generally, within the country, treatment options and technologies are not enough to cater for wastes categories (industries, higher learning institutions, hospitals, and municipal). The diversity of wastes generated from different sectors exacerbate the complexity of handling hazardous, toxic and special wastes in Rwanda.

Furthermore, even where treatment facilities are installed, they are not adapted to the type of waste they treat resulting in poor performance even in a breakdown after short period of operation. Wastes characterization has been found as the major issue in addition to underestimation of waste streams/flows which result in the overloading of the treatment facilities[72].

On the other hand, some of the existing interim storages of hazardous wastes have been abandoned and in some cases it is not easy to locate them. For example, the storages at Nyanza-Kicukiro are abandoned and on maintenance is done to. **Figure 8.1** and **Figure 8.2** show the comparison of the photos taken in September 2023 and the photos reported in the report on 2015 during the inventory of POPs. It is clearly seen that the place is coved by the bushes.

Figure 8. 1: Comparison of the photos taken during the burial of POPs from MINAGRI (a), in 2015 during POPs inventory and in September 2023 during the national survey on chemicals and hazardous wastes (c) at Nyanza - Kicukiro. ((a) and (b): REMA 2015; (c) Photo, September 2023).

[71] GoR, 2018: Short and Medium term Hazardous, Toxic and Radioactive Wastes Control Strategy and Plan in Rwanda
[72] GoR, 2018: Short and Medium term Hazardous, Toxic and Radioactive Wastes Control Strategy and Plan in Rwanda

Figure 8. 2: *Comparison of the photos taken in 2015 during POPs inventory and in September 2023 during the national survey on chemicals and hazardous wastes at Nyanza – Kicukiro ((a) and (b): REMA 2015; (c) Photo, September 2023).*

The main objective of this plan is the protection and safety of the environment and health through efficient and effective temporally management of chemicals and hazardous wastes in Rwanda. The generation of chemicals and hazardous wastes is an inevitable consequence of development and therefore it will not be possible to eliminate its generation altogether.
However, concerted effort must be made to move towards "zero hazardous wastes" in the long term. Efforts in planning chemicals and hazardous management must thus be concentrated on cleaner production and the waste management which Favors, in the following order of preference, waste avoidance, minimization, reuse, recycling, treatment and disposal being the last resort. In addition, the plan prioritized safety, compliance with regulations and effective wastes management practices.

Table 8. 1: Key considerations for an interim storage facility for chemicals and hazardous wastes in Rwanda, 2023.

SN	Considerations	Description
1	Compliance with regulations	The plan shall be in position to adhere to all applicable regulations governing the storage and handling of chemical and hazardous wastes in Rwanda. Among those regulations include but not limited

SN	Considerations	Description
		to National Integrated Solid Waste Management Strategy, National Pharmaceutical Sector Strategic Plan (NPS-SP) 2018-2024, and Medical Wastes Management Plan.
2	Site selection and design	The location of the storage facility shall be chosen considering proximity to sensitive areas, emergency response access, and infrastructure availability. The facility shall be designed to prevent leaks, spills and unauthorized access.
3	Inventory management	All chemical and hazardous wastes stored on site shall require a detailed inventory which shall be maintained. This shall include accurate labelling, categorization, and tracking of each waste stream. Part of the inventory management shall include a system for easy identification and retrieval of specific wastes when needed.
4	Storage infrastructure	Appropriate containers, drums, or tanks specifically designed for chemicals and hazardous wastes shall be used. This shall ensure that containers are compatible with the waste being stored and are properly sealed to prevent leaks or releases. The storage infrastructure shall be regularly inspected and maintained.
5	Handling and Transportation Procedures	Clear protocols shall be developed for safe handling, transfer, and transportation of hazardous wastes within the storage facility. In addition to that, employees shall be trained on proper handling techniques, PPE use, and the prevention of cross-contamination.
6	Emergency response and	An emergency response plan shall be established to address potential accidents, spills, or releases. Regular instructions and

SN	Considerations	Description
	contingency planning	employees training on emergency procedures shall be conducted. Spill containment equipment shall be appropriately maintained and communication protocols with emergency responders shall be established.
7	Waste minimization and recycling	Practices to minimize waste generation and promotion of recycling whenever possible shall be implemented. Those shall include, waste segregation, reuse of materials, and exploring alternative treatment methods to reduce the volume or toxicity of the wastes.
8	Employee training and awareness	Employees shall be regularly trained and educated on the proper management and handling of chemical and hazardous waste. A safety culture by raising awareness about potential risks, safe work practices, and the importance of compliance with regulations shall be promoted.
9	Record keeping and reporting	Accurate records of waste shipments, disposal methods, and any incidents/accidents shall be maintained. Any spills, leaks, or non-compliance issues shall be promptly reported to appropriate regulatory agencies as required.
10	Regular inspections and audit	Routine inspections and internal audits shall be conducted to identify potential issues or areas for improvement. Corrective actions shall be implemented as necessary to address any non-compliance, safety concerns, or operations inefficiencies.

Source:[73]

[73] Gef & PNUD, 2020. Environmental Sound Management of Mercury and Mercury Containing Products and their Wastes in Artisanal Small-scale Gold Mining and Healthcare

8.3 Detailed plan

SN	Type of Wastes	Proposed facility/storage infrastructure	Inventory management method	Handling and Safety protocols	Emergency response strategy	Record keeping strategy	Communication with stakeholders' strategy	Concerned Institutions
1	**Mercury and Mercury Contaminated Wastes**	**Above ground in storage building at waste generator's premises** [74] The facility shall include: ▪ Tight disposal containers ▪ Concrete barrier constructions ▪ Clay sealing layers ▪ Synthetic sealing layers ▪ Hydraulic barriers ▪ Mechanic support ▪ And shall kept locked	▪ The identification number of mercury containers ▪ Include the name and address of the mercury waste producer. ▪ The name and address of the responsible for the filling ▪ The quantity of the mercury ▪ The purity of the mercury and description of the impurities including the analytical report ▪ Confirmation that the containers have been used exclusively for the transport/storage of mercury[75]	▪ Provide comprehensive training to all personnel involved in waste handling on the properties of mercury, including its toxicity, potential health effects and safe handling practices [76], ▪ Identification and Segregation of mercury waste from other types of hazardous wastes to prevent contamination and reaction, ▪ Train the employees on the procedures for handling and storing mercury waste including spill response and cleanup, ▪ Mandate the use appropriate PPE specifically designed for mercury, ▪ Use appropriate labelling and colour coding to clearly identify waste containers, ▪ Regular inspect and replace damaged or worn-out PPE, ▪ Ensure proper ventilation and temperature control, ▪ Develop SOPs for handling and transportation, ▪ Use suitable equipment to minimize physical contact and prevent spills or breakages, ▪ Seal and label wastes containers during transportation,	▪ Establish an emergency response plan, ▪ Train the employees on the necessary actions in case of spills, leaks, or another incident, ▪ Maintain spill kits, absorbents, and neutralizing agents in accessible locations.	▪ All the documents containing the information including the certificate accompanying the container, destocking records, mercury dispatch after temporary storage, destination and intended treatment shall be kept for 3 years after the termination of the storage. ▪ Maintain records and documentation of waste disposal, including manifest, certificates of destruction, and required reporting	▪ Clearly post emergency contact information, including local authorities and specialized hazardous wastes response teams	▪ Rwanda FDA, ▪ MINICOM, ▪ REMA, ▪ MEDIASOL, ▪ Rwanda Forensic Institute, ▪ National Reference Laboratory, ▪ REG, Enviroserve Rwanda, ▪ Hospitals, ▪ MoH, ▪ Depot Karisimbi Ltd, ▪ RMS Ltd, ▪ Rwanda Meteo, ▪ Universities and Higher learning institutions, ▪ REB, ▪ RURA, ▪ RSB, ▪ RICA, ▪ Landfills and dumpsites in Kigali and Six secondary cities.

[74] UNEP, 2011. Basel Convention Technical Guidelines: Technical guidelines for Environmentally Sound Management of Wastes consisting of elemental Mercury and Wastes containing or Contaminated by Mercury
[75] UNEP, 2017. Global Mercury Assessment
[76] https://wedocs.unep.org/bitstream/handle/20.500.11822/11505/Technical_options_for_storage_and_disposal_of_mercury.pdf?sequence=1&isAllowed=y

SN	Type of Wastes	Proposed facility/storage infrastructure	Inventory management method	Handling and Safety protocols	Emergency response strategy	Record keeping strategy	Communication with stakeholders' strategy	Concerned Institutions
				▪ Use specialized tools such as mercury-resistant syringes, or transfer funnels for safe transfer of mercury wastes.				
2	**Polychlorinated biphenyls (PCBs)**	▪ **Storage building/ with storing bunds**[77] This must have: ▪ weather resistant storage building or trailers, ▪ Onsite storage containers designed for PCBS such as drums, ▪ Enough security ▪ Available PCB wastes segregation procedures, ▪ Weather proofing, ▪ Adequate ventilation, ▪ These interim storages need to be outdoors and on impermeable surfaces.	▪ All PCB transformers, PCB voltage regulators, PCB large capacitors and all PCB containers shall be marked, ▪ Storage area shall be marked, ▪ Label all items in the storage area with the date removed from service, ▪ Label the containers with the generation date of the first waste placed into the container.	▪ Educate personnel on the regulations and guidelines related to PCB management including proper PPE usage, ▪ Place all leaking items and uncontaminated waste into a compatible closed container, ▪ Add sufficient absorbent materials to soak up the volume of a leaking items, ▪ Prepare s spill prevention, Control and Countermeasures plan for containers of liquid PCBs, ▪ Ensure proper ventilation and temperature control, ▪ Use appropriate labelling and color-coding to clearly identify PCB-containing materials, ▪ Store PCBs in containers that are made of high-density polyethylene, ▪ Ensure the containers are sealed, leak proof, and properly labelled with the PCB content and concentration, ▪ Make storage areas with restricted access to prevent unauthorized handling or release.	▪ Establish procedures for immediate response to PCB spills, including notifying designated personnel, evacuating the area and implementing containment measures, ▪ Train the employees on the implementation of decontamination procedures and spill cleanup techniques	▪ Maintain copies of manifests and importing documents for all PCB containing materials received, ▪ Maintain an up-to-date inventory of all PCB-containing materials in the facility, ▪ Keep record of PCB waste storage activities, ▪ Record findings, observations and corrective measures taken during inspection, ▪ Keep records of spill incident date, location quantity released, cleanup procedures and disposal of	▪ Clearly post emergency contact information, including local authorities and specialized hazardous wastes response teams	▪ REMA, ▪ REG/EDCL, ▪ WASAC, ▪ RSB, ▪ RICA, ▪ RURA.

[77] REMA, 2016. Updated National Implementation Plan of the Stockholm Convention on Persistent Organic Pollutants

SN	Type of Wastes	Proposed facility/storage infrastructure	Inventory management method	Handling and Safety protocols	Emergency response strategy	Record keeping strategy	Communication with stakeholders' strategy	Concerned Institutions
						contaminated materials		
3	**Asbestos and asbestos containing waste**	▪ **Asbestos transfer stations**[78] ▪ Where Asbestos containing materials can be temporarily stored before being transported to the final disposal.	▪ Perform a comprehensive survey and assessment of potential asbestos containing materials, ▪ Assign unique identification numbers or codes to each asbestos material to facilitate tracking and inventory management, ▪ Utilize spreadsheets, databases, or specialized inventory management software to record and organize information about asbestos containing materials, ▪ Clearly label each asbestos containing material with appropriate number, ▪ Ensure labels contain necessary information and id number.	▪ All personnel involved in handling asbestos waste should use appropriate PPE with high efficiency particulate air filters and protective eyewear, ▪ Provide training on proper donning, doffing and disposal of PPE, ▪ Establish a designated work area or containment zone for handling asbestos waste, ▪ Use sealed containers of bags specifically designed for asbestos waste storage to prevent fiber release, ▪ Avoid unnecessary breaking, cutting, or crushing of asbestos containing material to prevent the generation of airborne fibers, ▪ Prohibit eating, drinking, or smoking in areas where asbestos is handled, ▪ Use of licensed and authorized carriers for transporting asbestos to transfer stations.	▪ Develop and communicate an emergency response plan addressing potential asbestos incident, ▪ Train workers on emergency procedures, including evacuation routes, notification protocols, ▪ Train workers on proper use of emergency equipment, ▪ Establish a decontamination area with proper facilities including separate clean and dirty areas.	▪ Maintain detailed records of the asbestos containing materials and any associated documentation, ▪ Keep records of the acquisition or removal of asbestos containing material in storage including intended disposal or relocation, ▪ Retain all relevant records for specified period as required by regulations, ▪ Adhere to specific regulatory requirement for inventory documentation, reporting and notification as well as periodic	▪ Maintain effective communication channels to ensure that updates or changes in asbestos containing materials inventory are communicated to all relevant stakeholders.	▪ MININFRA, ▪ Rwanda Housing Authority, ▪ REMA.

[78] HSA. Guideline on Management and Abatement of Asbestos Containing Materials. ISBN NO. 978-1-84496-176-4

SN	Type of Wastes	Proposed facility/storage infrastructure	Inventory management method	Handling and Safety protocols	Emergency response strategy	Record keeping strategy	Communication with stakeholders' strategy	Concerned Institutions
						reporting obligations.		
4	**Pharmaceutical and medical wastes**	**Cabinets or storage rooms with lockable containers at generator's premises**[79] This shall have: ▪ Good lighting and passive ventilation, ▪ Supply of cleaning equipment and protective clothing, ▪ Be cleaned regularly.	▪ Identify different waste categories, such as expired medications, unused drugs, contaminated materials, sharps, ▪ Document waste generation points, storage locations, ▪ Utilize spreadsheets, databases, or specialized software to record information, ▪ Use colour coding or labelling to clearly identify different types of waste, ▪ Regularly update the inventory records to reflect waste generation.	▪ The storage area shall have a biohazard sign, ▪ Regular inspection and cleanup, ▪ Workers shall be trained in site spillage procedures, ▪ Ensure that infectious wastes are kept cool, ▪ Ensure that the storage should be air conditioned or refrigerated, ▪ Follow appropriate segregation practices to separate different types of waste and prevent cross contamination, ▪ Use of containers that are leak-proof, puncture –resistant, ▪ Regularly monitor and record the temperature to maintain proper storage condition, ▪ Use lockable containers for temporary storage on site, ▪ Ensure that the facility has security measures and prevent unauthorized access, ▪ Ensure PPE is properly worn, fitted, and disposed after each use, ▪ Avoid overfilling sharps containers and ensure secure closure,	▪ Maintain a readily accessible list of emergency contact numbers, ▪ Develop an emergency response plan specific to medical and pharmaceutical wastes, ▪ Establish procedures for immediate response protocols including proper use of PPE, ▪ Ensure the availability of fire extinguishers and proper trained personnel to use them, ▪ Provide guidance on immediate	▪ Maintain detailed records of disposal dates, methods employed and any required regulatory notification, ▪ Document and report incidents as required by regulatory agencies and police.	▪ Regularly update training and communicate programs to incorporate new guidelines and best practices, ▪ Clearly communicate emergency procedures and contact information to all relevant stakeholders.	▪ MOH, ▪ RBC ▪ National Reference Laboratory, ▪ Province Hospitals (All) ▪ District Hospitals (All) ▪ All Private and Public Hospitals, ▪ All Private and Public Health centres, ▪ RSB, ▪ RICA, ▪ REMA.

[79] UNDP & Gef. Off-site Transport and Storage of healthcare Waste. https://cdn.who.int/media/docs/default-source/wash-documents/wash-in-hcf/training-modules-in-health-care-waste-management/module-14---off-site-transport-and-storage-of-health-care-waste.pdf?sfvrsn=db4f438a_2

SN	Type of Wastes	Proposed facility/storage infrastructure	Inventory management method	Handling and Safety protocols	Emergency response strategy	Record keeping strategy	Communication with stakeholders' strategy	Concerned Institutions
				▪ Use designated medication collection programs or authorized disposal methods.	actions to take in case of exposure.			
5	**Chemical wastes**	**Hangar Storage infrastructure[80]:** ▪ with proper ventilation, proper containers designed for each type of chemical waste to be stored	▪ Maintain a comprehensive inventory plan to track the types, quantities, and storage location of chemical wastes, ▪ Regularly inspect a and monitor the inventory for accurate records, and identify any leaks, spills, or deterioration of containers, ▪ Utilize spreadsheets, databases, or specialized inventory management software to record and organize information about chemical wastes, ▪ Clearly label each chemical waste container with appropriate number, ▪ Ensure labels contain necessary information and id numbers.	▪ Choose a location that meets a regulatory requirement, ▪ Use suitable containers for storing different types of chemical waste such as drums, bins, or tanks, ▪ Containers should be compatible with stored chemicals, sealed and labelled with relevant hazard warning, ▪ Consider segregating incompatible chemicals to prevent reactions and cross-contamination, ▪ Implement safety protocols including signage, safety showers, eyewash stations and fire protection systems, ▪ Ensure that personnel have access to PPE appropriate for chemicals stored, ▪ Train employees on safe handling practices, ▪ Establish security measures, such as restricted access and surveillance, ▪ Store chemical wastes separately and securely to minimize the risk of theft of unauthorized handling.	▪ Develop an emergency response plan specific to interim chemical waste storage facility, ▪ Train personnel on emergency procedures including spill response, fire safety, evacuation plans and communication protocols, ▪ Ensure the availability of the spill's response equipment and containment materials.	▪ Maintain copies of manifests and shipping documents for all chemical wastes generated, ▪ Maintain an up-to-date inventory of all types of chemical wastes in the storage facility, ▪ Keep record of waste storage activities, ▪ Record findings, observations and corrective measures taken during inspection, ▪ Keep records of spill incident date, location, quantity released, cleanup procedures and disposal of contaminated materials.	▪ Clearly post emergency contact information, including local authorities and specialized hazardous wastes response teams	▪ Universities, ▪ Higher learning institutions, ▪ Research Institutions ▪ Secondary schools, hospitals, ▪ NIRDA, ▪ REB, ▪ REMA, ▪ MINICOM, ▪ RRA, ▪ RSB, ▪ RICA.

