Practical Considerations for Managing Laboratory Guanidinium Thiocyanate (GTC)-Containing Waste from HIV Viral Load and Early Infant Diagnosis Platforms

Countries Collaboration
Version 1, February 2026

WNWN
International, Inc.

PEPFAR
U.S. President's Emergency Plan for AIDS Relief

ASLM
AFRICAN SOCIETY FOR LABORATORY MEDICINE

Note from the authors:

From liquid hazard to safer solid: Sawdust acts as a natural absorbent, soaking up the GTC waste and making it ready for high-temperature incineration. Simple, effective, and compliant.

Contents

I. List of Acronyms

APHL	Association of Public Health Laboratories
ASLM	African Society of Laboratory Medicine
CDC	Centers for Disease Control and Prevention
DBS	Dried Blood Spots
EID	Early Infant Diagnosis
GTC	Guanidinium Thiocyanate
GITC	Guanidinium Isothiocyanate
HIV	Human Immunodeficiency Virus
MDGI	Millennium Development Goals Initiative
MOH	Ministry of Health
PCR	Polymerase chain reaction
PEPFAR	President's Emergency Plan for AIDS Relief
POC	Point of Care
PPE	Personal Protective Equipment
UNDP	United Nations Development Programme
VL	HIV viral load (VL) testing
ZEMA	Zambia Environmental Management Agency

II. Sponsoring and Collaborating Institutions

This project was implemented through the **African Society for Laboratory Medicine (ASLM)** with funding and technical support under the **United States President's Emergency Plan for AIDS Relief (PEPFAR)**.

The collaborating countries that have evaluated and provided feedback on the selected disposal options are **Eswatini, Ethiopia, Kenya, Malawi, Mozambique, Nigeria, Uganda, Zambia, and Zimbabwe.**

The **WNWN International, Inc.** team involved in conducting research, experiments, and drafting this report include **Edward Krisiunas, Viktor Hristov, Richard Morgan,** and **Slobodanka Pavlovic.**

III. Introduction

The advancements in clinical laboratory-based technology analytical platforms for the President's Emergency Plan for AIDS Relief (PEPFAR) HIV viral load (VL) and Early Infant Diagnosis (EID) testing has improved lives of many across the world. With such technologies come the challenges of waste disposal. Waste can be in the form of blood specimens after being analyzed, assorted laboratory products, and personal protective equipment (PPE). Many of these platforms generate effluent/liquid waste, that may require additional treatment before disposal.

Many of the PCR diagnostic platforms use reagents containing Guanidinium thiocyanate (GTC) to lyse viral particles such as Hepatitis B and C, Ebola, and SARS-CoV 2 and allow for the extraction of RNA or DNA. GTC can also be found within the liquid waste contained in some Point of Care (POC) testing cartridges. It has been reported that the potential exists for a reaction of GTC liquid with bleach (sodium hypochlorite) or other acid-based chemicals that could elicit a toxic gas – Hydrogen Cyanide (HCN). As such, several methods of disposal of this effluent have been investigated and researched across the globe. Methods for treatment of this waste may be constrained in low-income / limited resource settings. A common disposal practice is pouring this effluent into a sink located in the VL/EID or molecular testing laboratory. **This should not be considered** a disposal option as laboratories may also discard bleach-containing solutions that may react in the plumbing or traps and possibly releasing HCN gas in other areas of a laboratory. Laboratory drains also usually lead to general sewer systems, which may lead back to surface waters or water tables. The initial purpose of this document was to share with the 9 participating countries (Eswatini, Ethiopia, Kenya, Malawi, Mozambique, Nigeria, Uganda, Zambia, and Zimbabwe) a range of treatment and disposal options that could be considered for the management of Guanidinium Thiocyanate (GTC) or Guanidinium Isothiocyanate (GITC) VL/EID waste streams from HIV VL/EID molecular platforms. The countries were asked to select the option or options of those presented that best suit their needs.

Training / work instructions were provided on the various options to designated locations/personnel in each country to assist in the selection process. Countries were requested to provide and share their assessments on the selected options. The information obtained from these assessments will be utilized to update the options relative but not limited to ease of application, cost, and health/safety for staff and the environment. Updated information on the disposal options will be shared with the broader audience of end users.

Responsible Parties – End Users of this document

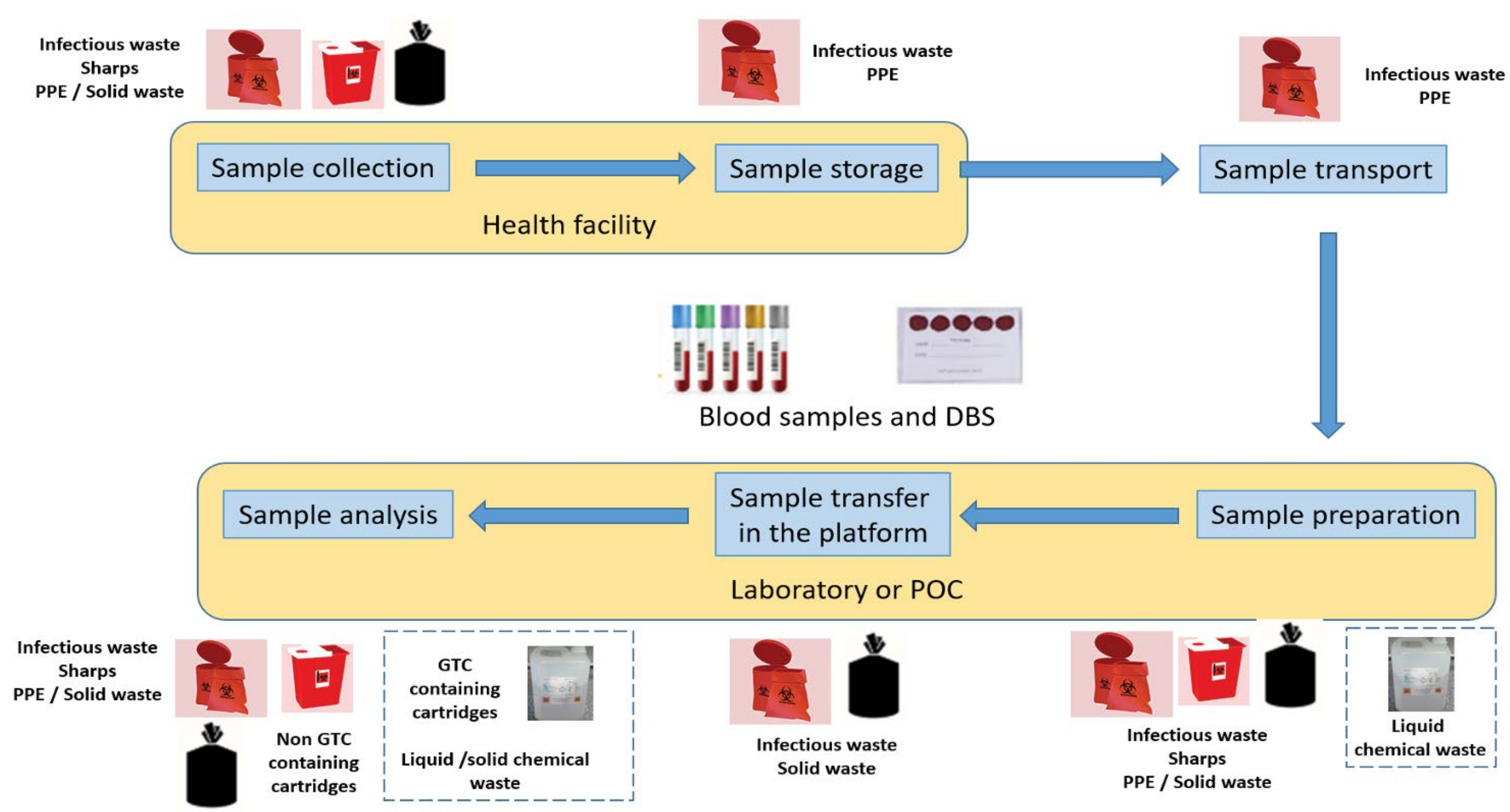
Personnel that should be involved in the selection, application, and assessment of these options include those with oversight of healthcare facilities at national level such as a Ministry of Health and Ministry of Environment as facility level involvement will be required from Facility Administrators, Laboratory Management / staff, and waste management staff. The above regulatory and facility management personnel can utilize the **Disposal Options Matrix (below/pages 9 - 12)** which lists disposa l methods to be considered along with the advantages and disadvantages for each method. From there, each method's background is discussed followed by a decision tree to assist the end user if that option is being considered. Work Instructions for each of these options are further available in the Appendices. The instructions can be modified to meet local needs.

IV. Clinical Laboratory Waste Management- General Overview

Waste management in healthcare facilities involves different departments, each producing distinct waste streams with specific handling and disposal requirements.

The handling and disposal of infectious waste from clinical laboratories however presents unique challenges due to the diverse range of pathogens and their potential risks to public health and the environment. This type of waste includes various materials such as culture media, specimens, contaminated equipment, and discarded consumables. The quantity and types of infectious waste generated can vary significantly depending on the laboratory's activities and specialization. For example, microbiology laboratories commonly produce culture plates and broth media containing viable microorganisms, while histology laboratories generate pathological waste like biopsy specimens and tissues, which may harbor infectious agents. Similarly, HIV VL/EID testing laboratories also produce a variety of potentially infectious and hazardous waste streams, including waste streams containing GTC which is the focus of this document. The diagram below presents a holistic view of all the possible waste streams along the HIV VL/EID path from specimen collection and transport to processing/testing and finally disposal. Except for the GTC containing waste streams, all other items have treatment options available.

Clinical Laboratory HIV VL and EID Associated Waste Streams Flow Diagram from specimen collection to specimen analysis



Dotted line represents waste products of concern

V. Waste Disposal Option Matrix – Discussion and Overview

The following matrix provides an overview of the most common / discussed options for management of GTC-containing liquid waste from HIV molecular testing platforms as well as GTC-containing cartridges. These waste mitigation methods have been shared, to varying degrees, with numerous users of VL/EID platforms. Fortunately, some options are being implemented in a few countries and feedback is being organized. These countries are trying to assess the cost for disposal of the approach selected. Discharge to drain/sewer remains a common practice in several countries that should be replaced with the options discussed below. Some countries have planned to store GTC liquid waste until an environmentally friendly method has been identified.

Disposal options undertaken will likely reflect the local context – geographical location, local and national regulations/ norms/guidelines/policies, availability of resources/capacity, environmental hazards, human toxicity, and worker hazards if manipulation of the waste is required before disposal (e.g., use of ground charcoal or charcoal dust or cement encapsulation of small quantities of waste liquid). The specimen disposal matrix utilizes a scoring scale of 1 to 5 with 1 being least favorable and 5 being most favorable. This is provided as an example for scoring and can be adjusted by the assessment team in each respective country.

The disposal option matrix is a dynamic tool and will be updated periodically with additional treatment options that continue to be assessed as well as feedback from countries utilizing this document. It is hoped that as countries implement their selected waste disposal methods, they will also find alternative treatment options that can be shared with their laboratory colleagues around the world.

Each end user of this document is encouraged to complete their own assessment using the "Waste Disposal Option Matrix". A blank version can be found below.

A. CATEGORIES OF THE WASTE DISPOSAL OPTION MATRIX

- **Methods:** Lists the current disposal options in alphabetical order that are being considered and researched to date as part of this project.
- **Factors to be considered in the selection of a disposal option (This is not an exhaustive list):**
  - **Availability:** The degree to which a waste disposal option is accessible, operable, or obtainable within a country.
  - **Cost*:** Each option must be assessed for costs that could include material, labor, and treatment/disposal costs. Examples of factors associated with costs are provided below.
  - **Complexity:** Some disposal options may be considered complex as they will require a higher skill set from personnel performing the disposal method.
  - **Environmental Hazard:** Impacts on the environment would include air, water and land.

- **Human Toxicity:** Impacts to human toxicity dovetail with environmental hazards. There may be short-term public health impacts that occur during the treatment of a waste stream.

- **Regulatory Compliance:** Many countries have evolving regulations/licensing requirements that could apply to the activities described here. It is important for the producers of waste to review regulatory requirements and discuss them with the appropriate authorities for the disposal of the GTC-containing waste streams as there could be costs associated with obtaining a license.
- **Worker Hazard:** There will be varying occupational hazards associated with each of the methods of disposal that will require specific protective equipment for staff.

* Factors to consider for cost include but are not limited to:

Fee for service	Equipment operating costs
Fee for transport	Labor
Fee for consumable	Personal Protective Equipment
Fee for treatment equipment	Final disposal if there is an end product

Information on these factors will continue to evolve as countries implement solutions. This information is to be entered in a “Country Cost Table” (section VII below) to assist with completing the decision matrix.