[80] NLSIU, 2019. Handbook on chemicals and hazardous waste management and handling in India. Center for Environmental law, education, research, and advocacy/National Law School of India University

SN	Type of Wastes	Proposed facility/storage infrastructure	Inventory management method	Handling and Safety protocols	Emergency response strategy	Record keeping strategy	Communication with stakeholders' strategy	Concerned Institutions
6	**Other chemical and hazardous wastes** (Used motor oils, tires and other garage wastes, E-wastes, Pesticides and biocides, Expired or damaged fertilizers)	**Above ground Banker** (for motor oils, tires and other garage wastes) with storage materials that must include sand and vermiculite[81]. **It should be[82]:** ▪ Roofed, containers equipped with covers, ▪ Protected from excess heat and direct sunlight, ▪ Have walls with thick and of suitable materials, ▪ Located in remote area. **Portable or prefabricated storage building** (for pesticide and biocide and damaged fertilizers) which can	▪ Identify different waste categories, such as motor oils, tires and other garage wastes, E-wastes, pesticides and biocides, and damaged fertilizers. ▪ Document waste generation points, and storage locations, ▪ Utilize spreadsheets, databases, or specialized software to record information, ▪ Use colour coding or labelling to clearly identify different type of wastes, ▪ Regularly update the inventory with required tools records to reflect waste generation, ▪ Keep an inventory of wastes and include the waste name, delivery date, quantity, and location within the storage area. This will help in determining future needs, ▪ Have copies of map indicating the location of the storage facility, the storage unit floor	▪ Technical supervision and surveillance 24/7, ▪ Regular temperature control and smoke detection during operation and no-operation times[84], ▪ Avail fully functional fire extinguishers at the storage facility (Garage wastes and E-waste), ▪ Batteries that are swelling, smoking, leaking, or overheating should be treated with extreme caution, ▪ Treated fractions (plastics, metals, batteries) must be stored separately untreated materials, not in the same banker[85], ▪ Garages and e-wastes must be stored in cool dry location, ▪ Leaking batteries should be placed in acid-resistant containers, ▪ Properly use PPE that may include full body coveralls, apron, gloves, hard hats, shoes disposable shoe covers, respirators, face shields or vented goggles, ▪ Ensure that workers wash and change before leaving storing facility, ▪ Store pesticides and biocides wastes separately from other chemicals, ▪ Post signs on the door, building, or fence that indicate pesticides waste storage such as "Danger pesticide,	▪ Ensure a good communication with external local fire services, ▪ Consider designating responders in the emergency action plan with specific training, ▪ Ensure evacuation plans are written and communicated with employees, ▪ Have a storm water management program in place for response where required, ▪ There should be prominent hazard warnings in place, ▪ Develop a contingency plan to establish with the local emergency	▪ Maintain detailed records of chemicals and hazardous containing materials and any associated documentation, ▪ Keep records of the acquisition or transfer of chemical and hazardous wastes containing material in storage including intended disposal, ▪ Retain all relevant records for specified period as required by regulations, ▪ Adhere to specific regulatory requirement for inventory documentation, notification as well as periodic reporting	▪ Avail the safety instructions into Kinyarwanda language	▪ RRA, ▪ MINICOM, ▪ PSF, ▪ Garages, ▪ REMA, ▪ Civil Aviation Authority, ▪ COPED, ▪ Agruni Ltd, ▪ Depot Karisimbi, Enviroserve Rwanda, ▪ Electronic refurbishing sector, ▪ RAB, ▪ MINAGRI.

[81] Herreras-Martinez, L, Anta, M., Bountis, R. (2021) et al. Recommendations for Tackling fires caused by lithium batteries in WEEE.
[82] CEC, 2016. Environmentally sound management of spent lead-acid batteries in Northern America: T
[84] WHO, 2017. Recycling used lead-acid batteries: Health considerations
[85] ISRI, 2020. Guide for developing lithium battery management practices at material recovery facilities.

SN	Type of Wastes	Proposed facility/storage infrastructure	Inventory management method	Handling and Safety protocols	Emergency response strategy	Record keeping strategy	Communication with stakeholders' strategy	Concerned Institutions
		be repositioned easily in case of a flood hazard[83]. The storage facility should be: ▪ Far enough away from other buildings or structures, ▪ Located in the area located not prone to flooding	plan and current inventory in secure place.	▪ Always keep the storage area neat and clean. ▪ Keep the area free of debris such as wastepaper, rags, or used cardboard boxes, which may provide an ignition source[86], ▪ Use non-flammable materials to reduce fire hazard, ▪ Use sealed floors, such as sealed concrete, epoxy-coated metal, or concrete, ▪ Proper precaution needs to be taken in case of personnel use particularly during loading/unloading of hazardous wastes[87].	response personnel, ▪ Work with fire and emergency response agencies to determine the best response before you need their assistance, ▪ Avail the fire extinguisher and fire/rescue telephone numbers outside the storage building.			
7	**Perfluoroalkyl and polyfluoroalkyl substances (PFAS)**	**On-site storage tanks within a fenced and roofed structure.** [88]	▪ Develop an inventory stock tracking system, ▪ Label containers clearly to identify the type of concentrate	▪ Use of PPE is highly recommended when exposure to PFAS exposure is anticipated, ▪ During the immediate cleanup, it is recommended to use self-contained breathing apparatus or positive pressure supplied air respirator, ▪ Decontamination of PPE and personal hygiene are paramount to prevent further exposure to PFAS.	▪ Source control. Accidental can occur from one of the storage tanks. The first step in any response is to stop the accidental discharge or release at the source, ▪ Containment tactics that prevent or minimize surface	▪ Maintain copies of manifests and shipping documents for all PFAS generated, ▪ Maintain an up-to-date inventory of all types of PFAS in the storage facility, ▪ Keep record of waste storage activities, ▪ Record findings, observations and	▪ Clearly post emergency contact information, including local authorities and specialized hazardous and chemical wastes response teams	▪ Fire and Rescue Brigade in Rwanda National Police (RNP), ▪ Supplier of Fire extinguisher, ▪ MINICOM, ▪ NIRDA, ▪ All Textile Industries in Rwanda, ▪ All paint industries in Rwanda,

[83] John Ayers, 2022. Pesticides storage and security. College of Agricultural Sciences. The Pennsylvania State University. https://extension.psu.edu/pesticide-storage-and-security
[86] Pesticide Environmental Stewardship. https://pesticidestewardship.org/storage/safety-and-security/
[87] RURA, 2017. Regulations governing the provision of services for hazardous waste management.
[88] ITRC, 2022. Per- and Polyfluoroakyl substances Technical and Regulatory Guidance

SN	Type of Wastes	Proposed facility/storage infrastructure	Inventory management method	Handling and Safety protocols	Emergency response strategy	Record keeping strategy	Communication with stakeholders' strategy	Concerned Institutions
					water runoff during and after emergency response activities, ▪ Apply initial recovery tactics.	corrective measures taken during inspection, ▪ Keep records of spill incident date, location, quantity released, cleanup procedures and disposal of contaminated materials.		▪ All Mattress Industries in Rwanda, ▪ All cosmetics and Hygienic Industries in Rwanda, ▪ All Mattress Industries in Rwanda, ▪ RFDA, ▪ RSB, ▪ RURA, ▪ University of Rwanda, ▪ All Food Industries in Rwanda, ▪ Civil Aviation Authority, ▪ All lubricant Industries in Rwanda, ▪ All Pharmaceutical Industries in Rwanda

8.4 Audit and continuous improvement of the plan

- Conduct routine inspections of storage areas, handling procedures, and waste management practices to identify any potential issues or non-compliance;
- Perform internal audits to assess the effectiveness of safety protocols and identify areas for improvement;
- Address any findings promptly and implement corrective actions as necessary.

8.5 The best treatment processes for the proper management of inventoried hazardous chemical wastes

S/N	Types of wastes	Proper disposal
1.	Mercury wastes	**1. Physico-chemical Treatment (Stabilization/Solidification):** Mercury wastes can be chemically stabilized and/or physically solidified using commercially available technologies. In many cases, a combination of both is used. In stabilization processes, mercury is brought into reaction with chemical agents that convert it into a substance that is thermodynamically more stable, less soluble, and less volatile, making it less mobile and thereby reducing release and exposure potential. In solidification processes mercury wastes are embedded in a solid and stable matrix. **Micro-encapsulation** means mixing the waste with the encasing material. **Macro-encapsulation** means pouring the encasing material over and around the waste mass, thus enclosing it in a solid block.
		2. Specially Engineered Landfill: A specially engineered landfill (SEL) is an environmentally sound system for solid waste disposal and is a site where solid waste is capped and isolated from each other and from the environment.
		3. Permanent Storage (Underground Facilities): Mercury wastes can be permanently stored in deep geological cavities (e.g., in an underground mine). The intent is to permanently isolate mercury wastes from the biosphere by including it as completely and permanently as possible in a suitable host rock via several natural and artificial barriers. A detailed case-by-case evaluation of the suitability of any such facility is critical to its effectiveness.

S/N	Types of wastes	Proper disposal
2.	Persistent Organic Pollutants	**1. Pre-treatment:** a. Adsorption and absorption b. Blending c. Desorption d. Dewatering e. Dismantling/disassembling f. Dissolution g. Distillation h. Drying
		2. Destruction and irreversible transformation methods: Available information on the technologies, especially for more recent ones, is constantly evolving. Each facility operator may determine if an appropriate level of destruction and irreversible transformation will be achieved using a particular technology in given conditions. Those technologies are summarized are Alkali metal reduction, Advanced solid waste incineration, Base catalysed decomposition, Catalytic hydrodechlorination, Cement kiln co-incineration, Gas phase chemical reduction, Hazardous waste incineration, Plasma arc, Plasma melting decomposition method, Supercritical water oxidation and subcritical water oxidation, and Thermal and metallurgical production of metals. Further details on the specificity of each technology can be found in the subsection IV.G.2 of the general technical guidelines (UNEP (2019), General technical guidelines on the environmentally sound management of wastes consisting of, containing, or contaminated with persistent organic pollutants).
		3. Specially engineered landfill: A specially engineered landfill should comply with requirements regarding location, conditioning, management, control, closure, and preventive and protective measures to be taken against any threat to the environment in both the short and long term. In particular, measures should prevent the pollution of groundwater through leachate infiltration into the soil. Protection of soil, groundwater and surface water should be achieved through a combination of a geological barrier and a synthetic bottom line system during the operational phase and through a combination of a geological barrier and a top liner during the closure and post-closure phases. Measures should be taken to prevent and reduce the production of gases and, as appropriate, introduce landfill gas collection and control systems.
		4. Permanent storage in underground mines and formations: Permanent storage in facilities located underground in geohydrologically isolated salt mines and hard rock formations is an option for separating hazardous wastes from the biosphere for geological periods of time. A site-specific security assessment conducted in accordance with pertinent national legislation, such as the provisions contained in European Council Decision 2003/33/EC of 19 December 2002 (establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Council Directive 1999/31/EC), Annex, appendix A, should be performed for every planned underground storage facility.
3.	Asbestos	**1. Temporary in-situ storage:**

S/N	Types of wastes	Proper disposal
		Asbestos waste that has been segregated, or waste which is too contaminated to be segregated and therefore must be classified as asbestos waste, should be stored separately in secure, covered, labelled, containers until transportation to an appropriate site takes place. It is recommended that appropriate containers or skips are used to store known asbestos waste as these are the easiest to transfer to transport vehicles without exposing contaminated materials. These should be labelled correctly and covered to prevent access to contained materials or asbestos fiber release and should be locked when not in use to restrict access.
		2. Final disposal of asbestos waste: Asbestos waste can be disposed of in appropriate landfill facilities designated as non-hazardous, for example a construction and demolition (C&D) waste facility. In this case, asbestos waste should only be disposed of in cells that are specifically dedicated for the disposal of asbestos waste. Any interaction between asbestos waste and biodegradable waste should be prevented. Any cells used to dispose of asbestos waste must have clear signs at all access points as, once capped with earth, contents will not be clear.
4.	Other chemical wastes	**1. Chemical or physical treatment:** The purpose of treating hazardous waste is to convert it into non-hazardous material or to stabilize or encapsulate the waste in such a way that it will not leak or rep-resent a hazard when it is finally disposed of in the environment. Stabilization or encapsulating techniques are particularly necessary for inorganic wastes, in particular those containing toxic heavy metals.
		2. Disposal of solid waste in a monitored landfill: Solid inorganic chemical waste can usually be deposited in a specially monitored landfill. This procedure is however prohibited for reactive and flammable wastes. Such substances must therefore be disposed of in appropriate containers according to their chemical properties in order to minimize the risk of chemical reactions.
		3. Incineration: Incineration is the controlled combustion process used to degrade organic substances. Particulate emissions, including heavy metals in the form of particles, are controlled by the use of bag filters (both wet and dry), high energy scrubbers or, less frequently, electrostatic precipitators. High temperature incineration of organic hazardous wastes in properly designed and operating facilities can be performed in a manner that complies with standards regulating the emission of gaseous pollutants.
4	Medical wastes	**1. Incineration** This is the best method for handling infectious wastes, sharp wastes, pharmaceutical wastes, and chemical wastes.
		2. Decontamination and composting This is the best method for handling chemical wastes and non-infectious waste
5	PFAS containing and contaminated wastes	**1. Incineration** Although different PFAS waste disposal approach may be considered such as: landfills, and underground injection, the EPA recommend the incineration by high

S/N	Types of wastes	Proper disposal
		temperature chemical breakdown for the effective treatment and disposal of PFAS.[89]

[89] US-EPA, Feb 2020, Per- and Polyfluoroalkyl Substances (PFAS): Incineration to Manage PFAS Waste Streams.

Chapter 9: The institutional capacity and needs assessment

9.1 Introduction

The management of hazardous and chemical wastes falls under the sector of sanitation. This sector in Rwanda is quiet evolving and it involves a number of stakeholders including public institutions, NGOs, Civil societies, private sector, decentralized entities and donors[90]. Looking at the institutions that generate wastes in Rwanda, most of them do not have policy for waste management and appropriate facility for waste management[91].

However, the Government of Rwanda through REMA and UNDP has launched a five-year project to protect human health and the environment for adverse effects of hazardous wastes. The project will support public and private institutions to improve hazardous wastes management whereby approaches like Reuse, Reduce, Recycle and Recover will be prioritized. The project will support as well in identifying types, volumes, and locations of chemicals, toxic and hazardous wastes generation. The project will help the country towards sustainable solutions to minimize waste generation and strengthening policies and strategies that promote sustainable productions and consumption[92].

Given the significant impacts of hazardous and chemical wastes on land, air and water bodies, the country will base on its past experience and achievement in managing waste and banning plastic bags back in 2008 and the establishment of the e-waste recycling facility, to strengthen mechanisms toward a carbon neutral economy by 2050 to strengthen and improve the capacity on the institution level.

[90] GoR, 2018: Short and Medium term Hazardous, Toxic and Radioactive Wastes Control Strategy and Plan in Rwanda
[91] GoR, 2018: Short and Medium term Hazardous, Toxic and Radioactive Wastes Control Strategy and Plan in Rwanda
[92] https://www.rema.gov.rw/info/details?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=667&cHash=7d1a1ab5df6ae871585ad218826307ba

Furthermore, hazardous, and chemical wastes are still increasing due to the country's fast-growing economy, which is why the institutional capacity must not lag behind as well as meeting capacity needs as far as hazardous and chemical wastes management is concerned.

9.2 Storage of hazardous wastes expected to be disposed of by 2027

Table 9. 1: Storage of hazardous wastes expected to be disposed of by 2027 in Rwanda.

SN	Type of Waste	Quantity in Metric Tons
1	Polychlorinated Biphenyl (PCB) oil in transformers	122
2	Polychlorinated Biphenyl (PCBs) contaminated soil	250
3	Persistent Organic Pollutants (POPs) pesticides	3
4	Non-Persistent Organic Pollutants pesticides	44
5	Polybrominated diphenyl ethers (PBDE)	35
6	Products containing PBDE	35,000
7	Metric ton of Mercury (Hg)	1
8	Products containing mercury	40

Source: REMA[93]

Considering the characteristics of wastes being produced across the country, an assessment was conducted with the aim of understanding the institutional and needs to effective sound chemical and hazardous waste management. Using the questionnaire, 40 institutions were assessed on sound chemical and hazardous wastes management the outcome of the assessment will form an invaluable input in the elaboration of specific strategies to strengthen institutional framework. The figures below illustrate in brief the findings from the assessment on sound chemical and hazardous waste management. Details are provided from **Figure 9.1** to **Figure 9.6** and **Annex 10**.

[93]https://www.rema.gov.rw/info/details?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=667&cHash=7d1a1ab5df6ae871585ad218826307ba

The main goal of this section was to describe the existence status of projects implemented or being implemented on sound chemical and hazardous waste management within the visited institutions.

9.3 Projects and implementation capacity needs on sound chemical and hazardous waste management

Figure 9.1 show that among 40 institutions visited, only 32.5 % of the institutions have implemented projects on sound chemical and hazardous waste management while 67.5% of the institutions do not have any project being implemented or implemented on sound chemical and hazardous waste management which shows a significant gap within the institution in regard to promoting sound chemical and hazardous wastes management. **Figure 9.2** highlights involvement extent of the staff in sound chemical and hazardous waste management.

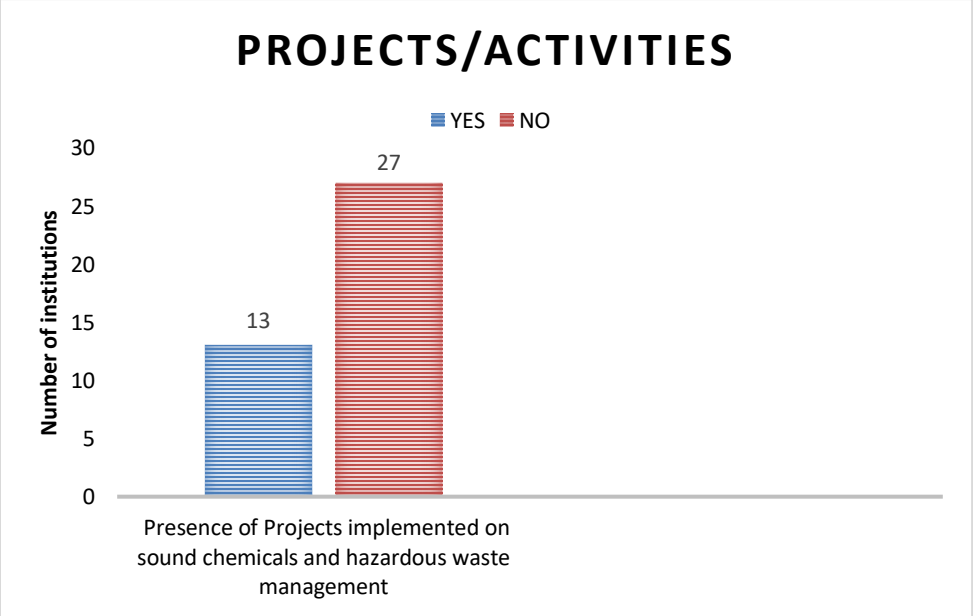


Figure 9. 1: *Presence of projects implementation on sound chemicals and hazardous waste management in Rwanda, 2023.*

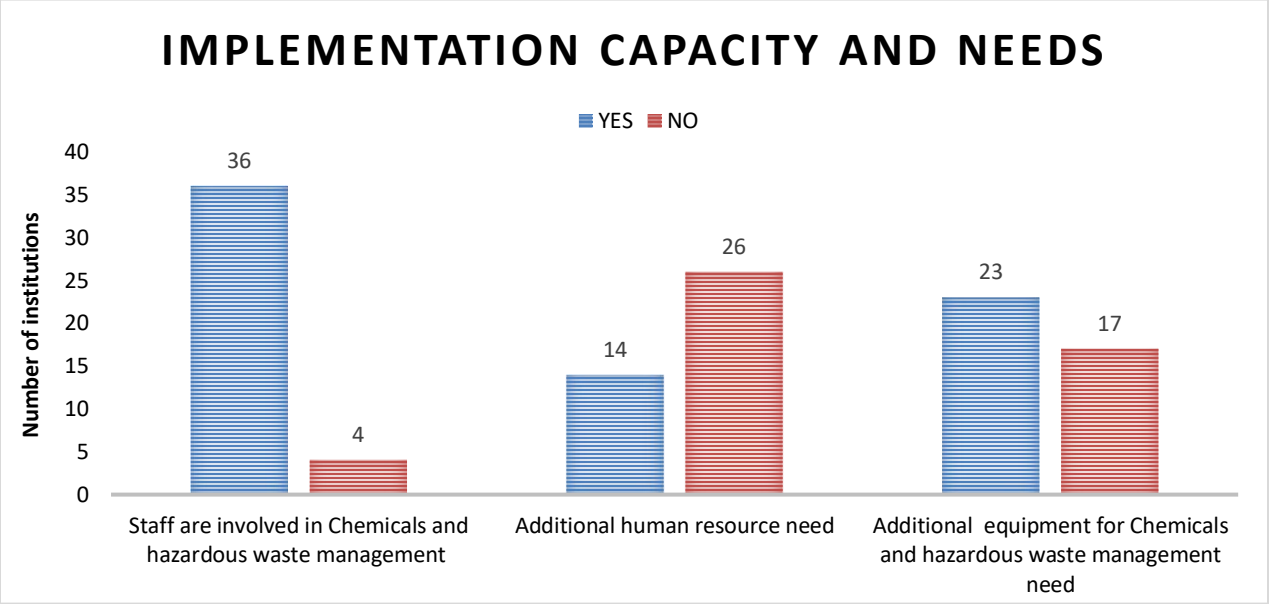


Figure 9. 2: *Implementation and capacity need regarding chemical and hazardous waste management in Rwanda, 2023.*

9.4 Training on sound chemical and hazardous waste management

Based on the findings, 90% of institutions have staff who are involved in sound chemicals and hazardous waste management while only 10% of the institutions indicated that they don't have any staff member involved in sound chemical and hazardous waste management practices. In addition to that, 35% of the institutions indicated the need for additional human resource in the sector while 65% of the institutions highlighted that they don't need additional human resource in the sector on sound chemical and hazardous waste management. On the other hand, 57.5% of the institutions indicated that they still need additional equipment for sound chemical and hazardous waste management while 42.5% of the institutions indicated that they don't need additional equipment in the sector. **Figure 9.3** show the status of training, staff trained including training need for effective performance on sound chemicals and hazardous waste management.

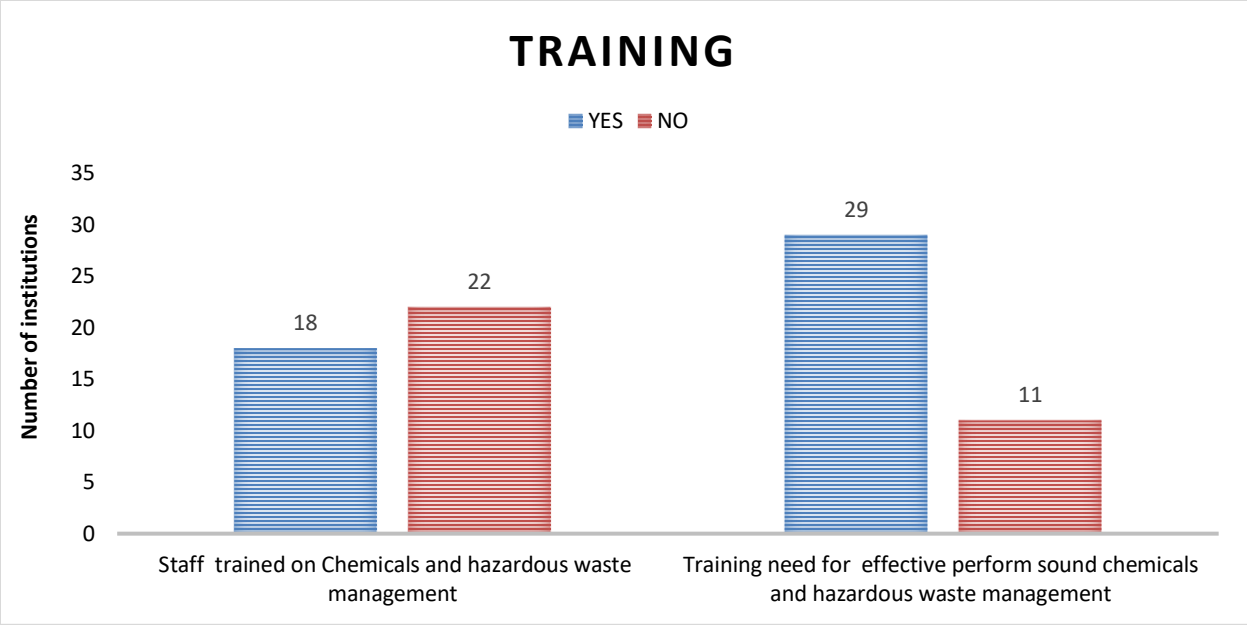


Figure 9. 3: *Training on chemicals and hazardous waste management in Rwanda, 2023.*

9.5 Financing for sound chemical and hazardous waste management

According to the findings, among the 40 institutions that were visited, 45% of them indicated that their staff have been trained on the chemicals and hazardous waste management while the remaining 55% indicated that their staff were not trained on the chemicals and hazardous waste management. Therefore, this has an impact on training needs within the visited institutions. That is why 72.5% of the institutions stated that they need training on effective performance on sound chemical and hazardous waste management while 27.5% of the institutions indicated that they don't have a training need for effective performance on sound chemical and hazardous waste management. **Figure 9.4** present the perception on financing consideration in various institutions for sound chemical and hazardous waste management in Rwanda.

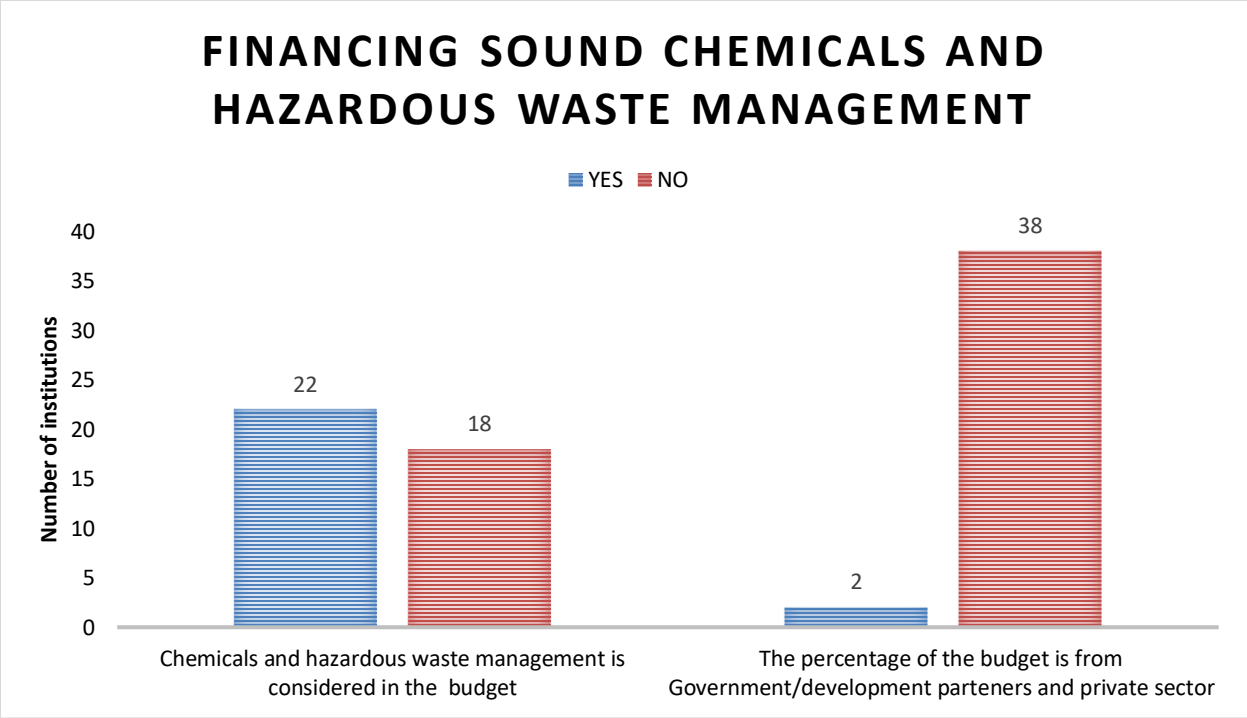


Figure 9. 4: *Financing for sound chemical and hazardous waste management in Rwanda, 2023.*

9.6 Information and networking for sound chemical and hazardous waste management

The main goal of this section was to assess the consideration of sound chemical and hazardous waste management in institution's budget and to indicate its source. Based on the findings, 55% of the visited institutions indicated that chemicals and hazardous waste management component is considered as part of their budget while the 45% of the institutions indicated that chemicals and hazardous waste management component is not considered as part of the budget. In addition to that, the institutions that consider chemical hazardous waste management in their budget, only 5% of institution's budget is from government and other potential donors while 95% of the institution's budget is not from those mentioned potential donors. This is because most of the organizations manage chemicals and hazardous wastes using their own budget. **Figure 9.5** highlights the findings on information and networking within the visited institutions on sound chemical and hazardous waste management.

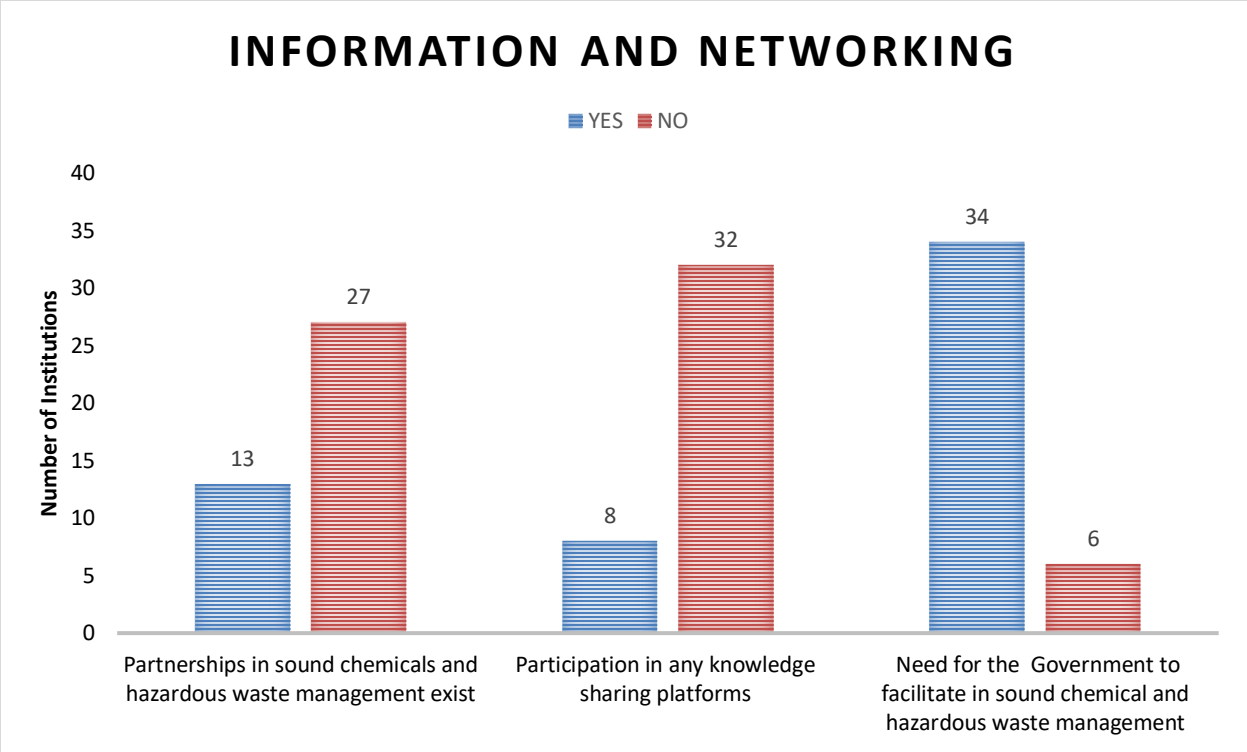


Figure 9. 5: *Information and networking for sound chemical and hazardous waste management in Rwanda, 2023.*

9.7 Mainstreaming for sound chemical and hazardous waste management

Based on the feedback from the respondents, 67.5% of the respondents indicated that there is no partnership in sound chemicals and hazardous waste management with other institutions, while 32.5% of the institutions indicated that a partnership with other institutions does exist on sound chemical and hazardous waste management. In addition to that, 80% of the institutions indicated that they have not participated in any knowledge sharing networks on sound chemical and hazardous waste management while only 20% of the institutions participated in such knowledge sharing platforms and networks. Furthermore, 85% of the institutions indicated that there is a need for the government to facilitate in sound chemical and hazardous waste management while only 15% of the institutions indicated that there is no need for the government to facilitate in the sector. **Figure 9.6** illustrate the mainstreaming status, under various institutions, for sound chemical and hazardous waste management in Rwanda.

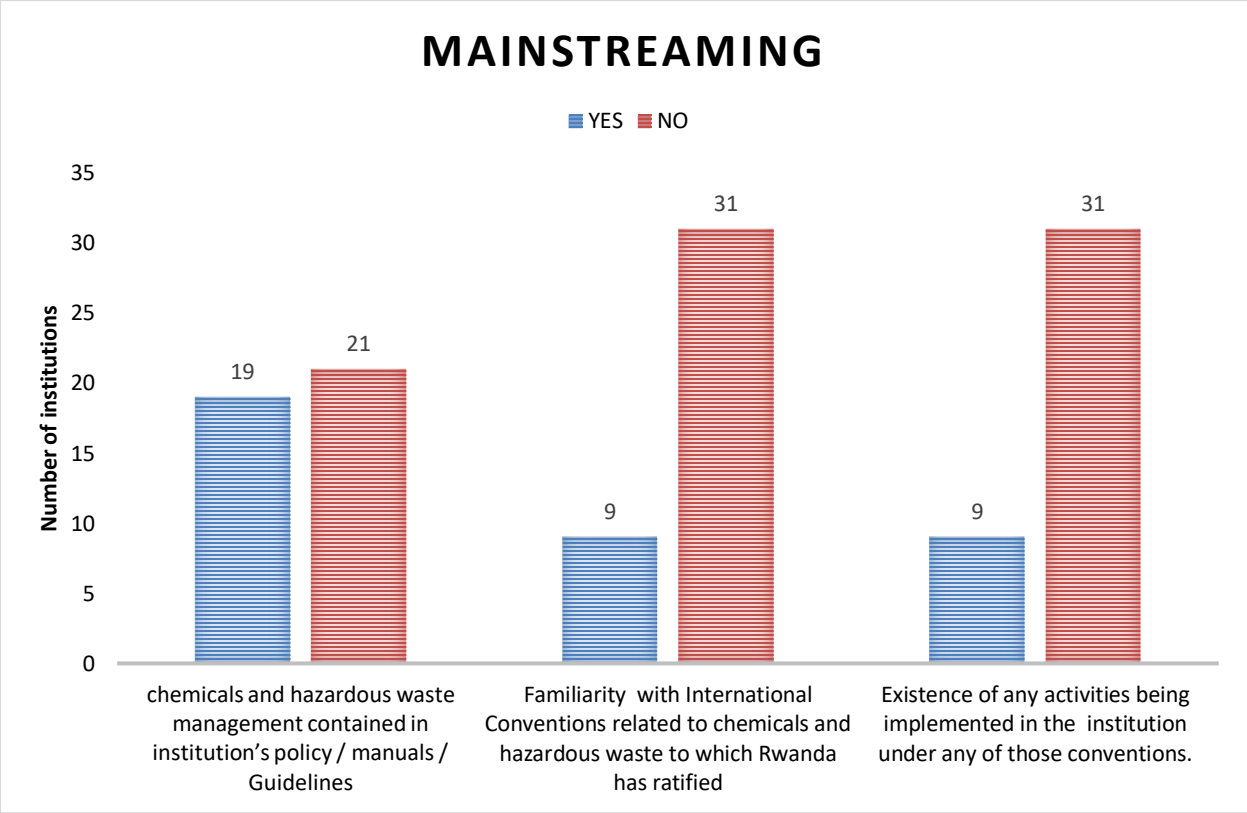


Figure 9. 6: *Mainstreaming for sound chemical and hazardous waste management in Rwanda, 2023*

The mainstreaming section assessed the inclusion of chemical and hazardous waste management into institution's guidelines and manuals, familiarity with related international conventions and implementation of activities relevant to those conventions within the visited institutions. Based on the figure above, 52.5% of the institutions do not have chemical and hazardous waste management contained in their policies and guidelines while only 47.5% of the institutions have chemicals and hazardous waste management being reflected in their policies and guidelines.

On the other hand, only 22.5% of the institutions are familiar with international conventions on chemicals and hazardous wastes while 77.5% of the institutions are not familiar with those conventions. In the same pace, only 22.5% of the institutions have implemented activities related

to those conventions while the remaining 77.5% of the institutions haven't implemented any activities related to conventions on chemicals and hazardous waste management.

9.8 Interim storage for sound chemical and hazardous waste management

This section assessed in general the existence of interim storage management facility within the visited institutions, plan for relocating stored waste, the existence of wastes sources, and future plan for managing chemical and hazardous wastes. **Figure 9.7** present the status on interim storage, under various institutions, for sound chemical and hazardous waste management in Rwanda.

Among the 40 institutions that were visited, only 57.5% of the institutions reported to have the facilities to store chemical or hazardous wastes while 42.5% of the institutions reported non-existence of the facilities to store hazardous or chemical wastes and concerning the plan for relocating the stored wastes, it was indicated that only 25% of the institutions have a plan for relocating the stored wastes while remaining 75% of the institutions do not have a plan for relocating the stored wastes.

In addition, 90% of the institutions indicated that they still have the source of hazardous wastes while only 10% of the institutions indicated that the source of their hazardous wastes no longer exists.

Furthermore, 67.5% of the institutions reported to have a future plan in chemical and hazardous waste management while 32.5% of visited institutions indicated that there is no future plan for chemical and hazardous waste management within their institutions.