WASTE DISPOSAL MULTI CRITERIA ANALYSIS TREATMENT OPTION MATRIX - GTC LIQUID WASTE AND CARTRIDGES

Example of scoring of Key Assessment Factors

Method	Availability	Cost	Complexity	Environmental hazard	Human Toxicity	Regulatory Compliance	Worker Hazard	Total Score
Cement Inertization[a]	5	3	4	3	3.5	3	3	24.5
Cement Kiln[*b]	3.5	1	5	4	4	3	5	25.5
Cement Kiln - Waste mixed with charcoal or sawdust[c]	3.5	1	4	4	4	3	3	22.5
Hi Temp Incinerator[*d]	3.5	1	3	3	3	3	3	21.5
Hi Temp Incinerator with charcoal or sawdust[e]	3.5	3	3	3.5	3.5	3	3	22.5
Precipitation[f]	3.5	3	3	4	4	3	4	24.5
Trans Boundary Movement[g]	5	1	1	5	5	3	2	22

* Disposal option for cartridges

Note: Scoring scale is 1 to 5 (1 = Least favorable / 5= Most favorable). Scoring is subjective.

Comments

a. Limit to small volumes of liquid <20 liters as cement/liquid mixture will weigh 20 kg/ 44 lbs.

b. Some but not all cement kilns have introduced material handling equipment to process 5-, 10-, or 20-liter containers of GTC waste (liquid or cartridges). This needs to be confirmed with the cement kiln vendor if available in the country.

c. Use of ground charcoal or charcoal dust or sawdust may incur additional costs (materials and labor). This may not be required by cement kilns, but it does provide calorific value to the process.

d. Operators must determine the method of introducing GTC liquid waste, which is usually non-flammable, into the incinerator. Fluid injection systems could make the management of such liquids easier but require specific equipment and training of staff for proper operation.

e. As with cement kilns, use of ground charcoal or charcoal dust or sawdust may incur additional costs (materials and labor). The appropriate ratio/mixture of liquid to ground charcoal/charcoal dust/sawdust needs to be determined at the local level based upon the variability of these components.

f. Cost of chemicals for titration and precipitation will need to be determined based upon the amount of liquid to be processed.

g. Use this method when storage of waste is not an option as well as no in country disposal method is deemed acceptable.

BLANK WASTE DISPOSAL MULTI CRITERIA ANALYSIS TREATMENT OPTION MATRIX - GTC LIQUID WASTE AND CARTRIDGES

Select the Matrix scheme below to enter values

Method	Availability	Cost	Complexity	Environmental hazard	Human Toxicity	Regulatory Compliance	Worker Hazard	Total Score
Cement Inertization[a]								
Cement Kiln[*b]								
Cement Kiln - Waste mixed with charcoal or sawdust[c]								
Hi Temp Incinerator[*d]								
Hi Temp Incinerator with charcoal or sawdust[e]								
Precipitation[f]								
Trans Boundary Movement[g]								

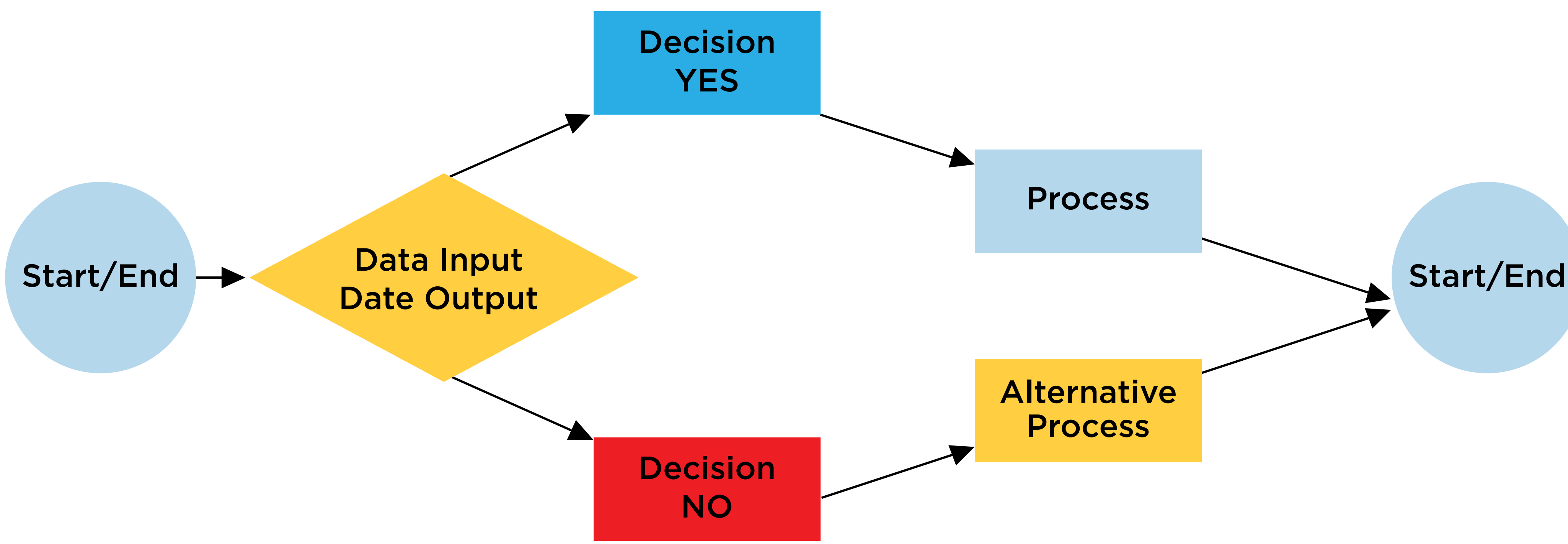
* Disposal option for cartridges

Note: Scoring scale is 1 to 5 (1 = Least favorable / 5= Most favorable). Scoring is subjective.

VI. Waste Disposal Options Section Overview

The following section describes in detail various options that can be utilized for the management of GTC-containing liquid and cartridge waste. Each section contains a brief background discussion of the option. It is then followed by a Decision Tree Flowchart. Each flowchart has a “Start and End” point (oval shape along with “Data Input/Output “point (diamond), “Decision Yes or No” point (parallelogram) and a “Process” or “Alternative Process” point (rectangle). This flowchart allows one to see the steps and decisions to consider in accessing each waste disposal option.

Decision Flow Chart Example



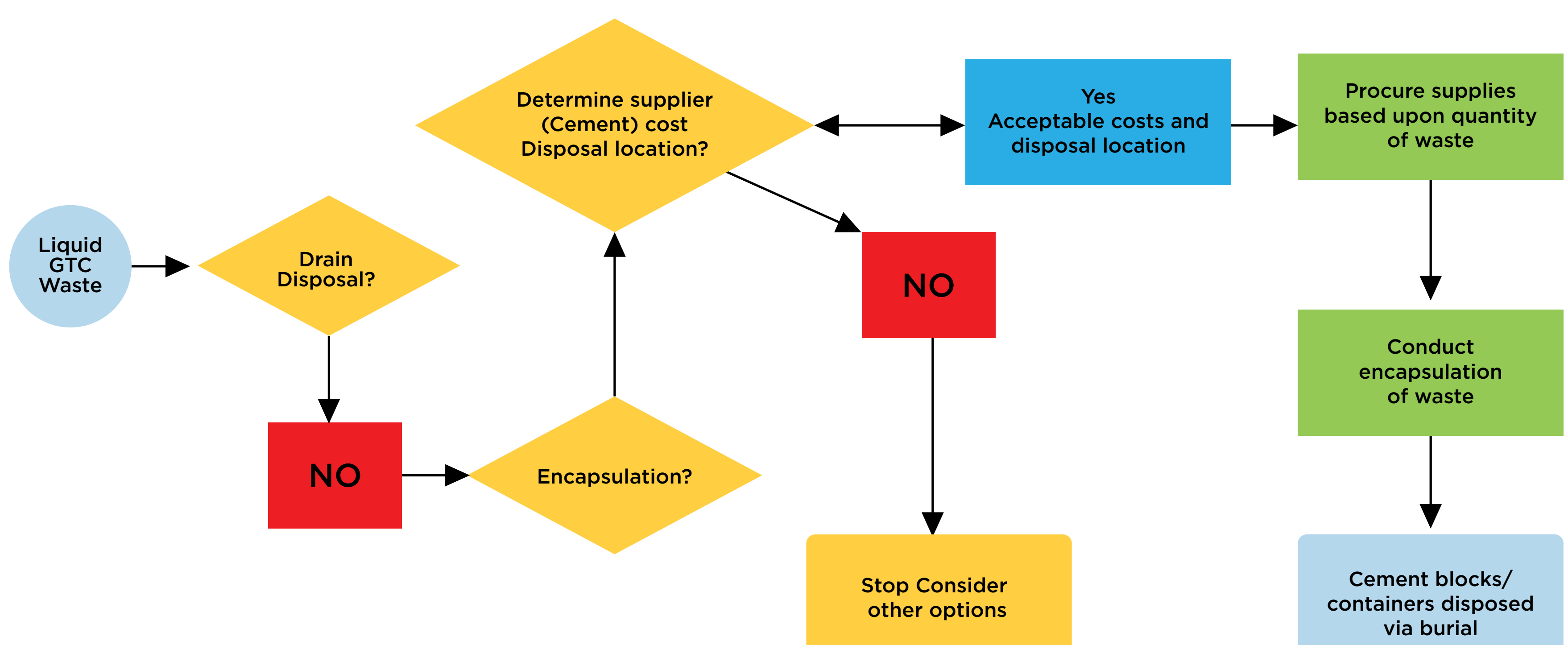
A. Cement Encapsulation - Inertization – Disposal of GTC containing liquid waste

Background

Encapsulation is one method of managing certain types of waste streams in their original containers (glass or plastic) such as pharmaceuticals and laboratory chemicals. Containers are placed in a plastic drum covered by material such as sawdust or vermiculite and then sealed with cement before burial of the drum. Inertization involves mixing actual waste (in their solid/final form such as powders/pills or liquid) added to the cement to represent a fraction of the final mixture. Caution: Please note that some chemicals may react with one of the chemical compounds in cement, e.g., Calcium oxide (CaO). An exothermic reaction may result based upon the chemical being added to CaO.

This strategy may be considered because cement is easily procured in many locations, and it does not require a great deal of skill to use. Conversely, data on leaching of encapsulated GTC remains to be researched but this approach has been used for other chemicals (i.e., phenol. methanol, formaldehyde)[1] including potassium cyanide. The plastic container in which the waste materials are mixed tend to be buried in dumps or landfills. Metal bins/containers are not recommended as they may corrode over time.

Cement Encapsulation – Inertization decision tree flowchart for GTC-containing liquid waste



[1]. Ferreira JA, Bila DM, Ritter E, Braga AC. Chemical healthcare waste management in small Brazilian municipalities. Waste Management & Research. 2012;30(12):1306-1311. doi:10.1177/0734242X12459551

B. Cement kiln – Disposal of GTC-containing liquid and cartridge waste

Background

Cement kilns are large industrial thermal processes used to produce cement, a key construction material. Cement kilns are in many countries and have been used to dispose of hazardous waste because they operate at higher temperatures (1400-1500°C / 2552-2732°F) than most other incinerators, elaborated in Section D (High-temperature incinerator – GTC-containing liquid and cartridge waste). Material handling is an important aspect of processing waste streams.

Photo: Cement kiln rotary chamber

Communication with the local/regional cement kiln is important to establish a working relationship and waste material acceptance criteria. Waste may need to be collected in single use plastic containers such as those shown below. This needs to be confirmed with the cement kiln.