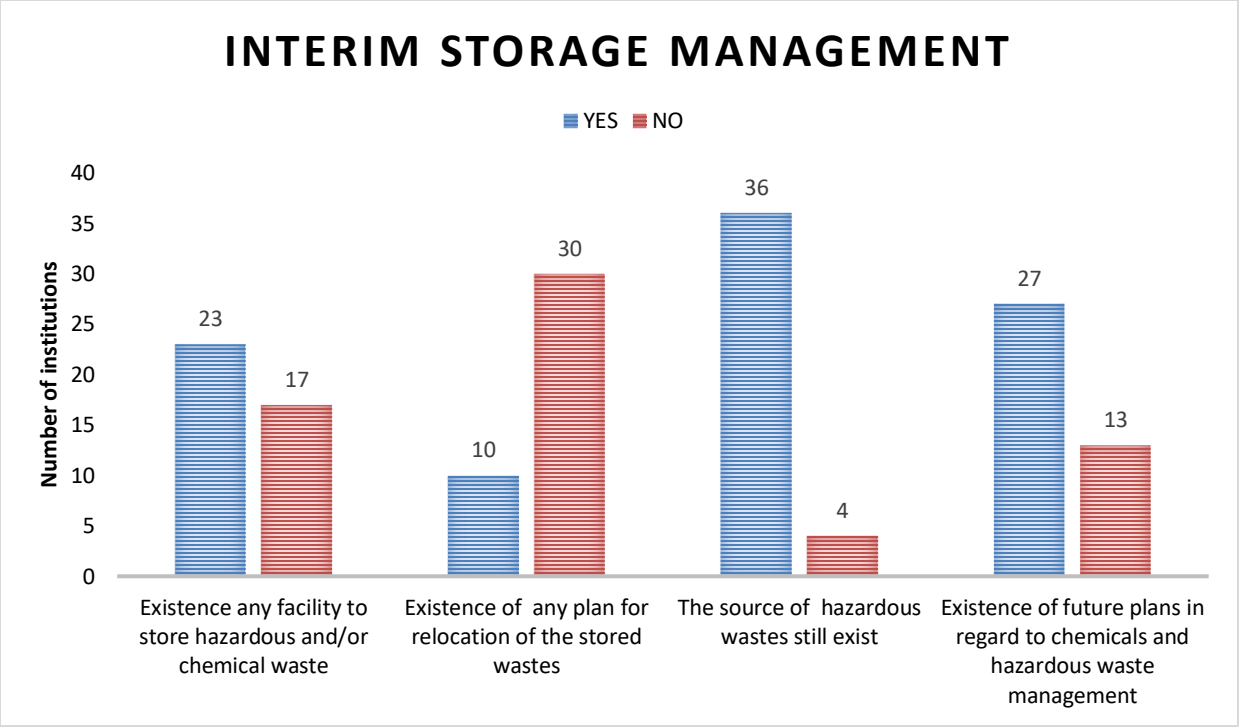


Figure 9. 7: *Interim storage for sound chemical and hazardous waste management in Rwanda, 2023.*

Chapter 10: General Recommendations

10.1 Introduction

Based on the finding of this inventory of for chemical and hazardous wastes management, this chapter shade light on the general recommendations to inform policy, support, and future interventions to achieve reductions in hazardous waste generation and releases including priority setting, potential waste management approaches. By referring to the key findings highlighted in **Table 10.1**, it was found that the quantity of expired chemicals and hazardous wastes is increasingly accumulating throughout the country from the various economic sectors but mainly from the public institutions even though the private sector is also concerned.

Therefore, the following general recommendation are proposed:

1. Enhance mechanisms for monitoring waste generator's progress in managing chemicals and hazardous wastes in environmentally sound manner;
2. Ensure proper and well-informed procurement of chemicals, mainly in public institutions, to avoid the gradual increase of expired chemicals;
3. Construction of interim storage facilities for chemical and hazardous waste while waiting the final treatment and disposal;
4. Maintain regular capacity building on the appropriate chemical and hazardous waste management for the concerned institutions;
5. Introduce awareness campaigns to educate public about the importance of chemicals and hazardous waste management;
6. Enhance the non-compliance fines as prescribed in the environmental law.
7. In most of consulted institutions and factories, it was observed that it is challenging for proper disposal of liquid wastes that contain hazardous chemicals for example liquid wastewater from the sink of an institution which use hazardous chemicals. Therefore, it is recommended for each concerned institution and factories to treat this type of

wastewater contaminated with hazardous chemicals before they can be released to the environment.

Table 10. 1: Summary for key findings of the survey

S/N	Item	Inventoried Amount
1	Mercury and Mercury contaminated wastes	1.5 tons of mercury wastes from electronic and electrical wastes
		150 kg of phased out thermometers containing mercury
2	PCBs oil and waste containing PCBs	1.1 tons of PCB oil from transformers
		12.7 tons of PCB contaminated wastes
3	POPs containing waste	Nyanza there are 3,028 kg of solid POP wastes
		200 litters of the obsolete insecticide Methamidophos located at Rwanda Agriculture Board Rubungo Station
4	Asbestos	From the previously inventoried 1,692,089.2 m^2 of asbestos, about 1,356,173.2 m^2 of asbestos materials were removed from buildings countrywide. The removed materials are deposited in 19 burial sites countrywide from which 6 sites have been closed and 13 sites are still operational.
5	Chemical wastes	In all consulted secondary schools, it was found that there is a total of 26.98 tons of expired chemicals which need to be disposed.
		Chemical Waste generated in higher learning institutions in Rwanda and research institutions were also estimated at 15.1 tons.
		The survey findings in agriculture sector also recorded around 472.3 tons of chemical wastes from the expired

S/N	Item	Inventoried Amount
		and damaged fertilizers, pesticides, biocides, and other chemicals used in research.
		Most of the visited industries produce fewer chemical wastes but a great number of hazardous wastes was observed in some industries and was estimated at around 85.54 tons per year

Comprehensively to different type of chemical and hazardous wastes inventoried in this report, this general recommendation is based on the findings of the assessed institutional capacity in the sound management of chemical and hazardous wastes, by focusing on projects implementation capacity, training, mainstreaming, financing capacity, interim storage and information and networking for the sound management of chemical and hazardous wastes in Rwanda **(Table 10.2)**.

Table 10. 2: General recommendation for chemical and hazardous wastes management

SN	Capacity needs	Associated risks/threats	Recommendation actions	indicators	Example of institutions
1	Training on the application of hazardous wastes and waste classification	Mishandling of hazardous wastes which can lead to safety hazard for both environment and employees	Design a training program that covers all aspects of chemicals and hazardous wastes management	Number of trainings provided on the classification and control of chemical and hazardous wastes	REMA, MOH, RURA, RSB, Customs
2	Institutional framework for managing hazardous and chemical wastes for institutions	Poor wastes management practices and non-compliance with regulations which can damage institution's reputation	Establish a framework with clear policies, procedures, guidelines, and protocols for chemical and hazardous waste management	Number of institutions implementing the framework	Prime Economic Zones Ltd, CIMERWA, DFMM Karisimbi, UTEXRWA Industry, COPED, AGRUNI Ltd, AgroPlast, ADENYA
3	Training institutions staff on chemical	Lack of necessary knowledge and skills to	Provide comprehensive training programs to staff	Number of staffs trained on the	All

SN	Capacity needs	Associated risks/threats	Recommendation actions	indicators	Example of institutions
	and hazardous wastes management	implement effective chemical and hazardous waste management	members on chemical and hazardous waste management	management of chemical and hazardous wastes	
4	Training on operation health and safety and emergency/spill responses	Inefficient emergency response for effectively managing emergency situation	Prioritize training programs on operation health and safety as well as emergency/spill response	Number of trainings provided on operation health and safety provided	Prime Economic Zones Ltd, CIMERWA, DFMM Karisimbi, UTEXRWA Industry, COPED, AGRUNI Ltd, AgroPlast, ADENYA
5	Education and awareness programs on effective enforcement of existing regulations and standards on hazardous wastes management	Authorities, civil servants, private sector and other stakeholders may lack the knowledge and skills necessary for the environmentally sound management of chemicals and hazardous waste.	Launch public awareness campaigns to educate public about the importance of chemicals and hazardous waste management. Establish effective communication channels between regulatory agencies, waste management facilities and generators	Number of awareness programs organized and implemented	Ministry of Environment, RBC, RAB, NIRDA / CPCIC, MAGERWA, REG, Rwanda Medical Supply (RMS)
6	Research, benchmark and develop website page for hazardous wastes information	Difficulties in obtaining the data/information required to develop a detailed Hazardous Waste Inventory and populate the web-based hazardous waste monitoring tool.	Explore the use of data sharing platforms or data bases that allow waste generators, regulatory agencies, and waste management facilities to upload and share data securely	Communication platforms/websites initiated and continuously upgraded	UR, INES, NIRDA, UTAB, RP
7	Establishment of a hazardous wastes reference center at every secondary city	Increased transportation and disposal cost in secondary cities that may rely on external resource for technical support	Establishment of a hazardous wastes reference center at secondary cities that can provide local expertise, technical support and training programs	Number of fully operational HZW reference centers	REMA, RURA, Districts

SN	Capacity needs	Associated risks/threats	Recommendation actions	indicators	Example of institutions
8	Disseminate information to stakeholders regarding waste minimization opportunities	Missed opportunities for waste reduction and increased waste disposal cost	Accelerate the rate of information dissemination through workshops, seminars, online platforms and publications	The number of wastes minimization opportunities adopted	MOE, REMA, Districts, PSF, RURA
9	Competent facilities for handling and treatment of hazardous and chemical wastes in general	Failure of waste treatment facilities in Rwanda that are unable to eliminate priority hazardous waste streams	Conduct comprehensive assessment of the existing facilities. Invest in upgrading and enhancing the capabilities of existing facilities to meet required competent standards. Foster partnerships between public institutions, private companies and academic institutions to pool resources, expertise and funding	The number of fully operational facilities installed	REMA, RURA, RSB, Customs
10	Capacity building of technical staff operating specific equipment for certain categories of hazardous and toxic wastes	Industries and priority economic sectors are reluctant to replace chemicals of concern/or products containing them with alternative substances.	Assess the skills and knowledge gaps of the technical staff operating the equipment. Develop specialized training programs and provide hands-on training	The number of technical staff trained	MoE, MoH, MINALOC, Districts, MININFRA, REMA, RURA, PSF
11	Administrative capacity in institutions with responsibilities to implement legislations on the management of hazardous wastes	Environmental, health and trade authorities do not actively participate in the development and implementation of project activities.	Conduct a thorough assessment of the existing administrative capacity in relevant institutions. Based on the identified capacity gaps, develop a comprehensive capacity	Number of administrative mechanisms taken for implementation of related legislation	MoE, MoH, MINALOC, Districts, MININFRA, REMA, RURA, PSF

SN	Capacity needs	Associated risks/threats	Recommendation actions	indicators	Example of institutions
			building plan outlining the objectives, strategies and activities		
12	Waste generators capacity for managing hazardous wastes in environmentally sound manner	Industries and priority economic are reluctant to replace chemicals of concern/or products containing them with alternative substances.	Organize training programs and capacity building initiatives specifically designed for hazardous waste generators. Promote waste minimization and recycling initiatives among waste generators by implementing waste minimization strategies Establish mechanisms for monitoring and evaluating waste generator's progress in managing hazardous wastes in environmentally sound manner	Number of wastes reduced per annum by the generators	MoE, MININFRA, REMA, RURA, WASAC, RSB, PSF.
13	Commercial banks capacity to finance environment project under favourable terms	Private sector partners are reluctant to invest in the management, collection, treatment /disposal of less viable/more complicated hazardous waste streams.	Establish partnership with development finance institutions, and work with stakeholders including projects developers, environmental consultants, and industry associations to develop a robust of pipeline of bankable environmental projects. Collaborate with regulators and policymakers to create an enabling environment for sustainable finance	The number of projects financed	PSF, local banks

10.2 Financial needs towards the long-term operation of waste management mechanisms

S/N	Type of Waste	Key activities	Comment	Targeted/ concerned Institutions	Estimated Cost in RWF	Time Frame
1	**Mercury and Mercury Contaminated Wastes**	Construction of interim storage facilities for mercury and mercury contaminated wastes	During the inventory of mercury and mercury contaminated wastes in this report, it was found that the existing interim storage at different institutions and organizations are not meeting the minimum requirements for storing mercury.	▪ REMA ▪ REG, Enviroserve Rwanda, ▪ Hospitals, ▪ MoH, ▪ RMB ▪ Depot Karisimbi Ltd, ▪ RMS Ltd, ▪ Rwanda Meteo, ▪ Universities and Higher learning institutions, ▪ REB, ▪ Secondary schools ▪ RURA, ▪ RSB, ▪ RICA, ▪ NIRDA	400,000,000.00	2023-2027
		Preparation and implementation of final disposal of mercury or mercury containing items	Mercury containing items can be safely collected, recycled, or disposed of in an approved waste disposal facility.		100,000,000.00	2023-2027
		Education on waste sorting and management.	Mercury is often used in everyday household objects including lamps, therefore there is a need for Education on waste sorting and management.		25,000,000.00	2023-2027

S/N	Type of Waste	Key activities	Comment	Targeted/ concerned Institutions	Estimated Cost in RWF	Time Frame
				▪ Landfills and dumpsites in Kigali and Six secondary cities.		
2	**Persistent Organic Pollutants (POPs)**	Construction of interim storage facilities for POP wastes	During the inventory on POPs carried out on this report, it was found that there are several interim storages for POPs wastes such as PCBs from transformers, POPs pesticides which are not properly stored.	▪ REMA, ▪ REG/EDCL, ▪ WASAC, ▪ MINAGRI ▪ RAB, ▪ RSB, ▪ RICA, ▪ RURA.	400,000,000.00	2023-2027
		Mark clearly the location of the existing interim storages of POP wastes in Rwanda.	During the inventory, it was found that the existing interim storage need to be marked by putting the fence and signage where necessary.		20,000,000.00	2023-2025
		Preparation and implementation of final disposal of inventoried POPs wastes	Among the best methods for POPs waste disposal in the incineration. Therefore, this report recommends that all POPs which are in different interim storage can be incinerated for final disposal.		17,000,000.00	2023-2027
3	**Asbestos and asbestos containing waste**	Removal of the remaining 20% of all inventoried asbestos in Rwanda and put them in interim storage	This report is showing that 80% of the inventoried asbestos has been removed and currently are in the prepared burial sites as interim storage. There is a need also to secure funds for removing the remaining 20% of asbestos in Rwanda.	▪ MININFRA, ▪ Rwanda Housing Authority, ▪ REMA.	100,000,000.00	2023-2027
		Putting fence and signage on the existing burial sites (existing interim storage) of asbestos	This report showed that there are 19 burial sites for asbestos across the country among which 6 are closed and other 13 are operational. However, in all burial site need to be secured and signage indicators need to be put.		57,000,000.00	2023-2025

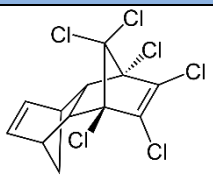
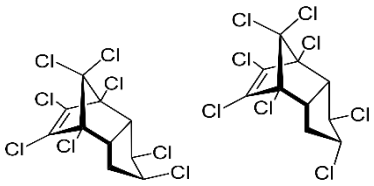
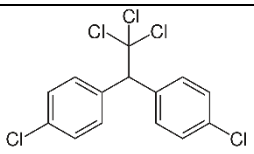
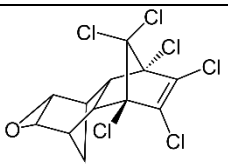
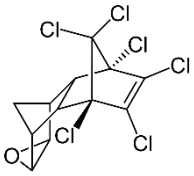
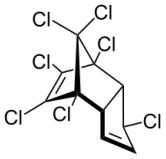
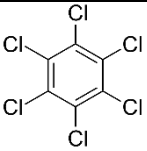
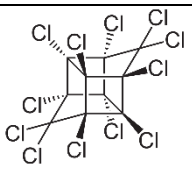
S/N	Type of Waste	Key activities	Comment	Targeted/ concerned Institutions	Estimated Cost in RWF	Time Frame
		Preparation and implementation of final disposal of asbestos in Rwanda	Private and government sectors should mobilize the budget funds from donors and stakeholders for complete eradication of the remaining 20%.		100,000,000.00	2023-2027
4	**Pharmaceutical and medical wastes**	Availing the wastewater treatment Plant at each health facility	As it has been mentioned in this report, liquid waste amount is the highest compared to other type of pharmaceutical and medical wastes in Rwanda, however, few hospitals have tangible means to treat liquid wastes.	▪ MOH, ▪ RBC ▪ National Reference Laboratory, ▪ Province Hospitals (All) ▪ District Hospitals (All) ▪ All Private and Public Hospitals, ▪ All Private and Public Health centres, ▪ RSB, ▪ RICA, ▪ REMA.	500,000,000.00	2023-2027
		Monitoring and management of existing incinerator	The existing incinerators need to be properly maintained		100,000,000.00	2023-2027
		Preparation for disposal of waste residues from Sterilwave 250 incinerators in a district municipal landfill			25,000,000.00	2023-2027
		Education on waste sorting and management			25,000,000.00	2023-2027
5	**Chemical wastes, hazardous wastes** (eg., chemical	Construction of interim storage facilities for chemical and hazardous waste	The inventory for wastes, hazardous wastes in this report showed that there is an urgent need to avail interim storage facilities for chemical and	▪ Universities, ▪ Higher learning institutions,	500,000,000.00	2023-2027

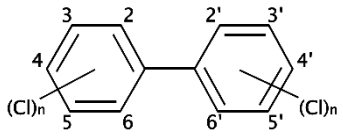
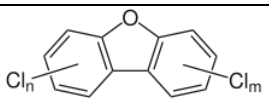
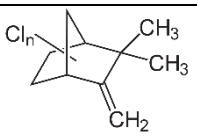
S/N	Type of Waste	Key activities	Comment	Targeted/ concerned Institutions	Estimated Cost in RWF	Time Frame
	wastes, used motor oils, tires and other garage wastes, E-wastes, Pesticides and biocides, Expired or damaged fertilizers)		hazardous waste at different places in Rwanda.	▪ Research Institutions ▪ Secondary schools, hospitals, ▪ NIRDA, ▪ REB, ▪ REMA, ▪ MINICOM, ▪ RRA, ▪ RSB, ▪ RICA, ▪ MINAGRI, ▪ RAB, ▪ One acre fund,		
		Collection/ Transportation of all chemical wastes to the interim storage	As expired chemicals are distributed in different places from the country for example in secondary schools, there will be a need to collect these chemical wastes		60,000,000.00	2023-2027
		Sorting and separations of chemical wastes depending on their properties	Chemical wastes always need to be sorted compared to their both chemical and physical properties, this is to facilitate the final disposal either by incineration or through other means.		25,000,000.00	2023-2027
		Sorting and separations of chemical wastes depending on their proposed approaches for final disposal			25,000,000.00	2023-2027
		Preparation and implementation of final disposal of chemical wastes in Rwanda			25,000,000.00	2023-2027
		Availing the wastewater treatment Plant at each institution which use chemicals	Among all the institutions which have been visited for the inventory of chemical and hazardous waste, very few can estimate the amount of liquid waste produced with chemical		200,000,000.00	2023-2027