20 liters / 5.3-gallon containers

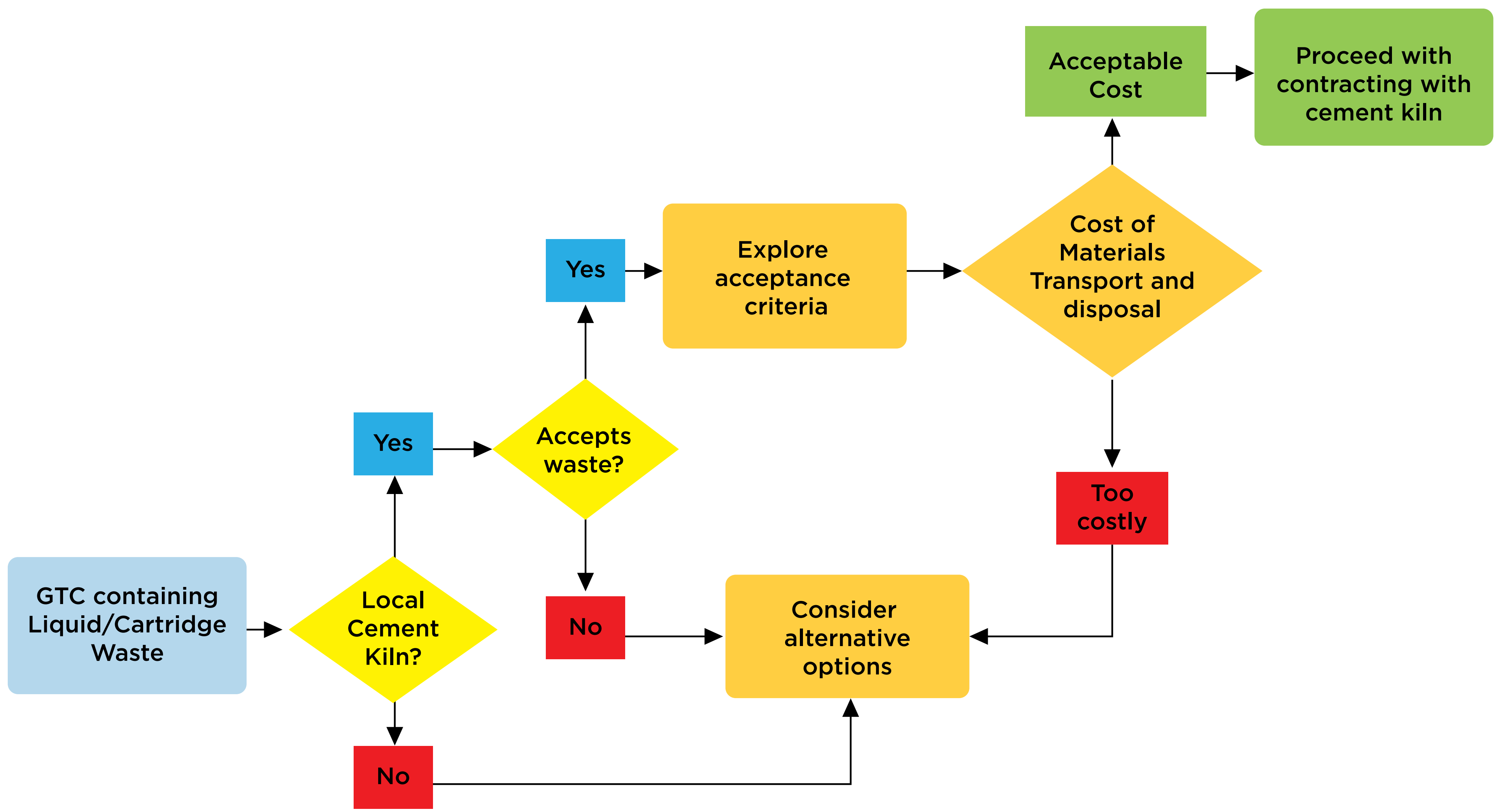
Loading platforms for waste container

Ram feed for waste containers

This strategy can be considered because in countries where cement kilns are located and accepting this waste stream, there will be no legacy waste – containers and liquid or cartridges will be destroyed.

Conversely, not all cement kilns are willing to accept this waste, and fees may need to be negotiated on disposal AND transport. Cement kilns may wish to receive small volume containers (5 liters were 10 or 20 liters) which will increase disposal costs.

Cement kiln decision tree flowchart – GTC-containing liquid/cartridge waste



C. Cement Kiln – Disposal of GTC containing liquid waste mixed with ground charcoal/charcoal dust or sawdust

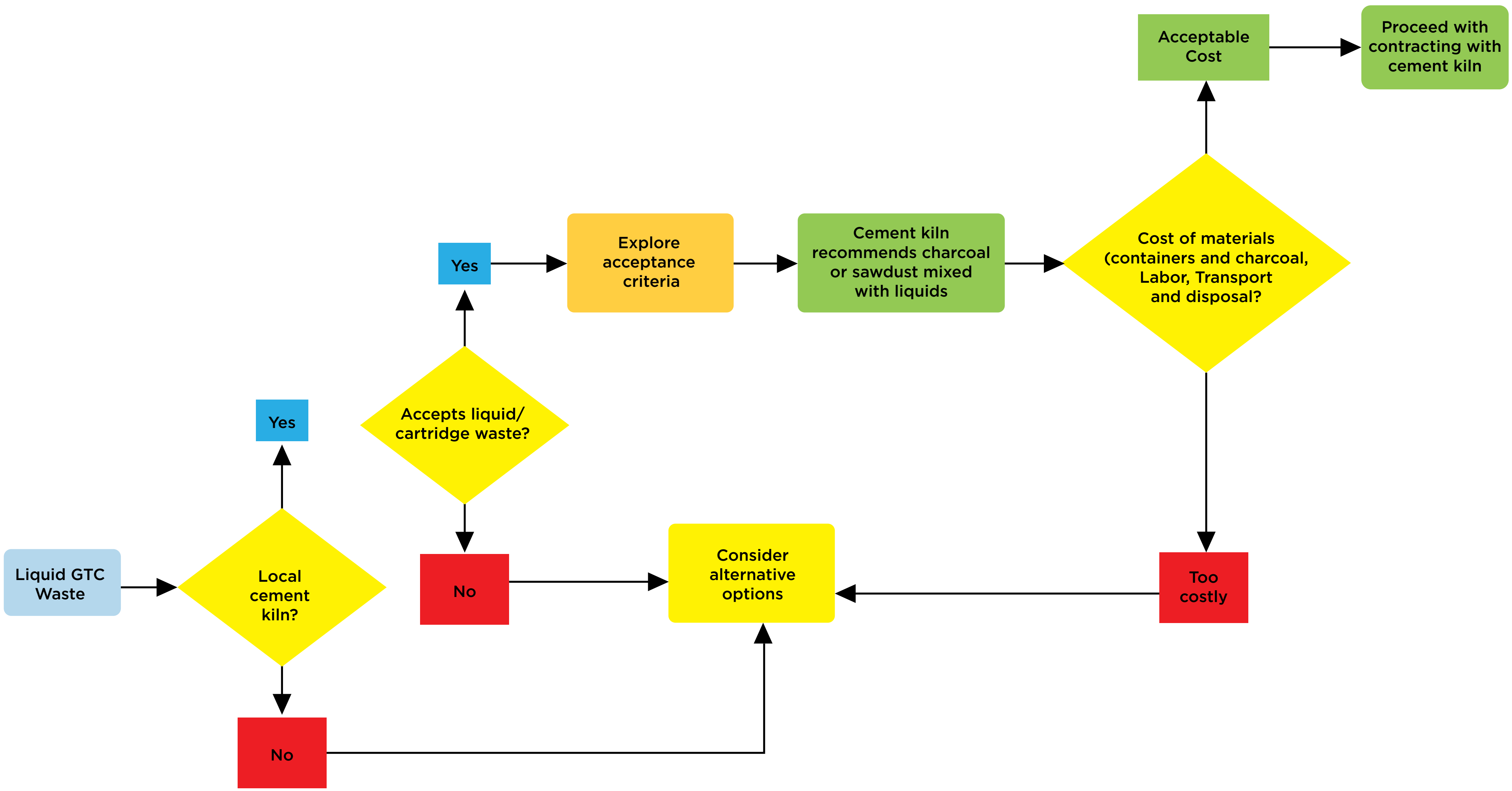
Background

As previously stated, cement kilns are large industrial thermal processes used to produce cement, a key construction material. Cement kilns are in many countries and have been used to dispose of hazardous waste because they operate at high temperatures (1400-1500°C / 2552-2732°F). Material handling is an important aspect of processing waste streams. Some cement kilns may prefer liquid waste to be mixed with a combustible material as normally GTC-containing liquid waste is not flammable.

Two such substances include charcoal or sawdust. Charcoal is readily available and low cost in many countries. If using charcoal, it will need to be ground into a fine powder to allow for absorption of the GTC liquid waste collected in containers as shown below. Charcoal dust can be an alternative. Like when considering charcoal (ground or dust), sawdust must be of a consistency to be easily mixed with liquid (sawdust of flour consistency may be too powdery. A more sugar like consistency will mix better with liquid.

20 liter / 5.3-gallon containers

Cement kiln decision tree flowchart – GTC-containing liquid waste mixed with ground charcoal/charcoal dust or sawdust



D. High-temperature incinerator – GTC-containing liquid and cartridge waste

Background

High-temperature incinerators (operational temperatures often referenced are a minimum 850°C primary chamber /1000°C secondary chamber) can be considered for disposal of GTC-containing waste. High-temperature incineration is often considered an acceptable practice as destruction of agents of concern, specifically chemicals, occurs when exposed to this thermal process. Material handling, however, will be an important aspect of processing waste containing GTC (liquid, cartridges, and other associated laboratory waste). The introduction of liquids will be based upon an assessment of the characteristics of the waste (is it combustible), type of container (plastic), and volumes. Small volumes (<4 liters/1 gallon) may be able to be mixed in with other combustible waste. However, this needs to be reviewed with the incinerator operator.

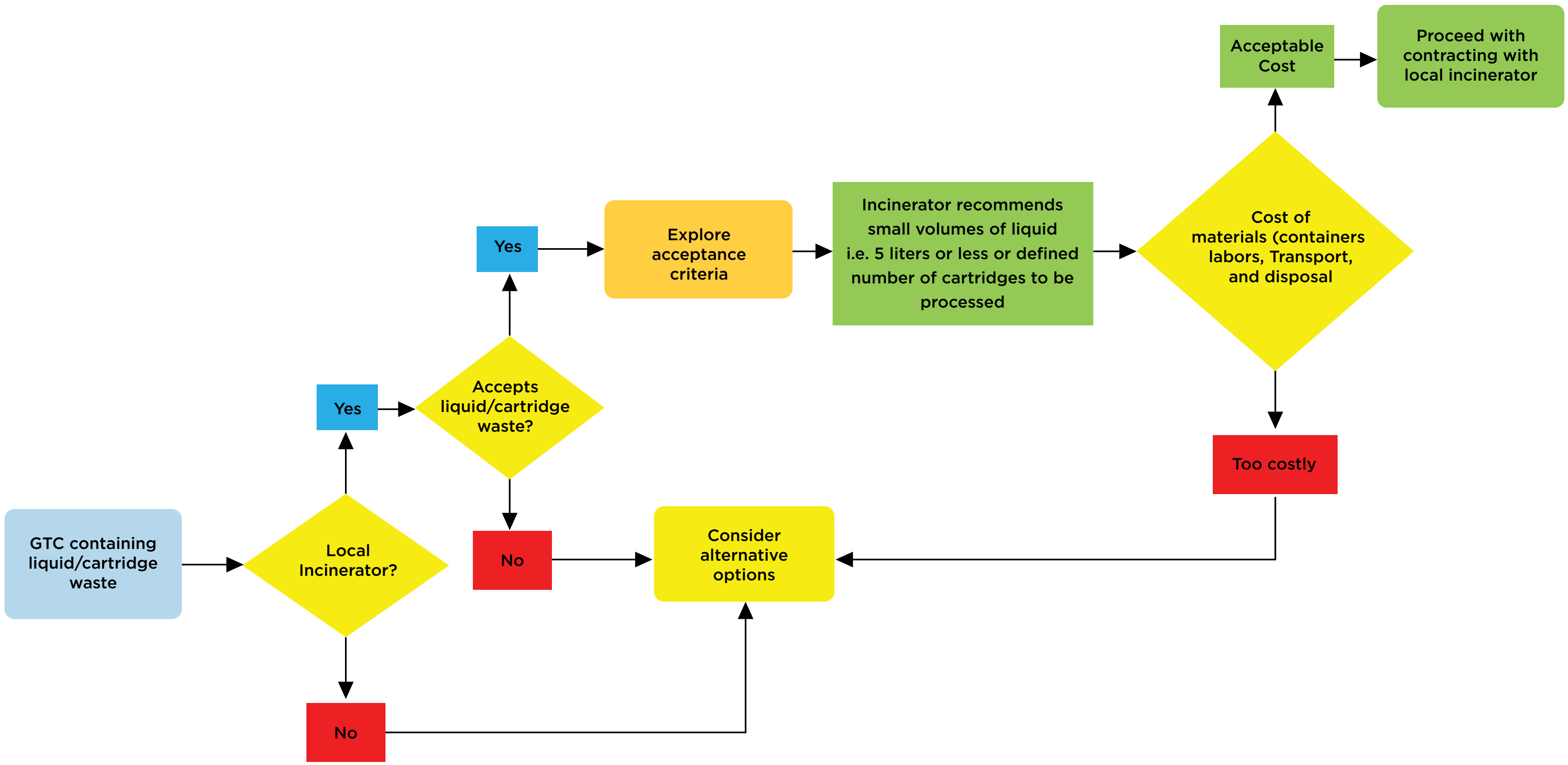
Facilities with onsite incinerators that would consider incineration of GTC liquid waste will need to determine the optimum volume and feeding mixture to ensure proper combustion of the liquid without compromising the combustion process.

Modern High-temperature incinerator with ram feed

Communication with the local/regional incinerator operator is important to establish a working relationship and waste material acceptance criteria. Waste may need to be collected in single-use plastic containers.

This strategy would be considered when appropriate incinerators are available, and the processing parameters have been established for the correct volume/container size have been confirmed for incineration. This may be no larger than a 1-liter plastic container.

High-temperature incinerator decision tree flowchart – GTC-containing liquid and cartridge waste



This is an example of a High-temperature incinerator requiring GTC liquid waste to be loaded in small volumes. This requirement will vary among treatment facilities and need to be agreed upon before waste is collected for treatment. Cartridges may be accepted as they contain small amounts of liquid waste as compared to larger containers of liquid waste.

E. High-temperature incinerator – Mixing of GTC Liquid Waste with ground charcoal/ charcoal dust, sawdust, or other dry absorbent materials

Background

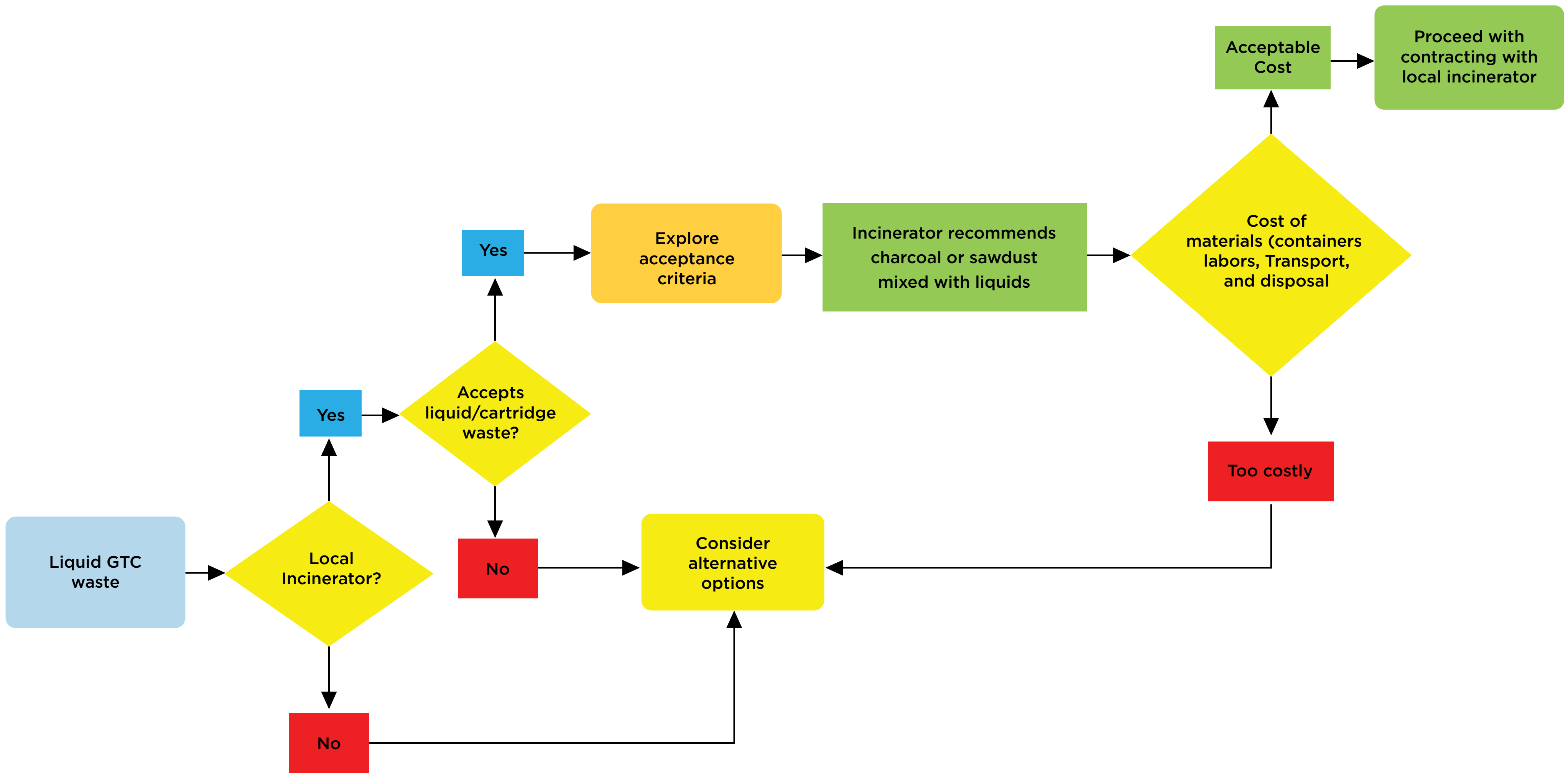
High-temperature incinerators (operational temperatures often referenced are a minimum 850°C primary chamber /1000°C secondary chamber) can be considered for disposal of GTC-containing waste. High-temperature incineration is often considered an acceptable waste disposal practice as the destruction of agents of concern; specifically, chemicals such as GTC, occur when exposed to this thermal process. Material handling, however, will be an important aspect of processing waste containing GTC (liquid, cartridges, and other associated laboratory waste). The introduction of liquids will be based upon an assessment of the characteristics of the waste (is it combustible), type of container (plastic), and volumes. Small volumes (<4 liters/1 gallon) may be able to be mixed in with other combustible waste. However, this will need to be reviewed with the incinerator operator.

Facilities with onsite incinerators that would consider incineration of GTC liquid waste will need to determine the optimum volume and feeding mixture to ensure proper combustion of the liquid without compromising the combustion process.

Modern High-temperature incinerator with ram feed

Communication with the local/ regional incinerator is important to establish a working relationship and waste material acceptance criteria. Waste may need to be collected in single-use plastic containers (see below). Acceptable containers and waste volumes must be confirmed with the incinerator facility.

High-temperature incinerator decision tree flowchart – GTC-containing liquid mixed with ground charcoal/ charcoal dust or sawdust



An example is a high-temperature incinerator requiring GTC liquid waste to be mixed with ground charcoal/charcoal dust or sawdust. This requirement will vary among treatment facilities.

F. Precipitation method for GTC-containing liquid waste

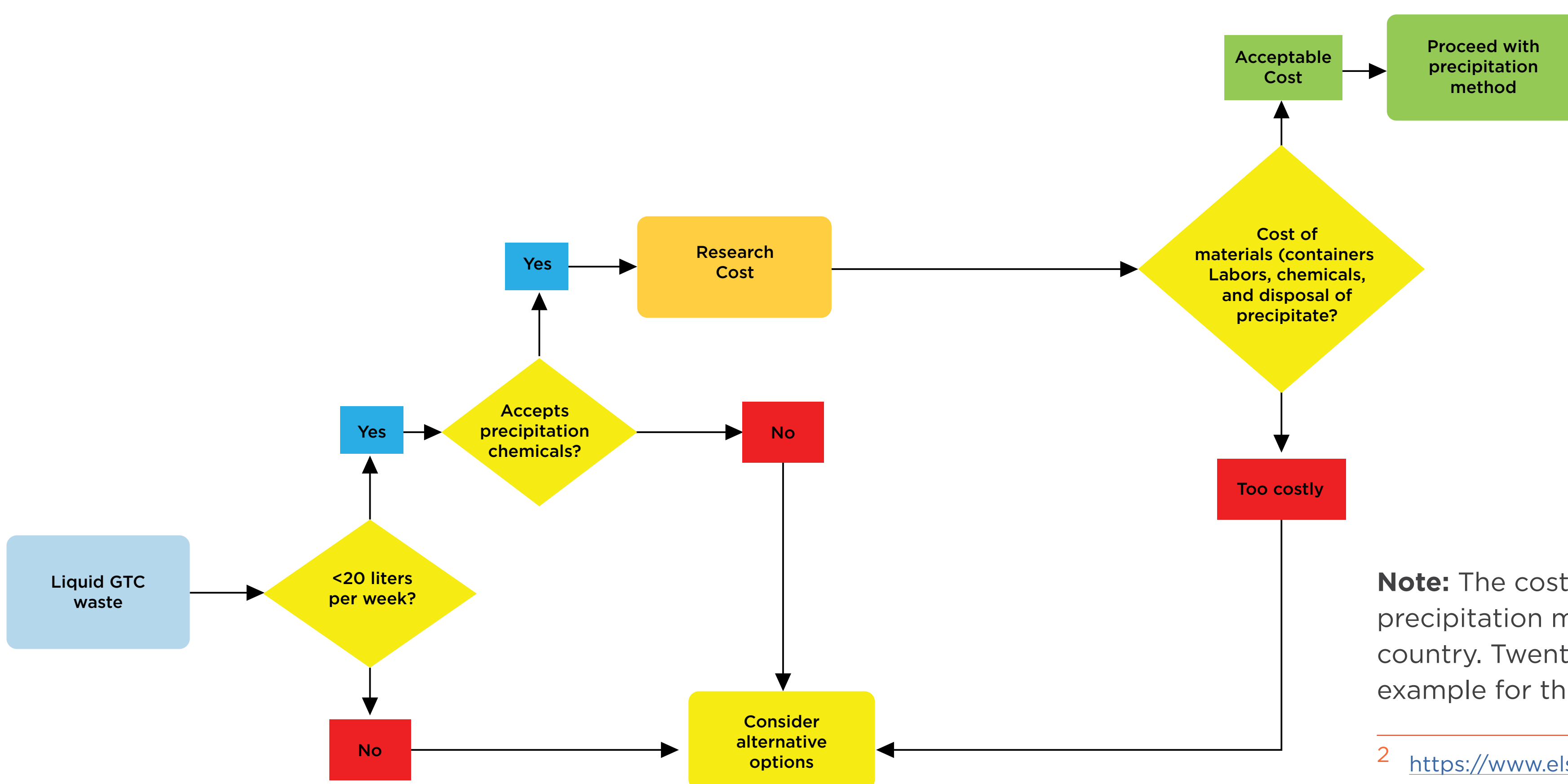
Background

Chemical precipitation is the most common technology used in the removal of metals from process wastewater. The soluble metals are converted to an insoluble form (a solid precipitate) by chemical polymerization, chemical reduction, or electrical reduction. The solid precipitate formed by this reaction is removed from the solution by settling and/or filtration. The unit operations typically required in this technology include pH adjustment, precipitation, coagulation/flocculation, solids/liquid separation, and dewatering.

The effectiveness of a chemical precipitation process is dependent on several factors, including the type and concentration of ionic metals present in the solution, chemical reagents used, reaction conditions (especially the pH of the solution), and the presence of other constituents that may inhibit the precipitation reaction[2].

The precipitation and titration protocols presented in this document were developed under this Project in collaboration with the Project stakeholders. To our knowledge, it is the first time that such a protocol has been applied relative to guanidine thiocyanate in viral load testing.

Precipitation method decision tree flowchart - GTC-Containing Liquid Waste



Note: The cost of chemicals for the precipitation method will vary in each country. Twenty liters is used as an example for this flow diagram.

[2] https://www.elsevier.com/books/nanotechnology-and-functional-materials-for-engineers/dahman/978-0-323-51256-5

G. Trans Boundary Movement (TBM)

Background

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal is a multilateral agreement negotiated under the United Nations Environment Program (UNEP) beginning in 1988. The negotiators of the Convention goal were to promote environmentally sound management of exported and imported waste, especially in LMICs.

The Basel Convention establishes standards for the transboundary movement of hazardous waste, solid waste, and municipal incinerator ash, including notice to and written confirmation from the receiving country prior to export. As of May 20, 2015, 190 states and the European Union are parties to the Convention. [3] The United States is a signatory to the Basel Convention but has not yet become Party to the Convention.

Basel Convention Requirements

The Convention requires that the exporting country notify the receiving country and any transit countries of the proposed shipment. The waste shipment may occur only after the transit and receiving countries have given consent for the shipment. The Convention also requires that an international movement document accompany the waste shipment from its point of origin until its ultimate recycling or disposal.

In addition, shipments of waste must be packaged, labeled, and transported in accordance with international requirements. If an accident occurs during the shipment of the waste, Basel requires that the responsible parties inform the potentially affected countries of the accident. Finally, parties to the Convention must submit an annual report to the Basel Secretariat summarizing the amounts and types of hazardous waste exported or imported and the destination and disposal methods.

Conducting Transboundary Movements

The process for conducting transboundary movements of waste involves multiple steps usually between two countries. This can also be a time-consuming and costly process. Provided below is a simple overview of the steps for transboundary movement.