S/N	Type of Waste	Key activities	Comment	Targeted/ concerned Institutions	Estimated Cost in RWF	Time Frame
			contamination, moreover, very few can show that they have the capacity to treat these contaminated waste wastewaters with chemicals.			
		Education on waste sorting and management	He best chemical and hazardous waste management always go with the best sorting.		25,000,000.00	2023-2027
6	**Perfluoroalkyl and polyfluoroalkyl substances (PFAS)**	Acquiring capacity building in PFAS testing and analysis	This report showed that there are two approach which can be used to test PFAS, one is screening methods and the other one is targeted PFAS analysis, although we have found that all the required instrumentations for this PFAS testing and analysis using the above methods are available in our country, there is an urgent need for capacity building in PFAS testing and analysis,	▪ RFDA ▪ UR ▪ RSB ▪ RFI ▪ MOH ▪ RBC ▪ NIRDA ▪ MINICOM, ▪ PSF,	100,000,000.00	2023-2027
		Research development and partnership in PFAS analysis and monitoring			100,000,000.00	2023-2027
		Availing guiding standards for PFAS especially for manufacturer and their customers	During this inventory for PFAS, it was found that there are no guiding standards for both manufacturer and customers.		50,000,000.00	2023-2027
				Grand Total	**2,979,000,000.00**	**RWF**

ANNEXES

Annex 1: List of dirt dozen (POPs)

	Name	Chemical structure	Use
1	Aldrin		Pesticides
2	Chlordane		Pesticide
3	DDT		Insecticide
4	Dieldrin		Pesticide
5	Endrin		Insecticide
6	Heptachlor		Pesticide
7	Hexachlorobenzen		Fungicide
8	Mirex		Insecticide and flame retardant

	Name	Chemical structure	Use
9	Polychlorinated biphenyls		Heat exchange fluids
10	Dioxins	There are various dioxins with different chemical formula	By-products of high-temperature processes
11	Polychlorinated dibenzofurans		By-products of high-temperature processes
12	Toxaphen		Insecticide

Annex 2: Sample historic and current uses of PFAS

Industry/ Application	PFAS Type	Documented Use and Examples of Some PFAS
Aviation and Aerospace	Polymer	Mechanical components made of fluoropolymers (such as PTFE and PFA tubing, piping, seals, gaskets, cables, and insulators)
	Nonpolymers	Hydraulic fluid additives made from PFSA salts (such as PFOS at about 0.1%) toprevent evaporation, fires, and corrosion
Automotive	Polymer	Mechanical components made of fluoropolymers, including wiring and cable, fueldelivery tubing, seals, bearings, gaskets and lubricants, and some polymer coatings on carpets
	Nonpolymers	Surface treatment for textiles, upholsteries, carpets, leather, and exterior surfaces
Biocides (Herbicidesand Pesticides)	Polymer	None reported
	Nonpolymers	Active ingredients such as short-chain sulfonamides in plant growth regulators andherbicides, and EtFOSA (sulfluramid) in ant and termite baits; inert enhancing ingredients in pesticides; PFPAs and PFPiAs as anti-foaming agents in solutions
Building and Construction	Polymer	Fluoropolymer membranes and coatings (such as PTFE, PVDF, and/or sidechain fluorinated polymers) in architectural materials (like fabrics, roofing membranes, metals, stone, tiles, concrete, radomes); adhesives, seals, caulks; additives in paints (for example, low- and no-VOC latex paints), varnishes, dyes, stains, sealants; surface treatment agent and laminates for conserving landmarks
	Nonpolymers	Additives in paints, coatings, and surface treatments (PASF- and fluorotelomer-based compounds, ammonium salt of PFHxA)
Cable and Wiring	Polymer	Coatings and jacketings made of fluoropolymers (such as PTFE and PVDF) for weathering, flame, and soil resistance, with cables used in many applications, including communication facilities, antennae, and computer networks
	Nonpolymers	None reported
Cosmetics/ Personal Care Products	Polymer	Dental floss and micro powders used in creams and lotions.
	Nonpolymers	Cosmetics, shampoos, nail polish, eye makeup, denture cleaners
Electronics	Polymer	Fluoropolymers (such as PVDF and PTFE) used in insulators, solder sleeves, printedcircuit boards, cell phones, computers, speakers, and transducers
	Nonpolymers	Flame retardants for polycarbonate resin (such as the potassium salt of PFBS)

Industry/ Application	PFAS Type	Documented Use and Examples of Some PFAS
Energy	Polymer	Fluoropolymer films (such as FEP, PVDF) to cover solar panel collectors, electrolytefuel cells, PTFE expansion joint materials for power plants
	Nonpolymers	Fuel cell and battery electrolyte (such as the lithium salt of PFAAs)
Firefighting/ Safety	Polymer	Fluoropolymers are used in firefighting equipment and protective clothing (such asthose woven with PTFE). Other polymer coatings using sidechain fluorinated polymers)
	Nonpolymers	Coatings and materials used as water repellents and some Class B foam (may contain PFCAs, PFSAs, and fluorotelomer-based derivatives), vapor suppression forflammable liquids (for example, gasoline storage)
Food Processing	Polymer	Fluoropolymer fabrication materials (such as PTFE) (liners for trays, ovens, grills)
Household Products	Nonpolymers	May be used as coatings on food packaging
	Polymer	Nonstick coatings (fluoropolymers such as PTFE); aftermarket treatment for textiles, upholsteries, carpets, and leather (such as FT-based sidechain fluorinated polymers)
Medical Products	Nonpolymers	Aftermarket treatment for textiles, upholsteries, carpets, and leather (such as PASFs; floor polishes (such as the ammonium salt of PFDA), coatings, and floor finishes (PFPAs and PFPiAs) and cleaning agents and alkaline cleaners; automobile waxes; may include PFAAs, PASF- and fluorotelomer-based derivatives
	Polymer	Fluoropolymers used in surgical patches, cardiovascular grafts, raw materials forhuman body implants (such as catheters, stents, needles, and other) given biocompatibility and extremely low coefficient of friction
Metal Plating	Nonpolymers	X-ray film, stain- and water-repellent protective medical fabrics (like surgical drapes and gowns) created from PASF- or fluorotelomer-based (meth)acrylatepolymers and polyurethanes
	Polymer	None reported
Oil Production	Nonpolymers	Wetting agent, mist suppression for harmful vapors, and surfactants (may includepotassium, lithium, diethanolamine and ammonium salts of PFOS or 6:2 FTS)
	Polymer	Lining of gas pipes
Mining	Nonpolymers	Marketed for and potential instances of use in oil well production
	Polymer	None reported

Industry/ Application	PFAS Type	Documented Use and Examples of Some PFAS
Paper and Packaging	Nonpolymers	Instances of surfactants used in ore mining flotation
	Polymer	Oil and grease and water repellent to paper, paperboard, molded pulp products (including food contact materials), and LDPE bags; examples include sidechain fluorinated polymers in which the PASF- or fluorotelomer-based alcohols or their acrylate or methacrylate esters are attached on side chains
PFAS Production	Nonpolymers	Phosphate ester salts (esterification of PASF or FT-based alcohols with phosphoricacid; PFPEs
	Polymer	Not applicable
	Nonpolymers	Emulsion polymerization processing aids for fluoropolymers (such as PTFE, FEP, PFA, PVDF), (co)monomer of sidechain fluorinated polymers; (co)monomer of fluoropolymers and to make fluoroelastomers; may use salts of long-chain PFCAs(such as PFOA and PFNA), salts of short-chain PFCAs (such as PFHxA), or PFECAs
Photolithography & Semiconductor	Polymer	Equipment raw materials (such as PFA) for molded wafer baskets to handlecorrosive liquids and gases, use as fluids in mechanical vacuum pumps
	Nonpolymers	Photolithography (such as using PFOS) in manufacture of semiconductor chips
Textiles (Upholstery, Carpets), Leather, andApparel	Polymer	Fluoropolymers (such as PTFE) are used in the construction of outdoor gear, clothing, and housewares; sidechain fluorinated polymers (such as PASF- or fluorotelomer-based (meth)acrylate polymers and -polyurethanes) may be used inoil- and water-repellent and stain release finishing and treatment coatings
	Nonpolymers	PFOA-based chromium treatment for paper and leather. Nonpolymer coatings used to treat textiles to provide oil- and water- repellent and stain release finishes

Source: "Guidance on PFAS Exposure, Testing, and Clinical Follow-Up," 2022[94]

[94] Guidance on PFAS Exposure, Testing, and Clinical Follow-Up. (2022). In Guidance on PFAS Exposure, Testing, and Clinical Follow-Up. Washington (DC): National Academies Press (US) Copyright 2022 by the National Academy of Sciences. All rights reserved.

Annex 3: Standard Analytical Methods for PFAS, Source: (USEPA, 2023)

Media	Method	Description
Drinking (Potable) Water EPA develops drinking water methods in support of the Safe Drinking Water Act (SDWA). Information on SDWA method development protocols	Method 537.1: Determination of Selected PFAS in Drinking Water by SPE and LC/MS/MS (2018/2020)	EPA method for the determination of 18 PFAS in drinking water, including HFPO-DA (one component of the GenX processing aid technology). First published in 2009 for the determination of 14 PFAS, this method was updated as more PFAS, that have the potential to contaminate drinking water, have been identified or introduced as PFOA/PFOS alternatives in manufacturing. Note: *Method 537.1 was updated in 2020 to version 2.0. The only updates were editorial and did not include any technical revisions.*
	Method 537: Determination of Selected PFAS in Drinking Water by SPE and LC/MS/MS (2009 - *listed for historical purposes*)	EPA method for the determination of 14 PFAS in drinking water. Note: *This is referenced for historical purposes only. Method 537 was updated in 2018 to Method 537.1 (above).*
	Method 533: Determination of PFAS in Drinking Water by Isotope Dilution Anion Exchange SPE and LC/MS/MS (2019)	EPA isotope dilution method developed to support measurements for the Fifth Proposed Unregulated Contaminant Monitoring Rule (UCMR) sampling effort. This method targets "short chain" PFAS (none greater than C_{12}), including perfluorinated acids, sulfonates, fluorotelomers, and poly/perfluorinated ether carboxylic acids. Method 533 measures a total of 25 PFAS.
Non-Potable Water and Other Environmental Media EPA develops methods for aqueous and solid (e.g., soil, biosolids, sediment) samples primarily through the Clean Water Act (CWA) and methods for solid waste (SW-846) under	Method 8327: PFAS Using External Standard Calibration and MRM LC/MS/MS (2019)	Direct injection method for non-drinking water aqueous (groundwater, surface water, and wastewater) samples. Validated for 24 analytes.
	Draft Method 1633	Draft, single laboratory validated, direct injection EPA method for 40 PFAS in wastewater, surface water, groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue.

Media	Method	Description
the Resource Conservation and Recovery Act (RCRA). • CWA analytical methods • Solid waste methods for RCRA		Note: EPA and the Department of Defense are collaborating on the development of this method. A multi-laboratory validation study will be conducted by DoD, in collaboration with EPA.
Source (Air) Emissions There are diverse sources of emissions, including chemical manufacturers, commercial applications, and thermal treatment incineration processes. EPA is developing test methods for measuring.	Other Test Method (OTM)-45	EPA method that measures PFAS air emissions from stationary sources. This method will help other federal agencies, states, tribes, and communities have a consistent way to measure PFAS released into the air. Currently, OTM-45 can be used to test 50 specific PFAS compounds. In addition to testing for these 50 specific PFAS, the method can also be used to help identify other PFAS that may be present in the air sample, which will help improve emissions characterizations and inform the need for further testing. EPA intends for the scientific community to provide feedback on OTM-45. EPA will consider and incorporate feedback to keep improving the method. Scientists and stakeholders can learn more about the process for submitting feedback in the introduction text of the method document. Direct link to OTM-45 (pdf). Field test study supporting OTM-45, in collaboration with Department of Defense.
	SW-846 Test Method 0010: Modified Method 5 Sampling Train	For semi/non-volatiles. A performance-based, Modified Method 5 that uses an isotope dilution train approach for GC/MS targeted and non-targeted analysis.

Media	Method	Description
	Modified Method TO-15	For volatiles. Uses SUMMA canisters for GC/MS targeted and non-targeted analysis.
Ambient Air EPA is considering both sampling and analysis methods, targeted and non-targeted for PFAS ambient air measurements. Applications will include fenceline monitoring for fugitive emissions, deposition, and receptor exposure.	Ambient/Near-Source *(coming soon)*	Field deployable Time of Flight/Chemical Ionization Mass Spectrometer for real time detection and measurement.
	Semivolatile PFAS *(coming soon)*	A performance-based method guide by EPA TO-13a.
	Volatile PFAS *(coming soon)*	Uses SUMMA canisters and sorbent traps for GC/MS targeted and non-targeted analysis.
Total These types of methods aim to quantify large groups of PFAS in environmental samples.	Total Organic Fluorine (TOF) *(coming soon)*	EPA is developing a potential rapid screening tool to identify total PFAS presence and absence. This eventual standard operating procedure will be used to quantify TOF. Note: *EPA is working to develop this method in 2021.*
	Total Organic Precursors (TOP) *(coming soon)*	EPA is considering the development of a method, based on existing protocols, to identify PFAS precursors that may transform to more persistent PFAS. Note: *TOP methods are commercially available. EPA will consider the need for a thorough multi-laboratory validation study in 2021.*

Annex 4: Medical waste questionnaire

N°	Record No.	Description of the current situation
General information		
	Date	
	Name of data collector	
	District	
	Name of Health facility	
	Name/position of contact:	
	Phone:	
	E-mail:	
Variable		
Number of Inpatient : ……/year		
Number of Outpatient : ……/year		
1	Is there any waste management plan in the health facility itself?	Yes/No
2	What are some of the obstacles to successful implementation of a plan facility?	
3	Has any waste management training been set up for the hospital staff?	Yes/No
4	Are waste segregated according at site of generation?	Yes/No
5	Plastic garbage bags are available in each infectious waste bin.	Yes/No
6.	Total number of infectious wastes generated in a year	…..Kg/year
7.	Total number of non-infectious wastes generated in a year	…..Kg/year
8.a	Total number of pharmaceutical wastes generated in a year?	…..Kg/year
9.	Total number of chemical wastes generated in a year	…..Kg/year
10.	Total number of sharps wastes generated in a year	…..Kg/year
11	Total number of Radioactive wastes generated in a year	…..Kg/year
12	Total of Liquid wastes (m3) produced in a year	….. m^3/year
12.a	Is a wastewater treatment plant available?	Yes/No
12.b	Is the waste treatment plant functioning?	Yes/No
13.a	Is an incinerator available?	Yes/No
13.b	Is Incinerator Functioning?	Yes/No
13.c	Types of incinerators used by hospitals?	1. Sterile wave 250 2. Montfort 3. Burner 4. ATI50 5. Other; specify:
14.c	Area for final disposal of ash	1. Open dumps landfill 2. Ground 3. Cemented 4. Other: Specify

Annex 5. Hazardous wastes

A.1. INSTITUTION INFORMATION

Date:
Name of data collector:
Name of institution:
Main activity of the institution:
Address:
Name and position of the respondent:
Telephone:
Email:

A.2. HAZARDOUS WASTES INFORMATION

According to the United Nations Environment Programme, hazardous waste is defined as any waste or combination of wastes with the potential to damage human health, living organisms or the environment.

1. Does your business unit generate any wastes that could be classified as hazardous? *(Answer by YES or No)*

ANSWER:

2. If your answer to the above question is **YES**, please complete the table below:

	TYPE OF HAZARDOUS WASTES	**QUANTITY GENERATED PER YEAR (in kg or L)**
1		
2		
3		
4		
5		

3. Does your company/organisation have any SOP[95] for handling, storage and disposal of hazardous wastes? *(Answer by YES or No)*

ANSWER:

4. Describe briefly how and where those hazardous wastes are stored?

ANSWER:

5. Does your company/organisation take any measure to try to avoid and/or minimize the generation of hazardous wastes? *(Answer by YES or No)*

ANSWER:

If *yes*, please specify how and if no, please specify why:

6. Does your organisation:

	Answer By **YES** or **NO**	**If yes, specify monthly or yearly quantities in kg or L**
Treat hazardous wastes		
Recycle or reuse hazardous wastes		
Dispose of hazardous waste		

[95] Standard Operating Procedure

If yes, please describe how each of the above is carried out and if no, please describe how the organisation get rid of the hazardous wastes it generates (*for e.g., sold to a recycling company or sent to landfill etc.)***:**

7. Describe any form of difficulties faced by your organisation regarding the handling, storage and disposal of hazardous wastes and your expectations from Government of Rwanda:

Annex 6. Chemical wastes

Date……

Name of the interviewer……..

Name of Industry/Institution……

Contact Person……..

Address……..

S/N	Name of the Product/Chemical		CAS number	Batch number	MFG date	EXP date	Date of Rejection	Quantity in the store	Reason for rejection	Proposed mode of disposal if available
	Common name	Trade name								

Annex 7. Interview questionnaire for institutional capacity assessment in chemical and hazardous waste management

This questionnaire aims at understanding the institutional and needs for effective sound chemical and hazardous waste management. Your responses will form an invaluable input in the elaboration of specific strategies to strengthen institutional framework.

1. Institution information

Date:

Name of institution …….

Main activity of the institution:

Respondent's name and position: ……

Tel:……

Email:.……

2. Projects/Activities

(a) What specific projects/mandates have you been/are implementing on sound chemicals and hazardous waste management? Please describe on a separate sheet or attach a file.

……

3. Implementation Capacity and Needs

(a) Please indicate the staff involved in Chemicals and hazardous waste management (e.g., researchers, laboratory scientists, laboratory technologists, technicians), their experience and specializations

……

(b) Please indicate the type and number of additional human resource your institution may need

……

(c) Please indicate the equipment for Chemicals and hazardous waste management in your institution.

……

(b) Please indicate the type and number of additional equipment your institution may need

……

4. Training

(a) Is there any of your staff who has been trained on Chemicals and hazardous waste management?

……

(b) Is there any specific training needed for your staff to effectively perform sound chemicals and hazardous waste management responsibilities?

……

5. Information and networking

(a) Does your institution have any institutional partnerships in sound chemicals and hazardous waste management (Yes/No)? Explain.

……

(b) Does your institution participate in any knowledge sharing networks/platforms (Yes/No)? Explain.

……

(e) In what ways can the Government facilitate sound chemical and hazardous waste management in your

institution?

……

6. Financing sound chemicals and hazardous waste management

(a) Is sound chemicals and hazardous waste management provided for in your institution's budget?

……

(b) What percentage of this funding is from the Government, development partners and private sector?

……

7. Mainstreaming

Is sound chemicals and hazardous waste management contained in your institution's policy / manuals / Guidelines?

……

(b) ***International conventions related to chemicals and hazardous waste***

(a) Are you familiar with International Conventions related to chemicals and hazardous waste to which Rwanda has ratified? Which ones?

……

(b) Please explain if there are any activities being implemented in your institution under any of those conventions.

……

8. Interim storage management

(a) Do you have any facility to store hazardous and/or chemical waste? Yes / No

(b) Is there any plan for relocation of the stored wastes? Yes / No

(c) Does the source of those hazardous wastes still exist?

……..

(d) What are the major challenges your institution is facing in the hazardous waste storage and disposal? Any suggestions on how to overcome these challenges.

……..

(e) What are your future plans in regard to chemicals and hazardous waste management?

……

Annex 8. Interview questionnaire on Per- and polyfluoroalkyl substances (PFAS)

This questionnaire on Per- and polyfluoroalkyl substances (PFAS), the questions are addressed to the whole supply chain including manufacturers, importers, distributors, and downstream users.

General Information

Date: yyyy-mm-dd
*……

Names of Data Collector:
*……
Position of Respondent
*……
Names of Respondent
*……
Tel. of Respondent:
*……
Address
*……

Place geographical coordinates

Latitude (x.y °): ……
Longitude (x.y °): ……

E-mail of Respondent
*……

Q1. Does your Institution/Factory use/have any of the following items: *(You can choose more than one item)*

- Cosmetic products/ personal Care Products (Dental floss and micro powders used in creams and lotions)
- Firefighting foams (eg.: Aqueous Film Forming Foam (AFFF))
- Paints, varnishes, paint additives (low- and No-volatile organic compounds, latex paints)
- Coatings, surface treatment materials, adhesives, sealants, caulks
- Polyvinylidene fluoride (PVDF)
- Fluoroethylene Vinyl Ether (FEVE resin)
- Fluorinated surfactants
- Biocides (Herbicides and Pesticides)
- Water repellent chemicals
- Textiles, leather and apparel, and textile related products that may contain Fluoropolymers.
- Paper and Packaging papers (e.g., Hygienic papers, food packaging papers, etc.)
- Fluorinated Ethylene Propylene (FEP)
- Ethylene tetrafluoroethylene (ETFE)
- Others(Write):……

Q2. How does your Institution/Factory obtain any of the above listed items in question 1?
You can choose more than one option below:

- Import
- Manufacture

- Distribute/Export
- Other(Write):……

Q3. Do you have materials safety data sheets or composition information/ingredients for any of the products listed in question 1/?

- Yes
- No
- Other (Write):……

Q4. What are the ingredients/composition for any of the products listed in question 1/?

- Write:
  ……
  ……..

Q5.a. What is the total amount in kg or L of the current stock for any of the products listed in question 1?

- Write:
  ……
  ……

Q5.b. What is the total amount of used/distributed for any of the products listed in question 1 in kg or L per year?

- Write:
  ……
  ……

6. Is your Institution/Factory aware of contamination that can be caused by Per- and polyfluoroalkyl substances (PFAS) to its products or manufactured materials?

- Yes
- No
- Other(Write):……

Q7. In any case one of ingredients or the product used may be containing Per- and polyfluoroalkyl substances (PFAS), did your Institution/Factory start looking for other alternatives to replace these ingredients or products which can be suspected to contain PFAS?

- Yes
- No
- Other(Write):……

Q8. Does your Institution/Factory plan to have the capacity to test PFAS contamination in the products or to manage/treat PFAS containing wastes?

- In plan
- Not planned
- Going to plan
- Other(Write):……

Thank you.

Annex 9: Datasheet for PCBs tracing, correcting, and reporting information on transformers.

Information and data on transformer			
Manufacturer		**Year of production**	
Serial number			
Power of transformer		**Type of cooling**	
Upper voltage		**Lower voltage**	
Total weight		**Liquid weight**	

Equipment conditions	Leakage	Corrosion

Observations	

Annex 10: Stakeholders feedback on capacity building needs

1. Projects/Activities		
SN	**Name of Institution**	**Presence of Projects implemented on sound chemicals and hazardous waste management**
1	Akagera business group and akagera motor	YES
2	Ritco Ltd	NO
3	ATMG Garage	NO
4	BMC clinic	NO
5	Nyarugenge District Hospital	YES
6	AMEKI COLOR LTD	NO
7	Dream Medical center hospital	NO
8	King Faisal hospital	YES
9	Baho International Hospital	YES
10	AFRICA LUBRICANT MANUFACTURING COMPANY LIMITED	YES
11	Crown Paints R Ltd	NO
12	Mediasol pharmaceutical depot ltd	NO
13	BUFMAR	NO
14	Agruni Ltd company	YES
15	Kagarama secondary school	NO
16	Rwanda Meteorological Agency	YES
17	Kabuye Sugar Work Ltd	NO
18	V-PLUS PACKAGING INDUSTRIES LIMITED	NO
19	VIVA PRODUCTS LTD	NO
20	Groupe scolaire st Joseph kabgayi	NO
21	G.S.KABGAYI A	NO
22	Petit seminaire saint Léon kabgayi	NO
23	GS.Gitarama	NO
24	Depot pharmaceutique Kalisimbi Ltd	YES
25	G.s Gishari	NO
26	GSNDL Byimana	NO
27	Mukingi Secondary school	NO
28	Ecole des Sciences Byimana	NO
29	Ruhengeri L2TH	NO
30	Kabgayi hospital	YES
31	CHUK	YES
32	KIGOMA SECONDARY SCHOOL (E.S.KIGOMA)	NO
33	Nyagatare district hospital	YES
34	GS Kigarama	NO
35	ES APAKAPE	NO
36	Es Murunda	NO
37	ALFA HOLDINGS LTD	YES
38	Gisenyi hospital	YES
39	E.S MUSAMBIRA	NO
40	GIHEMBE SECONDARY SCHOOL	NO

2. Implementation Capacity and Needs				
SN	**Name of Institution**	**Staff are involved in Chemicals and hazardous waste management**	**Additional human resource need**	**Additional equipment for Chemicals and hazardous waste management need**
1	Akagera business group and akagera motor	YES	NO	NO
2	Ritco Ltd	YES	NO	NO
3	ATMG Garage	YES	NO	NO
4	BMC clinic	NO	NO	NO
5	Nyarugenge District Hospital	YES	YES	YES
6	AMEKI COLOR LTD	NO	YES	YES
7	Dream Medical center hospital	YES	NO	NO
8	King Faisal hospital	YES	NO	NO
9	Baho International Hospital	YES	YES	YES
10	AFRICA LUBRICANT MANUFACTURING COMPANY LIMITED	YES	NO	NO
11	Crown Paints R Ltd	YES	NO	NO
12	Mediasol pharmaceutical depot ltd	YES	NO	NO
13	BUFMAR	YES	NO	NO
14	Agruni Ltd company	YES	YES	YES
15	Kagarama secondary school	YES	NO	NO
16	Rwanda Meteorological Agency	YES	NO	YES
17	Kabuye Sugar Work Ltd	YES	NO	NO
18	V-PLUS PACKAGING INDUSTRIES LIMITED	NO	NO	NO
19	VIVA PRODUCTS LTD	NO	NO	NO
20	Groupe scolaire st Joseph kabgayi	YES	NO	NO
21	G.S.KABGAYI A	YES	NO	YES
22	Petit seminaire saint Léon kabgayi	YES	NO	YES
23	GS.Gitarama	YES	NO	YES
24	Depot pharmaceutique Kalisimbi Ltd	YES	YES	YES
25	G.s Gishari	YES	YES	YES
26	GSNDL Byimana	YES	NO	YES
27	Mukingi Secondary school	YES	YES	YES
28	Ecole des Sciences Byimana	YES	YES	YES
29	Ruhengeri L2TH	YES	YES	YES
30	Kabgayi hospital	YES	YES	YES
31	CHUK	YES	NO	YES
32	KIGOMA SECONDARY SCHOOL (E.S.KIGOMA)	YES	NO	NO
33	Nyagatare district hospital	YES	YES	YES
34	GS Kigarama	YES	NO	YES
35	ES APAKAPE	YES	NO	YES
36	Es Murunda	YES	NO	YES
37	ALFA HOLDINGS LTD	YES	NO	NO
38	Gisenyi hospital	YES	YES	YES
39	E.S MUSAMBIRA	YES	YES	YES
40	GIHEMBE SECONDARY SCHOOL	YES	YES	YES

3. Training			
SN	**Name of Institution**	**Staff trained on Chemicals and hazardous waste management**	**Training need for effective perform sound chemicals and hazardous waste management**
1	Akagera business group and akagera motor	YES	NO
2	Ritco Ltd	NO	YES
3	ATMG Garage	YES	YES
4	BMC clinic	NO	NO
5	Nyarugenge District Hospital	YES	YES
6	AMEKI COLOR LTD	YES	YES
7	Dream Medical center hospital	YES	YES
8	King Faisal hospital	YES	NO
9	Baho International Hospital	YES	YES
10	AFRICA LUBRICANT MANUFACTURING COMPANY LIMITED	YES	YES
11	Crown Paints R Ltd	YES	NO
12	Mediasol pharmaceutical depot ltd	NO	NO
13	BUFMAR	NO	NO
14	Agruni Ltd company	YES	YES
15	Kagarama secondary school	NO	YES
16	Rwanda Meteorological Agency	NO	YES
17	Kabuye Sugar Work Ltd	YES	YES
18	V-PLUS PACKAGING INDUSTRIES LIMITED	NO	NO
19	VIVA PRODUCTS LTD	NO	NO
20	Groupe scolaire st Joseph kabgayi	NO	YES
21	G.S.KABGAYI A	NO	YES
22	Petit seminaire saint Léon kabgayi	NO	YES
23	GS.Gitarama	NO	NO
24	Depot pharmaceutique Kalisimbi Ltd	YES	YES
25	G.s Gishari	NO	YES
26	GSNDL Byimana	NO	YES
27	Mukingi Secondary school	NO	NO
28	Ecole des Sciences Byimana	NO	YES
29	Ruhengeri L2TH	YES	YES
30	Kabgayi hospital	YES	YES
31	CHUK	YES	YES
32	KIGOMA SECONDARY SCHOOL (E.S.KIGOMA)	NO	YES
33	Nyagatare district hospital	YES	YES
34	GS Kigarama	NO	YES
35	ES APAKAPE	NO	YES
36	Es Murunda	NO	YES
37	ALFA HOLDINGS LTD	YES	NO
38	Gisenyi hospital	YES	YES
39	E.S MUSAMBIRA	NO	YES
40	GIHEMBE SECONDARY SCHOOL	NO	YES

4. Information and Networking				
SN	**Name of Institution**	**Partnerships in sound chemicals and hazardous waste management exist**	**Participation in any knowledge sharing platforms**	**Need for the Government to facilitate in sound chemical and hazardous waste management**
1	Akagera business group and akagera motor	YES	NO	YES
2	Ritco Ltd	NO	NO	YES
3	ATMG Garage	NO	NO	YES
4	BMC clinic	YES	NO	NO
5	Nyarugenge District Hospital	YES	YES	YES
6	AMEKI COLOR LTD	NO	NO	NO
7	Dream Medical center hospital	YES	NO	YES
8	King Faisal hospital	YES	YES	YES
9	Baho International Hospital	NO	YES	YES
10	AFRICA LUBRICANT MANUFACTURING COMPANY LIMITED	YES	NO	YES
11	Crown Paints R Ltd	YES	NO	NO
12	Mediasol pharmaceutical depot ltd	YES	NO	NO
13	BUFMAR	NO	NO	YES
14	Agruni Ltd company	YES	YES	YES
15	Kagarama secondary school	NO	NO	YES
16	Rwanda Meteorological Agency	NO	YES	YES
17	Kabuye Sugar Work Ltd	NO	YES	YES
18	V-PLUS PACKAGING INDUSTRIES LIMITED	NO	NO	NO
19	VIVA PRODUCTS LTD	NO	NO	NO
20	Groupe scolaire st Joseph kabgayi	YES	NO	YES
21	G.S.KABGAYI A	NO	NO	YES
22	Petit seminaire saint Léon kabgayi	YES	NO	YES
23	GS.Gitarama	NO	NO	YES
24	Depot pharmaceutique Kalisimbi Ltd	YES	YES	YES
25	G.s Gishari	NO	NO	YES
26	GSNDL Byimana	NO	NO	YES
27	Mukingi Secondary school	NO	NO	YES
28	Ecole des Sciences Byimana	NO	NO	YES
29	Ruhengeri L2TH	NO	NO	YES
30	Kabgayi hospital	NO	NO	YES
31	CHUK	NO	YES	YES
32	KIGOMA SECONDARY SCHOOL (E.S.KIGOMA)	NO	NO	YES
33	Nyagatare district hospital	NO	NO	YES
34	GS Kigarama	NO	NO	YES
35	ES APAKAPE	NO	NO	YES
36	Es Murunda	NO	NO	YES
37	ALFA HOLDINGS LTD	NO	NO	YES
38	Gisenyi hospital	YES	NO	YES
39	E.S MUSAMBIRA	NO	NO	YES
40	GIHEMBE SECONDARY SCHOOL	NO	NO	YES

5. Financing sound chemicals and hazardous waste management			
SN	**Name of Institution**	**Chemicals and hazardous waste management is considered in the budget**	**The percentage of the budget is from Government/development partners and private sector**
1	Akagera business group and akagera motor	NO	NO
2	Ritco Ltd	NO	NO
3	ATMG Garage	YES	NO
4	BMC clinic	YES	NO
5	Nyarugenge District Hospital	YES	YES
6	AMEKI COLOR LTD	NO	NO
7	Dream Medical center hospital	YES	NO
8	King Faisal hospital	YES	NO
9	Baho International Hospital	YES	NO
10	AFRICA LUBRICANT MANUFACTURING COMPANY LIMITED	NO	NO
11	Crown Paints R Ltd	YES	NO
12	Mediasol pharmaceutical depot ltd	YES	NO
13	BUFMAR	YES	NO
14	Agruni Ltd company	YES	NO
15	Kagarama secondary school	NO	NO
16	Rwanda Meteorological Agency	YES	NO
17	Kabuye Sugar Work Ltd	YES	NO
18	V-PLUS PACKAGING INDUSTRIES LIMITED	YES	NO
19	VIVA PRODUCTS LTD	NO	NO
20	Groupe scolaire st Joseph kabgayi	NO	NO
21	G.S.KABGAYI A	NO	NO
22	Petit seminaire saint Léon kabgayi	YES	NO
23	GS.Gitarama	YES	NO
24	Depot pharmaceutique Kalisimbi Ltd	YES	NO
25	G.s Gishari	NO	NO
26	GSNDL Byimana	NO	NO
27	Mukingi Secondary school	NO	NO
28	Ecole des Sciences Byimana	NO	NO
29	Ruhengeri L2TH	YES	NO
30	Kabgayi hospital	YES	NO
31	CHUK	YES	NO
32	KIGOMA SECONDARY SCHOOL (E.S.KIGOMA)	NO	NO
33	Nyagatare district hospital	YES	NO
34	GS Kigarama	NO	NO
35	ES APAKAPE	NO	NO
36	Es Murunda	NO	NO
37	ALFA HOLDINGS LTD	YES	NO
38	Gisenyi hospital	YES	YES
39	E.S MUSAMBIRA	NO	NO
40	GIHEMBE SECONDARY SCHOOL	NO	NO

6. Mainstreaming				
SN	**Name of Institution**	**chemicals and hazardous waste management contained in institution's policy / manuals / Guidelines**	**Familiarity with International Conventions related to chemicals and hazardous waste to which Rwanda has ratified**	**Existence of any activities being implemented in the institution under any of those conventions.**
1	Akagera business group and akagera motor	YES	NO	NO
2	Ritco Ltd	NO	NO	NO
3	ATMG Garage	NO	NO	NO
4	BMC clinic	YES	NO	NO
5	Nyarugenge District Hospital	YES	YES	YES
6	AMEKI COLOR LTD	NO	NO	NO
7	Dream Medical center hospital	YES	NO	NO
8	King Faisal hospital	YES	NO	NO
9	Baho International Hospital	YES	NO	YES
10	AFRICA LUBRICANT MANUFACTURING COMPANY LIMITED	YES	NO	NO
11	Crown Paints R Ltd	YES	NO	NO
12	Mediasol pharmaceutical depot ltd	YES	NO	NO
13	BUFMAR	YES	NO	NO
14	Agruni Ltd company	YES	NO	NO
15	Kagarama secondary school	NO	NO	NO
16	Rwanda Meteorological Agency	YES	YES	YES
17	Kabuye Sugar Work Ltd	NO	NO	NO
18	V-PLUS PACKAGING INDUSTRIES LIMITED	NO	YES	YES
19	VIVA PRODUCTS LTD	NO	NO	NO
20	Groupe scolaire st Joseph kabgayi	NO	NO	NO
21	G.S.KABGAYI A	NO	NO	NO
22	Petit seminaire saint Léon kabgayi	NO	NO	NO
23	GS.Gitarama	NO	NO	NO
24	Depot pharmaceutique Kalisimbi Ltd	YES	YES	YES
25	G.s Gishari	YES	NO	NO
26	GSNDL Byimana	NO	NO	NO
27	Mukingi Secondary school	NO	NO	NO
28	Ecole des Sciences Byimana	NO	NO	NO
29	Ruhengeri L2TH	NO	YES	NO
30	Kabgayi hospital	YES	YES	YES
31	CHUK	YES	YES	YES
32	KIGOMA SECONDARY SCHOOL (E.S.KIGOMA)	NO	NO	NO
33	Nyagatare district hospital	YES	YES	YES
34	GS Kigarama	NO	NO	NO
35	ES APAKAPE	NO	NO	NO
36	Es Murunda	NO	NO	NO
37	ALFA HOLDINGS LTD	YES	YES	YES
38	Gisenyi hospital	YES	NO	NO
39	E.S MUSAMBIRA	NO	NO	NO
40	GIHEMBE SECONDARY SCHOOL	NO	NO	NO