3. http://www.basel.int/Countries/StatusofRatifications/PartiesSignatories/tabid/4499/Default.aspx

Steps of Transboundary Movement

Steps 1

Check whether your specific waste is defines as hazardous waste in your country regulations

Steps 2

Contact your country Basel Focal Point

Steps 3

Organize disposal and transport

Steps 4

TBM - Submit notification

Steps 5

TBM - Consent and Issue movement document

Steps 6

TBM - Conduct transboundary movement

Steps 7

TBM - Confirm disposal

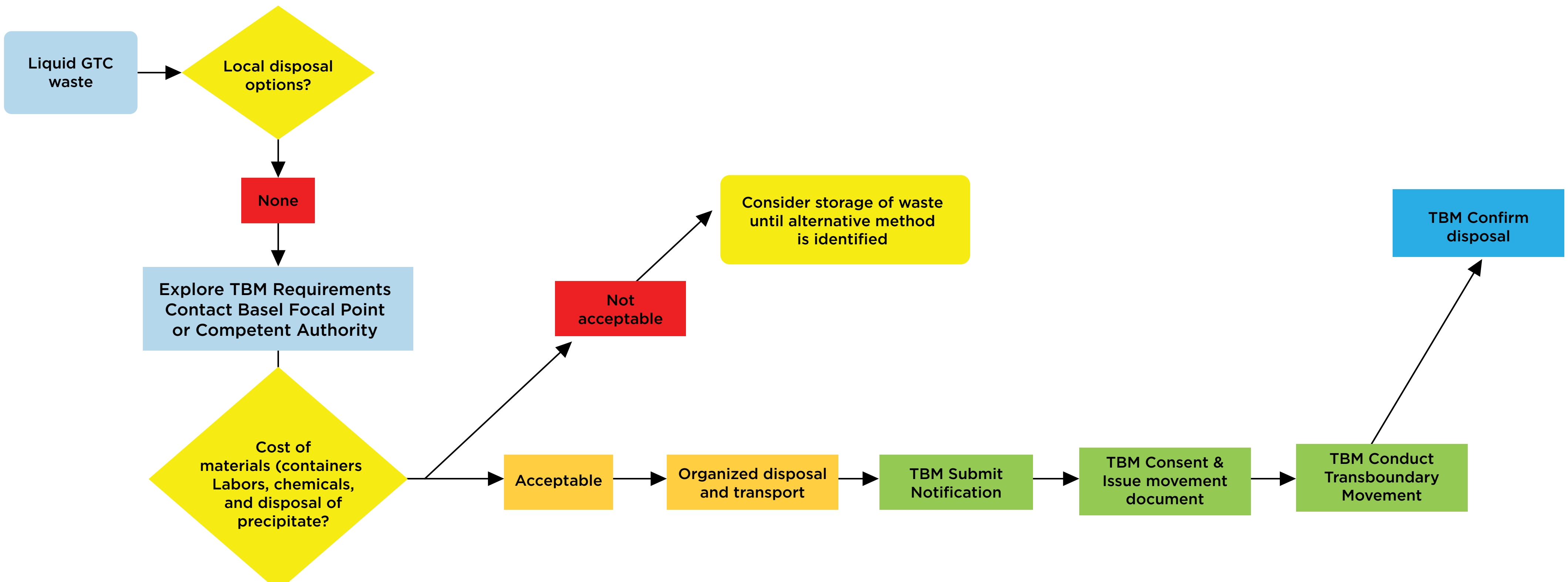
The Basel Convention (http://www.basel.int/) has information specifically related to Trans transboundary movement of hazardous waste. As indicated above, countries that are signatories to the convention have Basel Convention Competent Authority (CA) or Focal Points (FP).

Those individuals can be found on the following link: http://www.basel.int/Countries/CountryContacts/tabid/1342/Default.aspx

An import and export tool from transboundary movements can be found at:
http://www.basel.int/Implementation/Controllingtransboundarymovements/ExportandImportControlTool/tabid/4284/Default.aspx

Important information and links on TBM

Transboundary Movement (TBM) decision tree flowchart – GTC-containing liquid waste



VII. Occupational Exposure and Environmental Exposure Limit References

1. https://echa.europa.eu/
2. https://www.schc.org/assets/docs/ghs_info_sheets/Actute%20Oral%20Toxicity%20_Final%202018-03_.pdf
3. https://chem.echa.europa.eu/100.008.922/dossier-list/reach/dossiers/active?searchText=Guanidine%20thiocyanate
4. https://chem.echa.europa.eu/100.008.922/dossier-view/b5cb13e2-c07a-41f9-a2e5-b5c800b30be8/901aac4c-6d3e-4f9a-a672-e1bc84ad69aa_901aac4c-6d3e-4f9a-a672-e1bc84ad69aa?searchText=Guanidine%20thiocyanate
5. https://www.longdom.org/open-access/severe-toxicity-with-guanidine-thiocyanate-ingestion-2161-0495-1000325.pdf

VIII. Work Instructions

Work Instruction A - Cement Encapsulation - Inertization

Work Instruction B - Cement Kiln Disposal

Work instruction C - Disposal of liquid waste mixed with ground charcoal/charcoal dust or sawdust via cement kiln

Work Instruction D - Incinerator Disposal

Work Instruction E - Disposal of liquid waste mixed with charcoal dust or sawdust via high temperature incineration

Work Instruction F - Removal of GTC from Viral Load Effluent Waste Via the Precipitation Method

Work Instruction G -Trans Boundary Movement

WORK INSTRUCTION A: DISPOSAL OF LIQUIDS VIA CEMENT ENCAPSULATION/ INERTIZATION

1. Materials - Required to collect and transport liquid for mixing with cement

1.1. 5 to 10-liter plastic container with tight fitting cap or lid

1.2. 30 to 40 kg bag of ready-mix cement
1.3. Shovel
1.4. Container for mixing GTC liquid waste and cement

2. Personal Protective Equipment - Required to protect the employee from exposure

2.1. Heavy-duty rubber or leather gloves
2.2. Safety glasses
2.3. Protective clothing/jumpsuit
2.4. Mask/Respirator

3. Task – Mixing cement and GTC liquid waste

3.1. Don appropriate PPE.




3.2. Transfer cement to a bucket or wheelbarrow.
3.3. Transfer GTC liquid in a small volume but not more than 4 liters.
3.4. Mix cement and liquid until well mixed.

3.5. Transfer to a bucket or a concrete form. Fill items to capacity

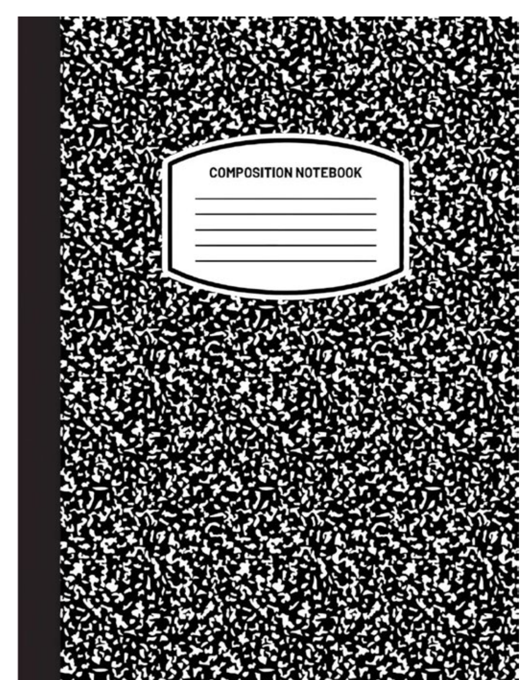
3.6. Allow the mixture to sit/set according to instructions on the bag of cement.
3.7. Store cement blocks and contact supervisor for disposal procedure.

4. Task: Clean up

4.1. After completion of creating cement blocks, clean all containers and tools that will be reused with water.

5. Task: Communications (Required to notify individuals responsible to collect/dispose of cement blocks)

5.1. Contact the supervisor to arrange for the disposal of the cement block.



6. Task: Recordkeeping (Required to document volume/ frequency of waste disposed)

6.1. Upon disposal of the cement block, a supervisor or designated person shall document the date and volume of waste removed and its final disposition (location of disposal).

WORK INSTRUCTION B: DISPOSAL OF LIQUIDS / CARTRIDGES VIA CEMENT KILN

Note: This approach requires a contract/arrangement with a cement kiln to determine acceptable capacities and costs for disposal (collection/transport/treatment).

1. Materials: Required to collect and transport liquid for disposal

1.1. 10 to 20-liter plastic container with tight fitting cap or lid

2. Personal Protective Equipment: Required to protect the employee from exposure

2.1. Nitrile or heavy-duty rubber gloves
2.2. Safety glasses
2.3. Laboratory coat

3. Task: Transfer GTC liquid into container

3.1. Don appropriate PPE.
3.2. Transfer GTC liquid to designated disposal containers.

3.3. Do not overfill.
3.4. Tightly secure all caps and closures.

4. Task - Clean up

4.1. Clean up all spills of liquid with absorbent towels and discard as solid waste.

5. Task: Labelling

5.1. Label container with:
5.1.1. Site specific information, or
5.1.2. Site specific information written on container
5.1.3. See example:

Generator Name
Address
Name of waste (VL – GTC waste)
Date

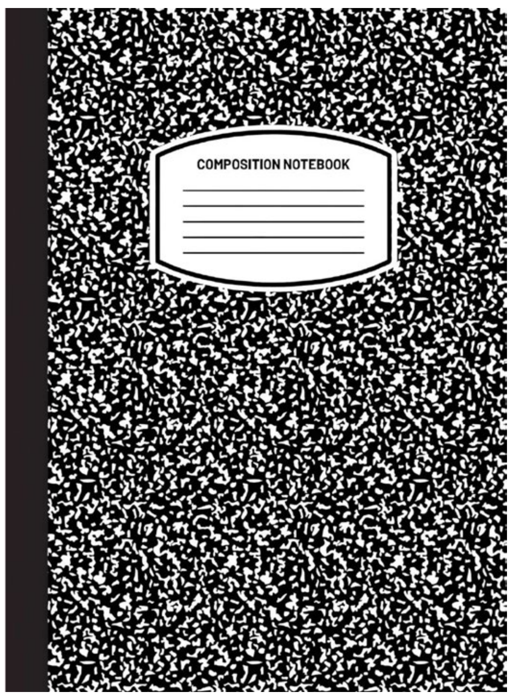
6. Task: Communications (Required to notify individuals responsible to collect waste)

6.1. Contact the laboratory manager to arrange for collection of waste.

6.2. The Laboratory Manager schedules the time and date of waste collection for disposal.

7. Task: Recordkeeping (Required to document volume/frequency of waste disposed)

7.1. Upon removal of waste, the laboratory manager or designated person shall document the date and volume of waste removed and its final disposition (location of treatment).



WORK INSTRUCTION C: DISPOSAL OF LIQUID WASTE MIXED WITH GROUND CHARCOAL/CHARCOAL DUST OR SAWDUST VIA CEMENT KILN

Note: This approach requires a contract/arrangement with a cement kiln to determine acceptable capacities and costs for disposal (collection/transport/treatment). Some cement kilns may not require the addition of ground charcoal/charcoal dust or sawdust as this will increase the weight of waste to be disposed of.

1. Materials - Required to collect and transport liquid for disposal

1.1. 10 to 20-liter plastic container with tight fitting cap or lid

Ground charcoal or charcoal dust or sawdust

- Experimentation with ground charcoal or charcoal dust has shown the ratio of approximately 11.5 liters of water to 10.6 kg of ground charcoal or charcoal dust may be adequate for disposal via cement kiln.
- For sawdust, 23 liters of liquid waste to 20kg of sawdust thoroughly mixed in within a drum appear to provide a dry/combustible mix.
- The use of ground charcoal or charcoal dust or sawdust may require trial and error to achieve a dry combustible mix.

2. Personal Protective Equipment - Required to protect the employee from exposure

2.1. Heavy-duty rubber or leather gloves
2.2. Safety glasses
2.3. Protective clothing/jumpsuit
2.4. Mask/Respirator

3. Task when using ground charcoal or charcoal dust – Transfer GTC liquid into container

3.1. Don appropriate PPE.

3.2. Transfer part of ground charcoal or charcoal dust to a designated disposal container.

3.3. Add GTC liquid to the designated disposal container.

3.4. Mix slowly as there will be dust.

3.5. Slowly add more ground charcoal or charcoal dust until a slurry paste like material is created and.

3.6. Once thoroughly mixed, tightly secure all caps and closures.

Note: Charcoal dust may be available at no cost in local markets where charcoal is sold. Charcoal dust may be swept into piles and have no value. This can be collected and transported back to a laboratory. Small quantities (< 4 liters) may be mixed in plastic bags to create slurry. This slurry can then be disposed of via incineration.

4. Task when using sawdust

4.1. Don appropriate PPE

4.2. Note acceptable saw dust quality
Too coarse - difficult to absorb material
Too fine/dust like - difficult to mix

Close-up of sawdust particles

4.3. Fill container with sawdust first.

4.4. Add GTC liquid to container.

4.5. Mix saw dust / Liquid mixture with a stirring rod or shovel

Final mixture of GTC waste and sawdust

4.6. Once thoroughly mixed, tightly secure all caps and closures.

5. Task: Clean up

5.1. Clean up all spills of liquid with absorbent towels, ground charcoal or charcoal dust, or sawdust and discard as solid waste.

6. Task: Labelling

6.1. Label container with:
6.1.1. Site specific information, or
6.1.2. Site specific information written on container
6.1.3. See example:

Generator Name
Address
Name of waste (VL – GTC waste/Charcoal mix)
Date

7. Task: Communications (Required to notify individuals responsible to collect waste)

7.1. Contact the laboratory manager to arrange for collection of waste

7.2. Laboratory Manager schedules time and date of waste collection for disposal with cement kiln

8. Task: Recordkeeping (Required to document volume/frequency of waste disposed)

8.1. Upon removal of waste, laboratory manager or designated person shall document the date and volume of waste removed and its final disposition (location of treatment).

WORK INSTRUCTION D: DISPOSAL OF LIQUIDS VIA INCINERATOR

1. Materials: Required to collect and transport liquid for disposal

1.1. 1 to 4-liter plastic container with tight fitting cap or lid (Container size to be determined by incinerator operator)

2. Personal Protective Equipment - Required to protect the employee from exposure

2.1. Nitrile or heavy-duty rubber gloves
2.2. Safety glasses
2.3. Laboratory coat

3. Task: Transfer GTC liquid into container

3.1. Don appropriate PPE.

3.2. Transfer GTC liquid to designated disposal containers.
3.3. Do not overfill.
3.4. Tightly secure all caps and closures.

4. Task:Clean up

4.1. Clean up all spills of liquid with absorbent towels and discard as solid waste.

5. Task: Labelling

5.1. Label container with:
5.1.1. Site specific information, or
5.1.2. Site specific information written on container
5.1.3. See example:

Generator Name
Address
Name of waste (VL – GTC waste)
Date

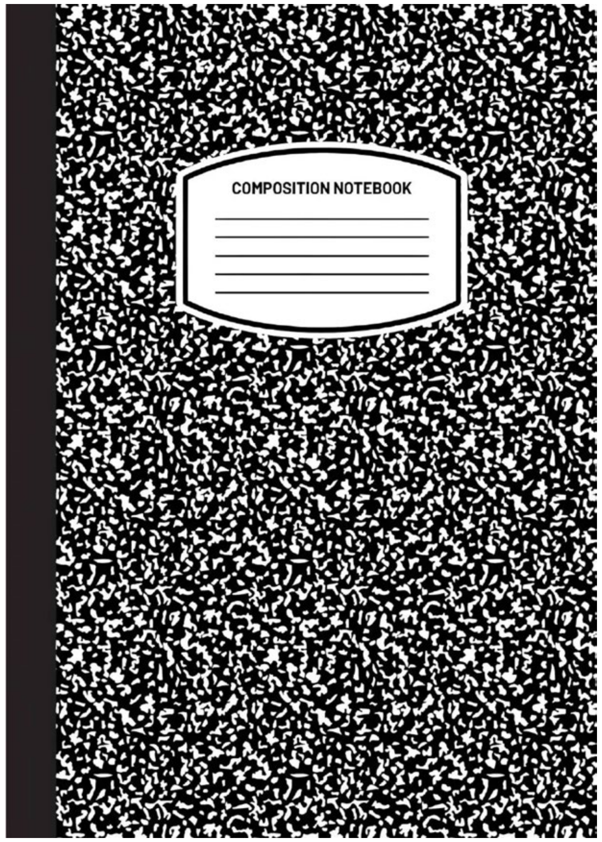
6.Task: Communications (Required to notify individuals responsible to collect waste)

6.1. Contact the laboratory manager to arrange for collection of waste.

6.2. The Laboratory Manager schedules the time and date of waste collection for disposal.

7. Task: Recordkeeping (Required to document volume/frequency of waste disposed)

7.1. Upon removal of waste, the laboratory manager or designated person shall document the date and volume of waste removed and its final disposition (location of treatment).



WORK INSTRUCTION E: DISPOSAL OF LIQUID WASTE MIXED WITH CHARCOAL DUST OR SAWDUST VIA HIGH TEMP INCINERATOR

Note: Quantities of liquid to be introduced into an onsite or offsite high-temperature incinerator need to be established based upon the type of incinerator (top, front, or ram feed unit) and loading capacity of the incinerator. Information for loading liquids should be requested from the incinerator vendor.

1. Materials - Required to collect and transport liquid for disposal

1.1. 10 to 20-liter plastic container with tight fitting cap or lid Ground charcoal or charcoal dust (approximately 11.5 liters of water to 10.6 kg of ground charcoal/charcoal dust) or sawdust

2. Personal Protective Equipment - Required to protect the employee from exposure

2.1. Heavy-duty rubber or leather gloves
2.2. Safety glasses
2.3. Protective clothing/jumpsuit
2.4. Mask

3. Task – Transfer GTC liquid into container

3.1. Don appropriate PPE.

3.2. Transfer part of ground charcoal or charcoal dust to designated disposal container.

3.3. Add GTC liquid to designated disposal container.

3.4. Mix slowly as there will be dust.

3.5. Slowly add more ground charcoal or charcoal dust

3.6. Once thoroughly mixed, tightly secure all caps and closures.

4. Task when using sawdust

4.1. Don appropriate PPE

4.2. Note acceptable saw dust quality

4.3. Fill container with sawdust first.

4.4. Add GTC liquid to container.

4.5. Mix saw dust / Liquid mixture with a stirring rod or shovel

4.6. Once thoroughly mixed, tightly secure all caps and closures.

If processing waste on site, depending on the size of the incinerator, larger volumes of liquid waste can be mixed using a shovel in larger drums. In Nigeria, their experience was mixing 23 L of liquid waste to 20kg of sawdust. The goal is to have dry material even after mixing with the sawdust.

(Information and photos courtesy of Orji Bassey (CDC/DDPHSIS/CGH/DGHT), Nigeria).

Sawdust placed into an incinerator along with red bag waste of processing (photo courtesy of Orji Bassey (CDC/DDPHSIS/CGH/DGHT), Nigeria)

5. Task: Clean up

5.1. Clean up all spills of liquid with absorbent towels or ground charcoal or charcoal dust, or sawdust and discard as solid waste.

6. Task: Labelling

6.1. Label container with:
6.1.1. Site specific information, or
6.1.2. Site specific information written on container
6.1.3. See example:

Generator Name
Address
Name of waste (VL – GTC waste/Charcoal mix)
Date

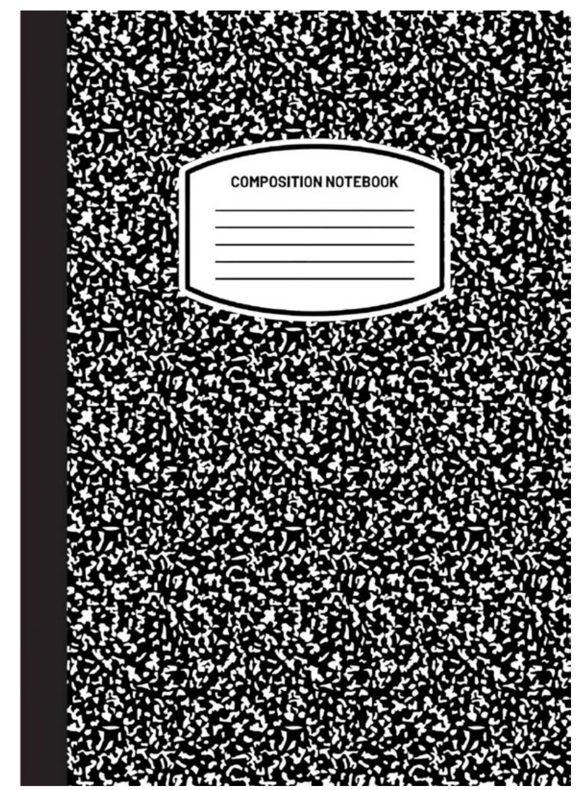
7. Task: Communications (Required to notify individuals responsible to collect waste)

7.1. Contact the laboratory manager to arrange for collection of waste.

7.2. The Laboratory Manager schedules the time and date of waste collection for disposal.

8. Task: Recordkeeping (Required to document volume/ frequency of waste disposed)

8.1. Upon removal of waste, the laboratory manager or designated person shall document the date and volume of waste removed and its final disposition (location of treatment).



WORK INSTRUCTION F: REMOVAL OF GUANIDINE THIOCYANATE FROM VIRAL LOAD EFFLUENT WASTE VIA THE PRECIPITATION METHOD

1. Materials and Chemicals

Materials required

Equipment Required
Mixing container – 10 L/2.5 gallon / can be a plastic container
Transparent or opaque container for preparing chemical reagents – 5-10 liters.
Analytical balance for weighing chemical reagents. Weight boats or other suitable weighing dish are required (a paper cup will suffice)
Laboratory plastic reagent scoops (a plastic spoon will suffice)
Mixing rod. (a plastic or wooden stick will suffice)
Water

10-liter transparent container for mixing waste

Supplies for procedure

Obtain GTC containing liquid waste – Determine amount of Copper (II) sulfate and Sodium thiosulfate to be used using below.

Chemicals required

Chemical	Formula	g/L required (estimate)
Copper (II) Sulfate pentahydrate	$CuSO_4$*5 (H_2O)	450 grams to 1.8 liters or 1800 milliliters; or 225 grams to 0.9 liters or 900 milliliters; or 112.5 grams to 0.45 liters or 450 milliliters
Sodium Thiosulfate pentahydrate	$Na_2S_2O_3$	450 grams to 0.9 liters or 900 milliliters 225 grams to 0.45 liters or 450 milliliters 112.5 grams to 0.22 liters or 225 milliliters

Note: One can use tap or distilled water

Note: Based on the volume to be treated, begin with lower amounts of chemicals and water.

Chemical reagents for precipitation

2. Personal Protective Equipment - Required to protect the employee from exposure

2.1. Nitrile or heavy-duty rubber gloves
2.2. Safety glasses
2.3. Laboratory coat

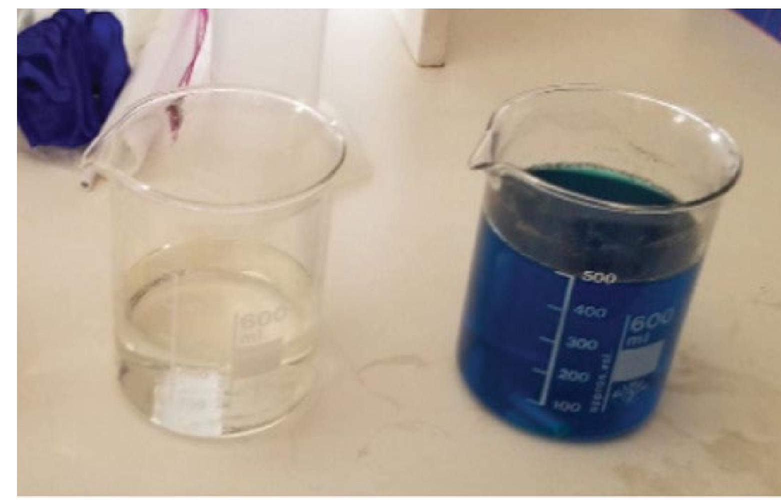
3. Task – Prepare chemicals to be added to a container of GTC containing liquid waste

3.1. Don appropriate PPE.

3.2 Prepare $CuSO_4$ and Na_2SO_3 reagents

3.2.1 To 1.8 liters of water add 450 grams of copper sulfate and dissolve by mixing with a stir rod. Solution will be blue in color. Stir until a majority of the chemical has dissolved. One can use a magnetic mixer with stir bar if available.

3.2.2 To 0.9 liters of water add 450 grams of sodium thiosulfate and dissolve by mixing with a stir rod as well.



Sodium thiosulfate Copper sulfate

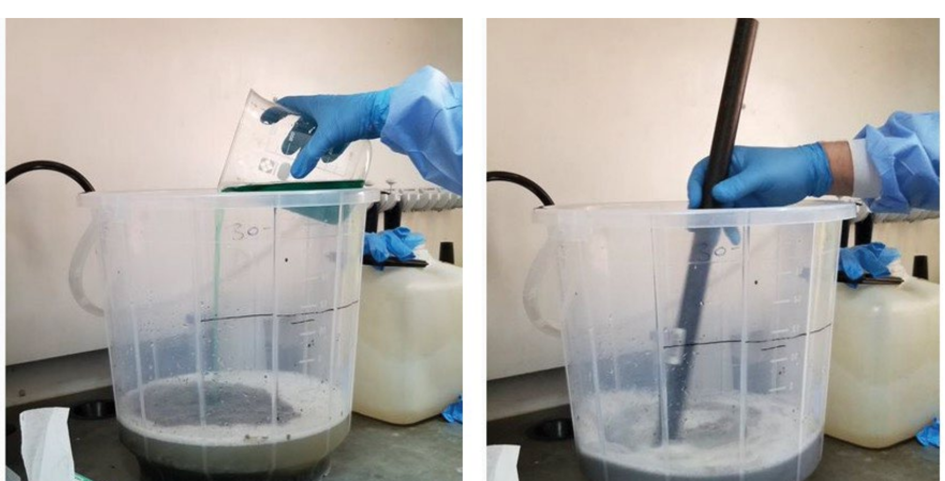
3.2.3 Add the sodium thiosulfate to the copper sulfate solution.

3.2.4 Solution will immediately begin to turn green in color (photo above). In approximately 3 minutes the solution will begin to turn yellow by oxidation in the air. This must be prevented by working quickly to the next step (see below).