7. Interim storage management					
SN	**Name of Institution**	**Existence of any facility to store hazardous and/or chemical waste**	**Existence of any plan for relocation of the stored wastes**	**The source of hazardous wastes still exists**	**Existence of future plans in regard to chemicals and hazardous waste management**
1	Akagera business group and akagera motor	YES	NO	YES	YES
2	Ritco Ltd	YES	NO	YES	YES
3	ATMG Garage	YES	NO	YES	NO
4	BMC clinic	YES	YES	YES	YES
5	Nyarugenge District Hospital	YES	NO	YES	YES
6	AMEKI COLOR LTD	NO	NO	NO	NO
7	Dream Medical center hospital	YES	NO	YES	YES
8	King Faisal hospital	YES	NO	YES	YES
9	Baho International Hospital	YES	YES	YES	YES
10	AFRICA LUBRICANT MANUFACTURING COMPANY LIMITED	YES	YES	YES	YES
11	Crown Paints R Ltd	YES	NO	YES	NO
12	Mediasol pharmaceutical depot ltd	YES	YES	YES	YES
13	BUFMAR	YES	YES	YES	YES
14	Agruni Ltd company	YES	NO	YES	YES
15	Kagarama secondary school	YES	NO	YES	NO
16	Rwanda Meteorological Agency	YES	YES	YES	YES
17	Kabuye Sugar Work Ltd	YES	NO	YES	NO
18	V-PLUS PACKAGING INDUSTRIES LIMITED	YES	YES	NO	NO
19	VIVA PRODUCTS LTD	NO	NO	NO	NO
20	Groupe scolaire st Joseph kabgayi	YES	NO	YES	YES
21	G.S.KABGAYI A	NO	NO	YES	YES
22	Petit seminaire saint Léon kabgayi	NO	NO	YES	YES
23	GS.Gitarama	NO	NO	YES	NO
24	Depot pharmaceutique Kalisimbi Ltd	YES	NO	YES	YES
25	G.s Gishari	NO	NO	YES	YES
26	GSNDL Byimana	NO	NO	YES	NO
27	Mukingi Secondary school	NO	NO	YES	YES
28	Ecole des Sciences Byimana	NO	NO	YES	YES
29	Ruhengeri L2TH	NO	YES	YES	YES
30	Kabgayi hospital	YES	YES	YES	YES
31	CHUK	YES	YES	YES	YES
32	KIGOMA SECONDARY SCHOOL (E.S.KIGOMA)	NO	NO	YES	NO
33	Nyagatare district hospital	NO	NO	NO	YES
34	GS Kigarama	NO	NO	YES	NO

35	ES APAKAPE	NO	NO	YES	NO
36	Es Murunda	YES	NO	YES	NO
37	ALFA HOLDINGS LTD	YES	NO	YES	YES
38	Gisenyi hospital	NO	NO	YES	YES
39	E.S MUSAMBIRA	NO	NO	YES	YES
40	GIHEMBE SECONDARY SCHOOL	NO	NO	YES	YES

Annex 11: Quantity of expired chemicals at different secondary schools in Rwanda

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District	Weight of expired chemicals and contaminated materials by District
						Kg	Kg
Ruhango	E.SC.Byimana	-2.145960277	29.74364152	61.375	245.5	265.146	1060.584
	G.S Bukomero	-2.14641132	29.74241362	2.45	9.8		
	E.S Mukingi	-2.1555078	29.742775	6	24		
	E S KIGOMA	-2.258988	29.7942916	2.87	11.48		
	GSNDL Byimana	-2.151717483	29.73467246	26.675	106.7		
	G.S GIHEMBE	-2.025221	29.8489826	38.92	155.68		
	MARIST BROTHERS	-2.58850846	29.75600803	52.8775	211.51		
	ISHURI RYISUMBUYE RYA RUHANGO	-2.224698466	29.79333997	73.9785	295.914		
Muhanga	G. S. GITARAMA	-2.0822235	29.7565447	96.12981	384.51924	282.07281	1128.29124
	PETIT SEMINAIRE SAINT LEON KABGAYI	-2.097268189	29.75461621	144.8	579.2		
	Groupe scolaire saint Joseph Kabgayi	-2.099105455	29.75292176	8.642	34.568		
	ECOLE SCIENTIFIQUE DES FILLES	-2.075420995	29.74830702	32.501	130.004		
Nyamagabe	G.S Mushubi	-2.348499227	29.44869969	5.036	20.144	306.69	1226.76
	G.S. MV Kibeho	-2.646299795	29.5546411	145.5	582		
	G.S.N.D. Kibeho	-2.647859075	29.55279489	61.085	244.34		
	ES MUDASOMWA	-2.514221882	29.4816147	8.125	32.5		
	ES KADUHA	-2.335488793	29.52130496	59.5	238		
	E.S.MUSHUBI	-2.348518131	29.44871677	3.944	15.776		
	Ecole des Sciences NYAMAGABE	-2.060907206	29.40596324	23.5	94		

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District Kg	Weight of expired chemicals and contaminated materials by District Kg
Nyaruguru	NYAMYUMBA SECONDARY SCHOOL	-2.585469673	29.56098897	1.1	4.4	10.1	40.4
	G S M M KIBEHO	-2.646150018	29.55465803	9	36		
Kamonyi	G.S Gihembe	-2.006675646	29.85486172	11.5	46	131.285	525.14
	G.S Ruyumba	-2.07292496	29.90890108	8	32		
	G.S Kamonyi			8	32		
	K.S St Albert Nyarubaka	-2.096642909	29.84211904	2	8		
	Ecole Secondaire Rutobwe			35.725	142.9		
	G.S Masaka	-2.014182712	29.97620902	36.1	144.4		
	G.S Ngamba	-1.877555755	29.89352359	24.5	98		
	E S MUSAMBIRA	-2.047827912	29.84346852	0.06	0.24		
	G S RUYUMBATSS			5.4	21.6		
Gisagara	G.S Kanogo	-1.899246603	29.62271394	20.895	83.58	115.515	462.06
	COLLEGE IMMACULEE CONCEPTIONM/SAVE	-2.545689586	29.77335981	25.5	102		
	E.S MAGI			5	20		
	ES KANSI	-2.685278505	29.77147973	8.4	33.6		
	E.S MAMBA	-2.474171879	29.91466514	30	120		
	ES .HIGIRO	-2.768225624	29.73054299	1.5	6		
	GROUPE SCOLAIRE DE St BERNADETTE DE SAVE	-2.541094568	29.77132954	5.165	20.66		
	Collège Saint Bernard Kansi	-2.702030034	29.7487216	19.055	76.22		
Huye	G.S Gatagara	-1.648643159	29.54013008	808.525	3234.1	1123.54	4494.16

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District Kg	Weight of expired chemicals and contaminated materials by District Kg
	INDATWA N'INKESHA SCHOOL G.S.O.B	-2.606955159	29.74476127	121.44	485.76		
	ENDP Karubanda	-2.592846751	29.74159607	59	236		
	SAINT MARY'S HIGH SCHOOL KIRUHURA	-2.458407916	29.75663665	11.025	44.1		
	PETIT SEMINAIRE 'VIRGO FIDELIS" DE BUTARE	-2.592976886	29.73321433	123.55	494.2		
Burera	E.S Kagogo	-1.753610946	30.2520393	119.045	476.18	405.08258	1620.33032
	G.S GAHUNGA	-1.4501537	29.6791417	49.238	196.952		
	E.S Kirambo	-1.496800477	29.83487057	97.0145	388.058		
	G.S APEDUC BUNGWE	-1.505102708	29.97262022	73.09608	292.38432		
	EEAR ES Kidaho	-1.378681732	29.74433793	49.5	198		
	G.S SAINT NICOLAS CYANIKA	-2.440190197	29.60291112	17.189	68.756		
Gicumbi	G.S Giti	-1.765895035	30.22938583	6.5	26	112.578	450.312
	G.S Shangasha	-1.52915763	30.07062896	5.5	22		
	G.S Miyove	-1.609187466	29.97249332	39.8	159.2		
	G.S Kagorogoro	-1.523794944	29.98682888	16.5	66		
	E.S Bwisige	-1.580132602	30.15467791	0.689	2.756		
	MARYHILL GIRLS'SECONDARY SCHOOL	-1.311139064	30.31754476	23.089	92.356		
	GSNDBC Byumba	-1.570689707	30.04811062	20.5	82		
Nyagatare	G.S Cyabayaga	-1.445095179	30.26144883	11.1	44.4	141.623	566.492
	G.S Tabagwe	-1.285072177	30.20782186	15.05	60.2		

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District Kg	Weight of expired chemicals and contaminated materials by District Kg
	Sect.Katabagemu (stock at sector)	-1.473754538	30.27667864	4.8	19.2		
	G.S Rurenge	-1.335286078	30.2732511	8	32		
	G.S Rwebare	-1.395899174	30.20903221	1	4		
	G.S Kabare II	-1.435043157	30.13651939	0	0		
	E.S Rukomo SOPEM	-1.379063673	30.24455026	16	64		
	Nyagatare Secondary School	-1.271209723	30.34244126	22.96	91.84		
	G.S Gikagati	-1.379629855	30.18148851	4.5	18		
	G.S GISHORORO	-1.445363259	30.19873614	19.313	77.252		
	GS NYAKIGANDO/TSS	-1.440801677	30.33607098	1.9	7.6		
	GS KIGEME A	-2.480944185	29.52812962	37	148		
Karongi	G.S St Joseph Birambo	-2.145625249	29.52072284	47.16	188.64	291.266	1165.064
	E.S Kirimbi	-2.25657254	29.22429024	0	0		
	G.S Vumbi	-1.867127805	29.30212633	31.5	126		
	ES Mabaza			45.6	182.4		
	G.S Bisesero	-2.165057839	29.33244398	0.056	0.224		
	E.S Ruganda	-2.220379835	29.49144645	0	0		
	College Saint Marie Kibuye	-2.061521836	29.34879296	157.65	630.6		
	ES KIRINDA	-2.18417197	29.57899153	5.3	21.2		
	G.S NGOMA	-2.093522428	29.57295528	4	16		
Rutsiro	G.S Bitenga B	-1.834843759	29.40647278	35.25	141	134.212	536.848
	E.S Nyabirasi	-1.763346809	29.34877737	7	28		
	G.S Kigarama	-1.9043493	29.3077843	25.5	102		

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District Kg	Weight of expired chemicals and contaminated materials by District Kg
	E.S APAKAPE	-1.8798248	29.3485433	53.85	215.4		
	E.S St Jean de Murunda	-1.907781691	29.37413448	8.112	32.448		
	G.S MVUBI	-1.866917514	29.30229516	4.5	18		
Kirehe	ES Nyarubuye	-1.616338641	30.39423873	0.34	1.36	20.547	82.188
	ES RUSUMO	-2.275147458	30.66799496	20.207	80.828		
Ngoma	G.S Kanazi	-2.208463221	30.4088115	3	12	93	372
	E.S Rukoma	-2.200462992	30.38094751	33	132		
	ES Sake	-2.222867771	30.38859881	28.5	114		
	G.S Kansana	-2.15514793	30.49601222	0.35	1.4		
	PETIT SEMINAIRE SAINT KIZITO-ZAZA	-2.149483072	30.43350339	4	16		
	E.S RURAMA	-2.190031753	30.59094705	4	16		
	G.S GAHIMA/TSS	-2.139308609	30.57504659	0.45	1.8		
	G.S. KABARE	-2.129935937	30.54800356	19.7	78.8		
Bugesera	Gashora Girls School	-2.222353003	30.23815914	7	28	93.35	373.4
	G.S Rilima	-2.159619763	30.23163465	31.85	127.4		
	G.S. RANGO	-2.296843387	30.04431381	54.5	218		
Gakenke	G.S CIM Rwankuba	-1.757611917	29.86561577	34.846	139.384	350.988	1403.952
	E.S Nemba/APRODESEC	-1.638223742	29.78898901	52.45	209.8		
	APEM	-1.541185927	30.2402498	43.6	174.4		
	E.S Nyarutovu	-1.631137906	29.79143001	30.5	122		
	G.S Rukura	-1.687383398	29.81916161	28.202	112.808		

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District Kg	Weight of expired chemicals and contaminated materials by District Kg
	G.S Nemba I			11	44		
	G.S ST JEROME JANJA	-1.679400429	29.67751708	99.088	396.352		
	ESP RULI	-1.828814634	29.84944769	21.29	85.16		
	G.S RUBAGA			4.33	17.32		
	GS KAGEYO	-1.605312662	30.0837847	17.182	68.728		
	GS KIREBE	-1.637566729	29.81841255	8.5	34		
Musanze	E.Sc Musanze	-1.501999904	29.61291886	41.55	166.2	165.875	663.5
	ESSA	-1.508460547	29.63601454	49.5	198		
	E.S St Vincent Muhoza	-1.502340184	29.63988993	21.5	86		
	E.S. Musanze	-1.500112773	29.61244978	31.2	124.8		
	GS MUHOZA II	-1.505764923	29.64514065	18.5	74		
	GSNDA-RWAZA	-1.542904998	29.69900368	3.175	12.7		
	G.S GAHIMA/TSS	-2.139122458	30.57494913	0.45	1.8		
	G S KAMPANGA	-1.447500454	29.57628954	6.85	27.4		
Rusizi	G.S Gihundwe	-2.495534659	28.91726245	79.305	317.22	423.936	1695.744
	G.S Nyabitimbo	-2.568838628	29.07214252	2	8		
	G.S Mako	-2.698509002	29.01017486	2	8		
	E.S Bugarama	-2.69532111	29.01144994	61.265	245.06		
	G.S Giheke	-2.472725109	28.97715916	71.602	286.408		
	Sainte Marie Reine Mubirizi	-2.081193846	29.75818029	52.875	211.5		
	ES BUGARAMA	-2.611719593	29.01718058	45.05	180.2		
	G.S. SAINT PIERRE NKOMBO	-2.405555634	28.90025586	55.069	220.276		

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District Kg	Weight of expired chemicals and contaminated materials by District Kg
	GS BUHOKORO			40.52	162.08		
	E.S GISHOMA	-2.632042439	28.94469469	14.25	57		
Rulindo	E.S Stella Matutina	-1.863814053	29.97956897	62.1	248.4	245.976	983.904
	E.S Nyamugari	-1.545466998	30.16018166	111.844	447.376		
	G.s Murama	-1.630542738	30.03380407	4	16		
	E.S Kiyanza	-1.75991013	30.06525023	16.278	65.112		
	G.S. Runyombyi I			12.877	51.508		
	G.S. Kiruli			12.877	51.508		
	LNDV Rulindo	-1.722295288	29.92421528	17.1	68.4		
	G.S.APAPEC MURAMBI	-1.792885821	30.04024722	4.5	18		
	G.S. Runyombyi			4.4	17.6		
Kicukiro	G.S Maraka			4	16	346.82	1387.28
	G.S Remera Protestant	-1.96191275	30.11922038	12.6	50.4		
	G.S St Vincent Pallotti	-1.979381782	30.07787809	1.365	5.46		
	King David Academy	-1.968245156	30.16080737	0	0		
	G.S Busanza	-1.986914609	30.14884381	0	0		
	GLORY ACADEMY	-2.011415921	30.0905666	55.4	221.6		
	KAGARAMA Secondary School	-1.99276328	30.097214	101.605	406.42		
	G.S KAREMBURE	-2.022014253	30.08601225	117	468		
	G.S CAMP KANOMBE	-1.977299231	30.17128242	7	28		
Gasabo	P.S Ndera	-1.950451781	30.17204448	15.5	62	47.85	191.4
	Riviera High School	-1.977185529	30.2097195	23.6	94.4		

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District	Weight of expired chemicals and contaminated materials by District
						Kg	Kg
	SINAI HILL ACADEMY	-1.96762202	30.17727353	4	16		
	E.S BUMBOGO	-1.88308304	30.1519721	4.75	19		
Gatsibo	G.S Muhura	-1.740492007	30.27187141	62.35	249.4	74.45	297.8
	G.S Bushyanguhe	-1.542776898	30.27078624	7.6	30.4		
	Kiziguro High School	-1.769868593	30.38325406	0	0		
	G.S Nyamirama	-1.636389891	30.33983947	0	0		
	Gasange	-1.805245777	30.29565216	4.5	18		
Nyamasheke	GSFA Kibogora	-2.321461507	29.18558167	20.7	82.8	168.56	674.24
	ES.S.S.F Shangi	-2.412983749	29.00773191	39.23	156.92		
	G.S Ruheru A	-2.749098706	29.4694587	16.32	65.28		
	G.S. Bushenge	-2.392258722	29.18435558	14.5	58		
	ISF Nyamasheke	-2.338340405	29.13275248	8.17	32.68		
	College officiel de Mburabuturo	-2.293492453	29.25876424	32	128		
	G.S. ST Joseph Nyamasheke	-2.335848272	29.09220376	10.5	42		
	Ecole Secondary de Gafunzo	-2.39909976	29.00800742	9.935	39.74		
	GS UMUCYO KARENGERA	-2.253426027	29.22479564	12.5	50		
	G.S Saint Paul Tyazo	-2.321356484	29.18558666	4.705	18.82		
Rwamagana	G.S Rwamagana protestant	-1.953506745	30.43868446	17.07	68.28	296.98351	1187.93404
	GS RWAMAGANA A	-1.949002838	30.42753391	4.02	16.08		
	GS KABARE	-1.887941499	30.45145314	2.9	11.6		
	GS GISHARI	-1.914067152	30.42411795	0.3	1.2		
	GS Karenge	-2.080438778	30.3099157	25.2	100.8		
	G S.St ALOYS	-1.949961081	30.42550445	25.5	102		

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District	Weight of expired chemicals and contaminated materials by District
						Kg	Kg
	LYCEE NOTRE DAME DE CITEAUX	-1.952628725	30.05923595	21.29	85.16		
	LIQUIDNET FAMILY HIGH SCHOOL	-2.028503605	30.37868238	55.1	220.4		
	GROUPE SCOLAIRE APAGIE MUSHA	-1.929240908	30.3313636	145.60351	582.41404		
Nyarugenge	COLLEGE SAINT-ANDRE	-1.977761334	30.05308942	70.5	282	120.6	482.4
	LYCEE DE KIGALI	-1.962186982	30.06903504	9	36		
	ESS HAMDAN B R KIMISANGE	-1.993824714	30.05482886	0	0		
	GROUPE SCOLAIRE APE RUGUNGA	-1.95689659	30.07090892	41.1	164.4		
Rubavu	Petit Seminaire Nyundo	-1.7044892	29.3308439	0	0	94.805	379.22
	GSNDA_Nyundo	-1.705379	29.3287884	61.4	245.6		
	College inyemeramihigo de Gisenyi	-1.6876565	29.2860209	14.61	58.44		
	GROUPE SCOLAIRE KANAMA CATHOLIQUE	-1.700270361	29.34894413	18.795	75.18		
KAYONZA	GS RWISIRABO	-1.404206376	30.39761945	7	28	556.72851	2226.91404
	NEW LIFE CHRISTIAN ACADEMY	-1.899396987	30.50483312	20.5	82		
	ES KAYONZA MODERN	-1.931690676	30.50233729	515.59851	2062.39404		
	FAWE GIRLS SCHOOL GAHINI	-1.860401064	30.49876492	13.63	54.52		
NYANZA	GS NYAGASOZI	-1.704456555	30.33216573	9	36	220.9145	883.658
	IGIHOZO SAINT PETER SECONDARY SCHOOL	-2.351426446	29.74858283	21.932	87.728		
	E.S. St Esprit de Nyanza	-2.348811275	29.74998196	65.5025	262.01		
	G.S. MUTUTU	-2.337342408	29.93390796	5	20		
	GS RWABICUMA	-2.350370957	29.74562249	3.9	15.6		
	E.A.V MAYAGA	-2.33911397	29.87638708	9.75	39		
	G.S MATER DEI-NYANZA	-2.347980901	29.74975669	15.75	63		

District	School	Latitude	Longitude	Weight of expired chemicals in Kg	Weight of expired chemicals and contaminated materials in Kg	Weight of expired chemicals by District Kg	Weight of expired chemicals and contaminated materials by District Kg
	St LOUIS DE MONTFORT NYANZA	-2.350795309	29.74909142	90.08	360.32		
NYABIHU	COLLEGE ADVENTISTE DE RWANKERI	-1.586804085	29.53314427	24.8515	99.406	126.4215	505.686
	G S RAMBURA	-1.682282387	29.52577967	19.25	77		
	GS RAMBURA FILLES	-1.678891988	29.52022131	8.62	34.48		
	G.S SHYIRA	-1.686516046	29.62893862	73.7	294.8		
Ngororero	CIC MURAMBA	-1.763928637	29.61658825	15.95	63.8	19.45	77.8
	G.S KINANIRA	-1.760884705	29.58478365	3.5	14		
				6.745,37	26.981.461,64	6.745,37	26.981.461,64

Annex 12: General requirements for all classes of landfills[96]

1. Location

1.1. The location of a landfill must take into consideration requirements relating to:

(a) the distances from the boundary of the site to residential and recreation areas, waterways, water bodies and other agricultural or urban sites;

(b) the existence of groundwater, coastal water, or nature protection zones in the area;

(c) the geological and hydrogeological conditions in the area;

(d) the risk of flooding, subsidence, landslides, or avalanches on the site;

(e) the protection of the nature or cultural patrimony in the area.