GTC solution before adding chemicals

3.3 Precipitation

Once the precipitation reagents have turned uniformly green in color, immediately and quickly add the precipitation reagent to 5 liters of GTC liquid waste.



GTC solutions after adding chemicals

Note: Roche GTC containing chemicals may be of a green/gray color

Note: Abbott m2000 and Alinity may be pink in appearance (See photo below)

Solution after adding Copper (II) sulfate and Sodium thiosulfate

Settle and decant

Allow the solution to settle overnight. Decant supernatant and dispose of it to a sink (photo below) and transfer precipitate into a separate container (glass or metal pan of drying) (Photo below).

Decanting supernatant into the sink

Precipitate into a separate container

Precipitate may be in the following forms:

1. Pudding like consistency
2. Dry / brittle material if baked. Thickness will vary based upon using a shallow versus deep pan

The Copper Thiocyanate CuSCN can disposed of by:

- Mixing with solid infectious waste that will be incinerated
- Mixed with cement for encapsulation
- Sent to a cement kiln for incineration
- Mix with sawdust to a paste-like consistency and incinerate
- Mix with charcoal dust to a paste-like consistency and incinerate
- Mixed with paint for use as a smoothing agent. (about 10% of precipitate by volume while still wet works well)

3. Chemical Analysis Requirements

None required.

4. Task - Cleanup/Disposal

4.1. Clean up all spills of liquid with absorbent towels and discard as solid waste.
4.2. Supernatant can be discarded to the sewer / drain and cuprous thiocyanate (precipitate) can be dried in an oven, air dried, disposed of using the cement encapsulation method, cement kiln, or high-temperature incineration.

5. Task – Labelling

5.1. Label container with:
5.1.1. Site specific information, or
5.1.2. Site specific information written on container
5.1.3. See example:

Generator Name
Address
Name of waste (VL – GTC Precipitant waste
Date

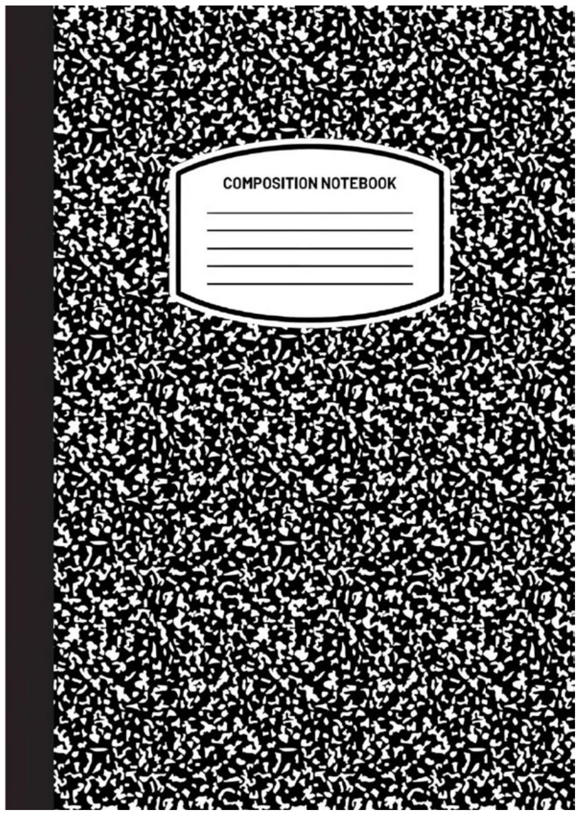
7. Task: Communications (Required to notify individuals responsible to collect waste)

7.1. Contact the laboratory manager to arrange for collection of waste.

7.2. The Laboratory Manager schedules the time and date of waste collection for disposal.

Task: Recordkeeping (Required to document volume/ frequency of waste disposed)

7.3. Upon removal of waste, the laboratory manager or designated person shall document the date and volume of waste removed and its final disposition (location of treatment).



WORK INSTRUCTION G: TRANSBOUNDARY MOVEMENT

Transboundary Movement of waste involves several steps. Facility management needs to coordinate these activities with in-country government officials. Generators should follow the following steps to determine if Transboundary Movement of GTC waste would be feasible.

Steps of Transboundary Movement

Steps 1
Check whether your specific waste is defines as hazardous waste in your country regulations

Steps 2
Contact your country Basel Focal Point

Steps 3
Organize disposal and transport

Steps 4
TBM - Submit notification

Steps 5
TBM - Consent and Issue movement document

Steps 6
TBM - Conduct transboundary movement

Steps 7
TBM - Confirm disposal

Titration and Precipitation Method for GTC containing effluent

WNWN International and the Project stakeholders have developed a precipitation method to remove guanidine thiocyanate (GTC) from liquid waste from HIV VL and EID testing platforms. Development and Assessment of a Waste Management Method for Liquid Effluent Containing Guanidinium Thiocyanate from HIV Viral Load and Early Infant Diagnosis Testing. GTC is the dominant hazardous chemical found in liquid waste from high throughput testing platforms and often requires laboratories to store large quantities of this mixed waste for disposition.
This Work Instruction presents two options for conducting the precipitation procedure. They are shown in **Diagram 1. One involves two steps – titration followed by precipitation. The second involves solely precipitation which is described in Work Instruction F above.** The first option requires procuring additional chemicals to conduct the titration procedure. While there is the additional cost of procuring these chemicals, it allows one to determine the exact amount / concentration of the precipitation chemicals needed, thereby, in the long term, having a lower cost of treatment. Using only the precipitation method is likely to use excess chemicals, thereby being less efficient and likely more costly.

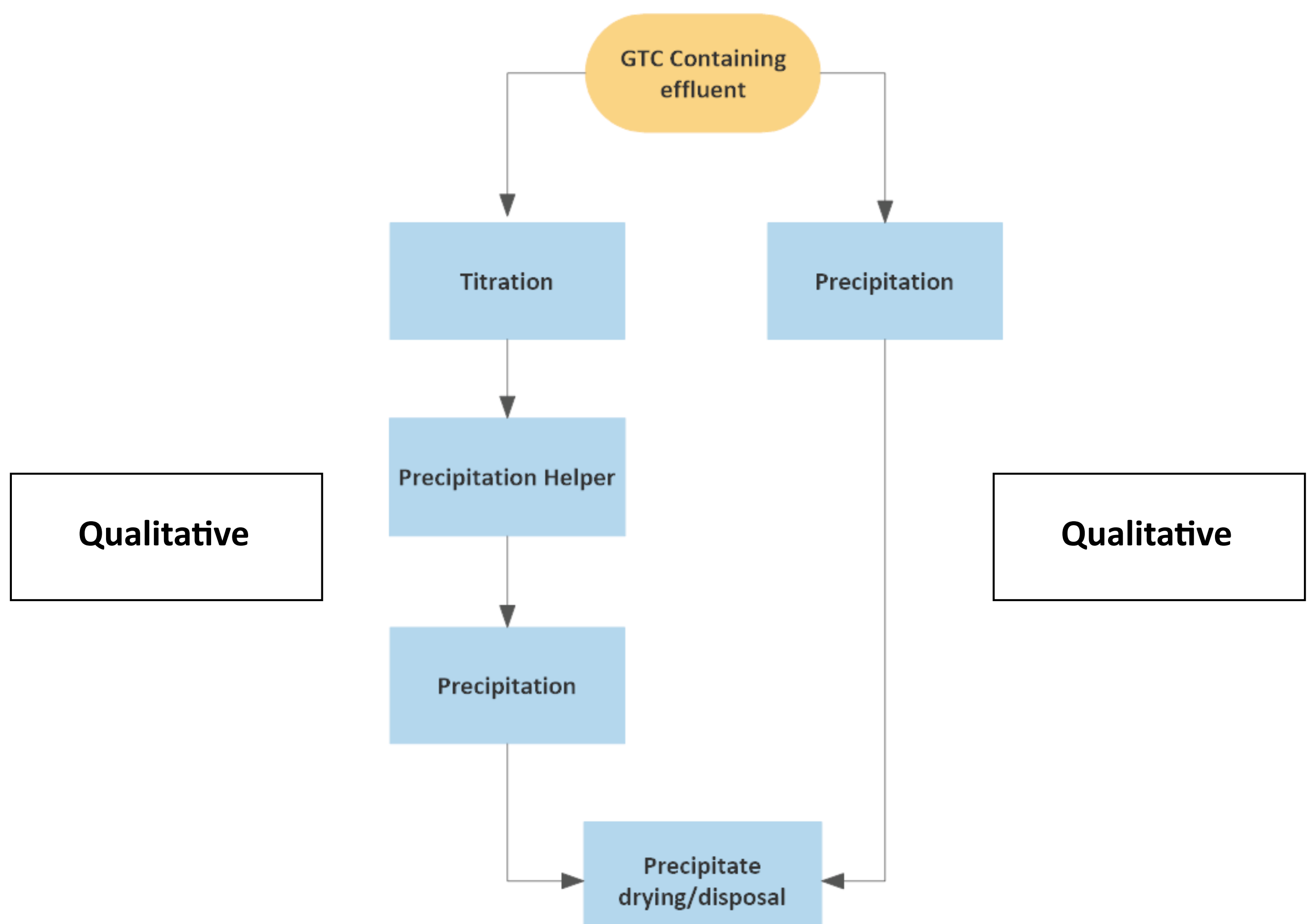


Diagram 1

1. Summary of Work instructions

This instruction describes the steps for bulk (up to 20 Litres) treatment of GTC-containing liquid waste from viral load and EID testing (VL-EID). The procedure has two parts:

Titration: Provides a calculated concentration that quantifies the amount of GTC in VL and EID waste and, in turn, quantifies the amount of chemicals copper (II) sulphate (CuSO4) and sodium thiosulfate (Na2S2O3) needed to perform the precipitation procedure.

Precipitation: results in a precipitate of non-hazardous solid cuprous thiocyanate from the GTC-containing effluent by reacting with CuSO4 and Na2S2O3.
Note: The precipitation method can also be conducted qualitatively and is after the Titration /Precipitation procedure

2. Required Chemicals and Materials

The chemicals and materials required are in Tables 1 and 2, respectively.

Table 1 - Chemicals

Chemical	Formula	CAS	MW	Purpose
Iron (III) Sulfate Pentahydrate, >96%	Fe2(SO4)3*5H2O	142906-29-4	490	For titration
Copper (II) Sulfate Pentahydrate	CuSO4*5(H2O)	7758-99-8	249.69	For precipitation
Sodium Thiosulfate Pentahydrate	Na2S2O3*5H2O	10102-17-7	249.18	For precipitation
Silver Nitrate 0.1N Solution	AgNO3	7761-88-8	169.873	For titration
Nitric Acid 69%	HNO3	7697-37-2	63.013	For titration
Guanidine Thiocyanate	CN3H5*SCN	593-84-0	118.34	Verification Standard and consumed in procedure
Copper(I) Thiocyanate	Cu (SCN)	1111-67-7	121.63	Verification Standard-produced in procedure

Table 2 - Materials

Figure 1:	Mixing container – One 5-liter to 10-liter plastic container. Preferably transparent or translucent or white. It can be any clean plastic bucket.
Figure 2:	Graduated cylinders to measure water for chemical dilutions
Figure 3:	Erlenmeyer Flask – 250ml or larger based upon waste volume to be treated. Alternately any container can be used (food jar) but must be transparent and clean
Figure 4:	Two 1- to-2-Liter containers – such as beakers
Figure 5:	Analytical balance/scale with weigh boats or other suitable weighing dishes (a paper cup or a piece of paper) will suffice, and laboratory scoops or plastic spoons
Figure 6:	Stirring plate, if available. Liquids can be mixed manually
Figure 7:	Mixing rod or a stick
Figure 8:	One pipette (0.25-5.0ml, depending on the concentration of your GTC). It can be automatic and adjustable or a traditional glass pipette. A variable pipette may be necessary.
Figure 9:	Shallow tray for drying precipitate. Note – do not use an aluminum pan
Figure 10:	One burette, typically 50ml (See photo below) or self-leveling burette
Figure 11:	Conical tubes for conducting titration procedure (minimum of 3 per titration)
	Small oven for drying precipitate (optional)

Figure 1: Mixing containers

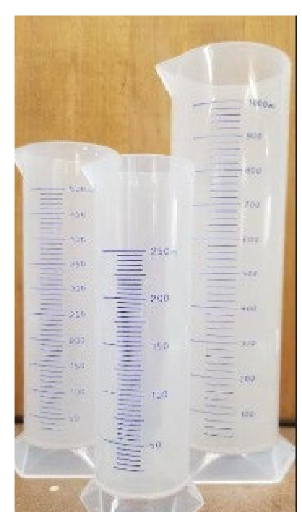


Figure 2: Graduated cylinders to measure water for chemical dilutions

Figure 3: Erlenmeyer Flask – 250ml or larger based upon waste volume to be treated. Alternately any container can be used (food jar) but must be transparent and clean

Figure 4: Analytical balance/scale with weigh boats or other suitable weighing dishes (a paper cup or a piece of paper) will suffice, and laboratory scoops or plastic spoons

Figure 5: Stirring plate, if available. Liquids can be mixed manually

Figure 6: Mixing rod or a stick

Figure 7: One pipette (0.25-5.0ml, depending on the concentration of your GTC). It can be automatic and adjustable or a traditional glass pipette. A variable pipette may be necessary.