1.2. The landfill can be authorized only if the characteristics of the site with respect to the abovementioned requirements, or the corrective measures to be taken, indicate that the landfill does not pose a serious environmental risk.

2. Water control and leachate management

Appropriate measures shall be taken, with respect to the characteristics of the landfill and the meteorological conditions, in order to:

- control water from precipitations entering into the landfill body,
- prevent surface water and/or groundwater from entering into the landfilled waste,
- collect contaminated water and leachate. If an assessment based on consideration of the location of the landfill and the waste to be accepted shows that the landfill poses no potential hazard to the environment, the competent authority may decide that this provision does not apply,
- treat contaminated water and leachate collected from the landfill to the appropriate standard required for their discharge.

The above provisions may not apply to landfills for inert waste.

[96] The European Directive 1999/31/EC on landfill of waste.

3. Protection of soil and water

3.1. A landfill must be situated and designed so as to meet the necessary conditions for preventing pollution of the soil, groundwater or surface water and ensuring efficient collection of leachates as and when required according to Section 2. Protection of soil, groundwater and surface water is to be achieved by the combination of a geological barrier and a bottom liner during the operational/active phase and by the combination of a geological barrier and a bottom liner during the operational/active phase and by the combination of a geological barrier and a top liner during the passive phase/post closure.

3.2. The geological barrier is determined by geological and hydrogeological conditions below and in the vicinity of a landfill site providing sufficient attenuation capacity to prevent a potential risk to soil and groundwater.

The landfill base and sides shall consist of a mineral layer which satisfies permeability and thickness requirements with a combined effect in terms of protection of soil, groundwater, and surface water at least equivalent to the one resulting from the following requirements:

- landfill for hazardous waste: $K \leq 1.0 \times 10^{-9}$ m/s; thickness ≥ 5 m,
- landfill for non-hazardous waste: $K \leq 1.0 \times 10^{-9}$ m/s; thickness ≥ 1 m,
- landfill for inert waste: $K \leq 1.0 \times 10^{-7}$ m/s; thickness ≥ 1 m, m/s: meter/second.

Where the geological barrier does not naturally meet the above conditions, it can be completed artificially and reinforced by other means giving equivalent protection. An artificially established geological barrier should be no less than 0.5 meters thick.

3.3. In addition to the geological barrier described above a leachate collection and sealing system must be added in accordance with the following principles so as to ensure that leachate accumulation at the base of the landfill is kept to a minimum:

Leachate collection and bottom sealing

Landfill category	nonhazardous	hazardous
Artificial sealing liner	required	required
Drainage layer ≥ 0,5 m	required	required

Member States may set general or specific requirements for inert waste landfills and for the characteristics of the abovementioned technical means.

If the competent authority, after consideration of the potential hazards to the environment finds that the prevention of leachate formation is necessary, a surface sealing may be prescribed. Recommendations for the surface sealing are as follows:

Landfill category	nonhazardous	hazardous
Gas drainage layer	required	not required
Artificial sealing liner	not required	required
Impermeable mineral layer	required	required
Drainage layer > 0,5 m	required	required
Topsoil cover > 1 m	required	required

3.4. If, on the basis of an assessment of environmental risks taking into account, in particular, Directive 80/68/EEC[97], the competent authority has decided, in accordance with Section 2 ('Water control and leachate management'), that collection and treatment of leachate is not necessary or it has been established that the landfill poses no potential hazard to soil, groundwater or surface water, the requirements in paragraphs 3.2 and 3.3 above may be reduced accordingly. In the case of landfills for inert waste these requirements may be adapted by national legislation.

4. Gas control

4.1. Appropriate measures shall be taken in order to control the accumulation and migration of landfill gas.

[97] OJ L 20, 26.1.1980, p. 43. Directive as last amended by Directive 91/692/EEC (OJ L 377, 31.12.1991, p. 48).

4.2. Landfill gas shall be collected from all landfills receiving biodegradable waste and the landfill gas must be treated and used. If the gas collected cannot be used to produce energy, it must be flared.

4.3. The collection, treatment, and use of landfill gas under paragraph 4.2 shall be carried out in a manner which minimizes damage to or deterioration of the environment and risk to human health.

5. Nuisances and hazards

Measures shall be taken to minimize nuisances and hazards arising from the landfill through:

- emissions of odors and dust,
- wind-blown materials,
- noise and traffic,
- birds, vermin, and insects,
- formation and aerosols,
- fires.

The landfill shall be equipped so that dirt originating from the site is not dispersed onto public roads and the surrounding land.

6. **Stability**

The emplacement of waste on the site shall take place in such a way as to ensure stability of the mass of waste and associated structures, particularly in respect of avoidance of slippages. Where an artificial barrier is established, it must be ascertained that the geological substratum, considering the morphology of the landfill, is sufficiently stable to prevent settlement that may cause damage to the barrier.

7. Barriers

The landfill shall be secured to prevent free access to the site. The gates shall be locked outside operating hours. The system of control and access to each facility should contain a programme of measures to detect and discourage illegal dumping in the facility.

8. Temporary storage of metallic mercury

For the purposes of temporary storage for more than 1 year of metallic mercury, the following requirements shall apply:

- Metallic mercury shall be stored separately from other waste.
- Containers shall be stored in collecting basins suitably coated so as to be free of cracks and gaps and impervious to metallic mercury with a containment volume adequate for the quantity of mercury stored.
- The storage site shall be provided with engineered or natural barriers that are adequate to protect the environment against mercury emissions and a containment volume adequate for the total quantity of mercury stored.
- The storage site floors shall be covered with mercury-resistant sealants.
- A slope with a collection sump shall be provided.
- The storage site shall be equipped with a fire protection system.
- Storage shall be arranged in a way to ensure that all containers are easily retrievable.

Annex 13: List of companies and factories consulted for chemical wastes generation

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
1	AQUASAN LTD	Gasabo, free zone	-	• No accumulated waste	• They recycle most of the waste generated during manufacturing	Recycling
2	Rwanda Plastic Industries	Kicukiro	-	• No accumulated waste	• They recycle most of the waste generated during manufacturing	Recycling
3	Bralirwa, Kigali	Kicukiro	• Laboratory chemical waste • Sludge, medical waste and waste from microbiology lab	• No accumulated waste	• They have contacted companies to handle those waste. •Ones are sent to be incinerated (medical waste and expired chemicals by COVINAGRI ltd and • Others are sent to landfill (sludge, unfit plastic	They have so called TPM (Total Productive Management), and ES (Environment Sustainability) programs used to monitor their activities so that waste generated

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
					bottles and rubbish) by UMURIMO MWIZA Ltd	can't exceed the critical limits settled.
4	INYANGE Industries Ltd	Gasabo	• Laboratory chemical waste • Cleaning chemicals used in wastewater treatment.	No accumulated waste	• They order the products to be used in their processes which they can consume so that no more waste can be generated except liquid waste.	They have a water treatment plan at their factory
5	Kabuye Sugar Work Ltd	Gasabo	• Laboratory chemical waste	• They can produce around 543.5 Kg of chemical wastes per year, but now, there is no accumulated waste.	-	• The chemical wastes are regularly collected by Depot pharmaceutique Kalisimbi for being disposed of.
6	Speranza Group Ltd	Gasabo, free zone	• Laboratory chemical waste	• They have around 10 tons in their interim	• By now no hazardous wastes are sent anywhere,	• The factory is storing these

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
			• Broken Glass bottles and unfit plastic bottles for drinking water	stored for Broken Glass bottles and unfit plastic bottles for drinking water	they're in storage waiting for RRA and REMA to take decision of their proper disposal.	hazardous wastes while waiting for proper disposal
7	SULFO Rwanda Ltd	Nyarugenge	• Chemical wastes/ Hazardous wastes	They can produce around 12000 kg per year of Hazardous and chemical wastes	They recycle most of the waste produced. The manufacturing processes do not generate waste. The wastes are from machine washing and plastic containers manufacturing.	They recycle most of the waste produced. The wastes from the machine-washing processes are brought to the wastewater treatment plant. The plastic wastes are recycled to manufacture the plastic containers.
8	Africa improved Foods	Gasabo, free zone	-	• No accumulated waste	-	-

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
9	Alfa Holdings Ltd	Gasabo, free zone	-	• No accumulated waste	-	
10	Crown Paints Rwanda Ltd	Gasabo, free zone	-	• No accumulated waste	• Garbage company they are taking all the produced wastes to the dump site	-
11	Mount Meru Soyco	Kayonza	• Solid waste(boxes) and ash	12000 Tons/year of Solid waste(boxes) and ash	• What has been observed is that all wastes are mixed, this is to say both hazardous and non-hazardous waste are mixed. • The major challenge that they have is that the existing garbage collector in Kayonza which is AGRUNI LTD is not enough for collecting all the	• For the liquid wastes, the factory has a water treatment plant.

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
					generated wastes from this factory effectively.	
12	AFRICA LUBRICANT MANUFACTURING COMPANY LIMITED	GASABO	• Laboratory chemical waste • Petroleum base oils from tank cleaning and from production line cleaning	• No accumulated waste	Waste is collected by authorized companies for recycling	Stored in drums and Pails before collection for disposal
13	VIVA PRODUCTS LTD	GASABO	-	• No accumulated waste	• They recycle most of the waste produced	• They recycle most of the waste produced
14	AMEKI COLOR LTD	Gasabo	-	• No accumulated waste	• They do not have hazardous chemical wastes	-
15	VPLUS PACKAGING RWANDA	Gasabo	-	• No accumulated waste	• They recycle most of the waste produced	• They recycle most of the waste produced

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
16	ALFA CABLES RWANDA	Gasabo	-	• No accumulated waste	• They recycle most of the waste produced	• They recycle most of the waste produced
17	CIMERWA	Rusizi	• E-wastes, • Used motor oils, • Tires, • Laboratory chemical waste	• They can produce around 8000 kg per year but, there is No accumulated waste	• All the hazardous wastes and Chemical wastes are Stored in small house while waiting to be incinerated (plastic and papers). The e_wastes were taken by Enviroseve. The used moto oil is stored in a big tank before being incinerated. While the chemicals from the laboratory were already incinerated.	They can incinerate their hazardous chemicals by themselves each month.
18	GreenCare Rwanda Ltd	Huye	• E-wastes • some medical wastes, lamps	• They can receive 288 tons per year of hazardous wastes,	• The beverage factories signed agreement with GreenCare to bring the	-

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
				mostly domestic wastes, glasses, and plastics.	wastes containing glasses to the landfill.	
19	AGRUNI LTD	Gasabo	• Batteries; • Tires; • Used motor oils; • Pesticides/biocides; • Expired or damaged fertilizers; • E-wastes.	• They can 16560 tons per year among which there is 1380 tons per month (from households); 450 tons per month (from private and business companies including restaurants). Total = 1830 tons per month	• They have some projects related to waste recycling.	• They have some projects related to waste recycling.
20	AMACO Paints Ltd	Kicukiro, Gahanga	• chemicals for Cleaning and • Chemical solvents	• No accumulated wastes	• They only buy what they need, so there is no product should get expired at the factory.	• All the wastes, include the liquids ones are collected and disposed by

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
					• The plastics wastes are being recycled here to make bottles and jerrycans for paint packaging.	the garbage collector company
21	Rwanda Fertilizers company Ltd	Gasabo, Free zone	• Expired or damaged fertilizers	• There is 4,300 kg of expired fertilizers in their warehouse (Kigali)	• By now, the hazardous wastes are stored in warehouse waiting for REMA to take decision of their proper disposal.	• The factory is storing these hazardous wastes while waiting for proper disposal
22	UTEXRWA Ltd	Gasabo, Gisozi	• Wastewater from laboratory and production system that contains chemicals (dyeing and cleaning chemicals) • Dyeing Chemicals	• They are recycling 1000 m^3 of wastewater per day. • No accumulated chemical wastes.	• They recycle the wastewater in their WTP, while other wastes are collected by hired company from disposal	• Wastewater are treated at the WTP of in the factory

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
23	AgroPlast Ltd	Kicukiro, Gahanga	-	• No accumulated waste	• They recycle most of the waste generated during manufacturing process	• Recycling
24	LuNa Smelter Ltd	Gasabo, Karuruma	• Laboratory chemicals and sludge	• No accumulated waste	• The expired chemicals are disposed by the hired company	• The contractor company collected the expired chemicals for incineration
25	SKOL Brewery Ltd	Nyarugenge, Nzove	• Laboratory chemical waste • Cleaning chemicals • Chemicals used in wastewater treatment. • Broken glass bottles	• No accumulated waste	• They only order the needed quantity of chemical products to avoid much waste generation. • They are recycling 1300 m^3 of wastewater per day	• They have a water treatment plant for liquid wastes treatment. • Other wastes like damaged bottles are disposed by AGRUNI Ltd

№	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
26	Chillington Rwanda Ltd	Kicukiro, Gatenga	-	• No waste accumulated	• They are recycling most of the metal scrap wastes produced	• Recycling, except for wastewater.
27	AgroPy Ltd	Nyarugenge, CHIC building	• Expired pesticides and other agrochemicals • The emptied containers that contain pesticides or agrochemical residues	• No accumulated wastes	• All wastes are collected and taken back to the factory HQ at Musanze	• Some waste is incinerated, disposed of by the hired company, while the liquid wastes are treated at our WTP.
28	ROBA Industries Ltd	Bugesera	• Chemical wastes/ Hazardous wastes • Chemicals containing-wastewater	• No accumulated wastes	• The liquid wastes are treated in the factory, while other wastes are collected and disposed by the hired company	• They are recycling some produced wastes
29	Kigali Leather Ltd	Bugesera	-	-	• Some chemical products and solvents are used in tis	• Other wastes from leather processing

Nº	Institution	Address	Type of waste generated (Hazardous/Chemical)	Chemical Waste Generated	Comment	Organization/factory measure taken to minimize these wastes
					factory; however, the liquid wastes were being discharged in the nearby wetland without pre-treatment. So, at the time of our visit, the factory was temporally shutdown for correction of such issues	were collected and disposed by the contractor company called Waste Collectors Ltd
30	Master Steel Ltd	Kicukiro, Gahanga	• No wastes	• No wastes generated	• Their production technology is very green, so they don't generate any wastes in production	• They are using green technology in steel and iron processing

Annex 14: List of consulted institution and contacted persons for this survey

This annex is attached as a separate document.

Annex 15: Definition of key terminology

1. Hazardous wastes

Hazardous waste is waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, or sludges. They can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes.

2. Chemical wastes

Chemical waste is any unnecessary or excess use of a chemical, or a chemical substance that could harm human health or the environment when released to the air, water, or land. Chemical waste is a subset of “environmental waste”. Many chemical wastes can be classified as hazardous waste. For safety and security, it is important to be able to recognize any dangers involved in storing and using certain chemicals. It is also important to know about chemical characteristics when disposing of chemicals to ensure that those wastes are disposed of properly.

3. Mercury

Mercury is a naturally occurring chemical element found in rock in the earth's crust, including in deposits of coal. On the periodic table, it has the symbol "Hg”, and its atomic number is 80. It exists in several forms that are: (1) Elemental (metallic) mercury, (2) Inorganic mercury compounds, or (3) Methylmercury and other organic compounds. Mercury is toxic. Exposure to mercury, even small amounts, may cause serious health problems.

4. Mercury wastes

According to Minamata Convention, mercury waste is defined as waste consisting of, containing or contaminated with mercury above the thresholds established by the Conference of the Parties (COP). Article 11 of the Minamata Convention requires parties to manage mercury waste in an environmentally sound manner.

5. Asbestos

Asbestos is a greyish mineral that easily separates into long flexible fibres, that is used to make materials that are fireproof, do not conduct electricity, and are chemically resistant, and that can cause serious lung disease if inhaled as a dust.

6. Persistent Organic Pollutants (POPs)

Persistent Organic Pollutants (POPs) are organic chemical substances, that is, they are carbon-based. They possess a particular combination of physical and chemical properties such that, once released into the environment, they: remain intact for exceptionally long periods of time. The first 12 POPs under the Stockholm Convention were aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene, polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDFs).

7. Polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are highly carcinogenic chemical compounds, formerly used in industrial and consumer products including insulating fluids (transformer oil) for transformers and capacitors, whose production was banned internationally by the Stockholm Convention on POPs in 2001. The group of chemicals known as PCB is one of the original twelve POPs covered by the Stockholm Convention. They possess properties including longevity, heat absorbance and form an oily liquid at room temperature that is useful for electrical utilities and in other industrial applications.

8. Per-and polyfluoroalkyl substances (PFAS)

Despite the lack of a universal definition of the per-and polyfluoroalkyl substances (PFAS), the U.S. Environmental Protection Agency (USEPA) defines PFAS as “chemicals with at least two adjacent carbon atoms, where one carbon is fully fluorinated and the other is at least partially fluorinated”.

Electronic wastes

Electronic waste or e-waste describes discarded electrical or electronic devices. It is also commonly known as waste electrical and electronic equipment (WEEE) or end-of-life (EOL) electronic