Figure 8: Shallow tray for drying precipitate. Note – do not use an aluminum pan

Figure 9: One burette, typically 50ml or self-leveling burette (see photo above)

Figure 10: Conical tubes for conducting titration procedure (minimum of 3 per titration) Methods

TITRATION PROCEDURE FOLLOWED BY PRECIPITATION

3.0 Determine the concentration of GTC in effluent waste solution

A. Pipette a 0.25-5ml aliquot of analyte (GTC containing liquid waste sample) into a 250ml Erlenmeyer flask.

B. A more concentrated sample will require a smaller sample to produce a titration volume that doesn't waste material and provides enough statistical significance. Concentrated 50% GTC samples will only require a 0.25ml sample while dilute effluent waste samples may need significantly more solution (up to 5ml). A 50% GTC sample of 500g of GTC dissolved into 1.00 liter of water. Table 3 below guides sample sizes to keep a titration between 10 and 25ml.

Table 3: Guide for titration values

Expected g/l GTC	Titrant conc (AgNO3)	MW GTC	Expected titration volume (low-end) ml	The expected Sample volume required (low-end) ml	Titration-(High end ml	Sample (high-end) ml
500	0.1	118	10	0.236	25	0.59
250	0.1	118	10	0.472	25	1.18
125	0.1	118	10	0.944	25	2.36
80	0.1	118	10	1.475	25	3.68
50*	0.1	118	10	2.36	25	6.9

* GTC control sample for titration procedure

C. Add 75-100ml of DI (deionized) water (H2O) to increase the volume. DI Water is required because tap water almost always contains Chlorides, forming a white precipitate with silver and interfering with precipitation. If the chlorides are below 30 mg/L, the analyst may use tap water.

D. The analyst should use iron sulfate as an indicator of titration of waste sample solution. See Table 4 below for an example of the expected red color. Add between 0.10g and 2.5g of this indicator. If unsure, add 2.5g of Fe2(SO4)3.

1. As an alternative, iron sulfate may be pre-dissolved in an acidic solution as follows:
   i. 30ml of DI H2O
   ii. 2 drops of concentrated HNO3
   iii. 3g of Fe2(SO4)3
   iv. Mix and store in a sealed containers

2. Add 1-3ml of this solution to each flash before titrating. A transfer pipette or medicine dropper are ideal for this application.

Table 4: The amount of indicator to add for each 1ml of sample titrated per GTC concentration

g/l GTC	Sample size (ml)	MW $FeSO_4$	MW GTC	moles Fe reqd.	g $Fe_2(SO_4)_3$ reqd.
500	1	490	118	4.24	2.08
250	1	490	118	2.12	1.04
125	1	490	118	1.06	0.52
80	1	490	118	0.68	0.33
50	1	490	118	0.42	0.21

E. Add 0.5ml (approximately ten drops) of 69% concentrated HNO_3 and mix well. You may also use H_2SO_4 (sulfuric acid), but do not use HCl (hydrochloric acid) as it will interfere with the reaction leading to invalid results.

F. Titrate the waste solution (containing the red $FeSO_4$ indicator) using the 0.10N $AgNO_3$ in the burette to a white endpoint (the red color will disappear) by slowly adding the $AgNO_3$ to the beaker while gently mixing. When the red color is gone, stop adding the $AgNO_3$ solution.

G. Record the endpoint (the amount of $AgNO_3$ in milliliters added) from the reading on the burette.

See Figures 1 through 5 below for the titration steps

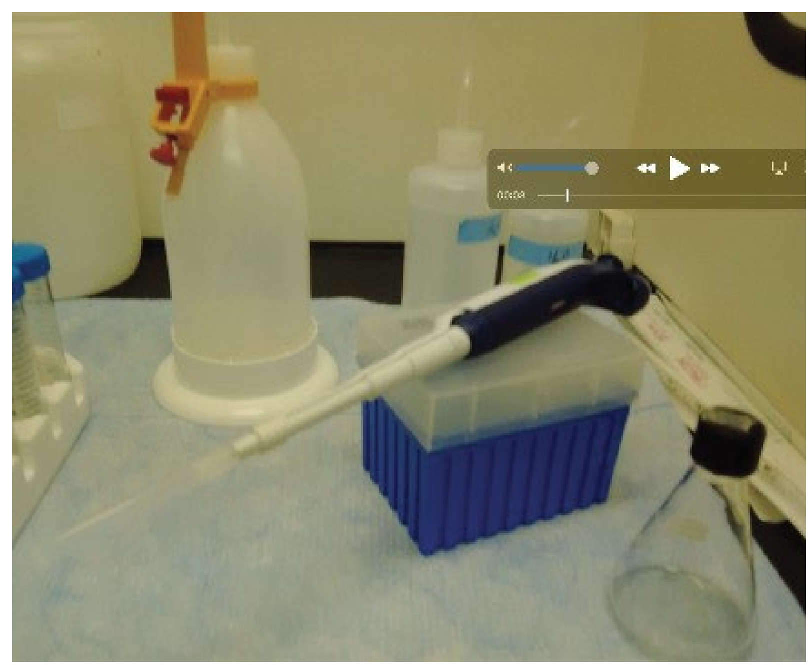


Figure 1: Titration setup. Burette, Erlenmeyer Flask, and Pipette.

Figure 2: Color before and after titration
Additional image examples are depicted below.

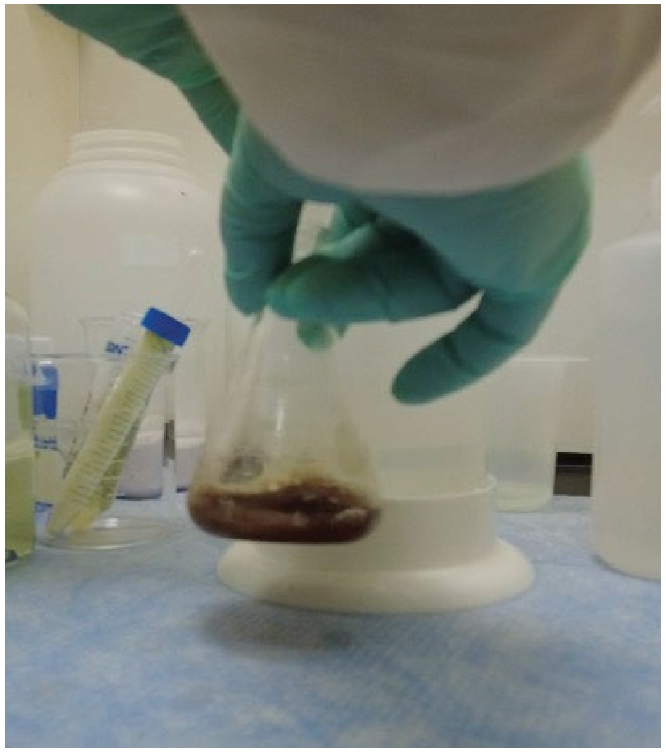


Figure 3: Titration example of the initial color

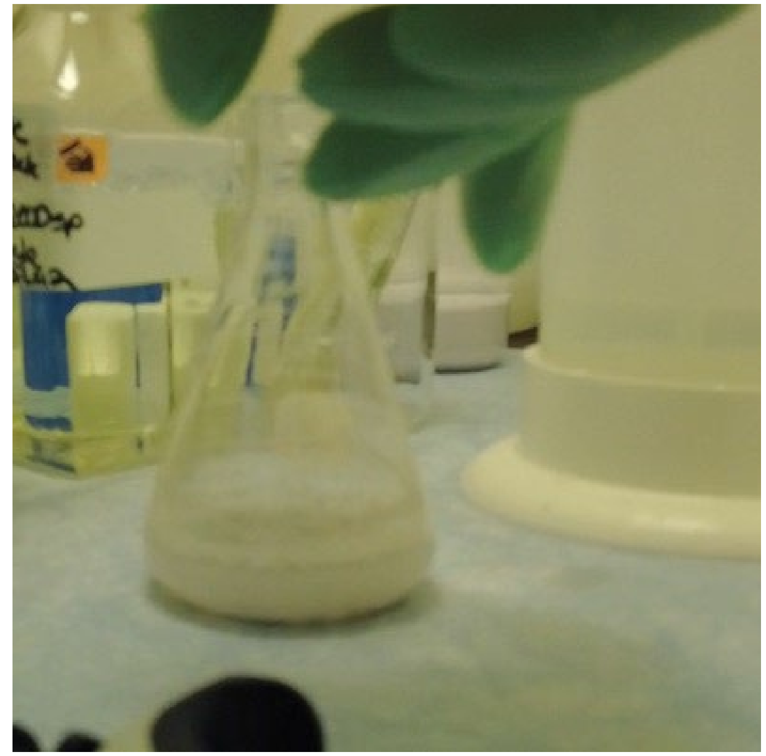


Figure 4: Titration example color at the end of titration

Figure 5: Titrating into a conical tube (instead of an Erlenmeyer flask)

H. Calculate the final concentration of GTC in the waste sample using this formula

$$\frac{g}{l}GTC = \frac{titrant\ vol\ (ml) * titrant\ conc\ (M) * MW\ GTC}{vol\ waste\ sample\ (ml)}$$

I. Example:
A 5ml sample of solution (vol waste sample) is taken and titrated vs. 0.1M $AgNO_3$ (titrant). The Molecular Weight of GTC is 118 g/mol (MW GTC). If you needed 20ml of $AgNO_3$ to change the color of the waste solution to a white (not red) endpoint (titrant vol), what is the concentration of GTC in your sample?

$$\frac{g}{l}GTC = \frac{20(ml) * 0.1(M) * 118\ g/mol}{5\ (ml)}$$

$$\frac{g}{l}GTC = 47.2\ g/l$$

Once the concentration of the GTC is known, it can inform the subsequent steps below for the "Precipitation Helper (separate Excel sheet) and Quantitative Precipitation Procedure" below.

3.2 Precipitation of Guanidine Thiocyanate – Quantitative

This procedure is used when the concentration of GTC in the bulk waste has been determined by the quantitative titration method above.

A. **Prepare the Copper sulfate (CuSO4) solution**

For every 1g/l of GTC x liters of the solution to be treated, add 2.11 g of CuSO4 into a container and dissolve into 7 ml of water for each g of CuSO4. This is easiest with a stir bar.

Example: A 1-liter solution of 5% (50 g/l) GTC

$$\frac{50g}{l} \times 1l\ x2.11 = 105.5g\ CuSO4$$

Dissolve 105.5 g $CuSO_4$ into enough water to dissolve properly.
The solubility of $CuSO_4$*$5H_2O$ is 316 g/liter.
316 g / liter equates to 0.316 grams/milliliter
105.5 grams / .316 grams = 334 ml of water

B. **Prepare the $Na_2S_2O_3$ solution**

Use the same amount of $Na_2S_2O_3$ as $CuSO_4$ in grams, as in step 3.2 above.

Example: a one-liter solution of 5% GTC using 105.5 g of $CuSO_4$ would also use 105.5 g of $Na_2S_2O_3$
Dissolve in just enough water to become soluble. The solubility of $Na_2S_2O_3$ is 700 g/liter.

700 grams / liter equates to .7 grams/milliliter

If the amount (grams) of sodium thiosulfate needed is the same as $CuSO_4$, 105.5 grams / 0.7 grams = 151 ml of water

C. **Add the $Na_2S_2O_3$ to the $CuSO_4$. The solution color** will change from blue to green.

Figure 6: CuSO4 color before combining solutions

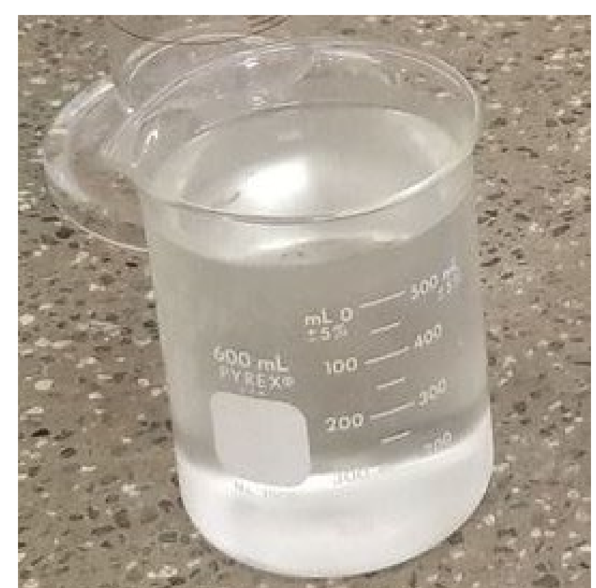


Figure 7: Na2S2O3 color before adding to $CuSO_4$

Figure 8: Solution changing from blue to green

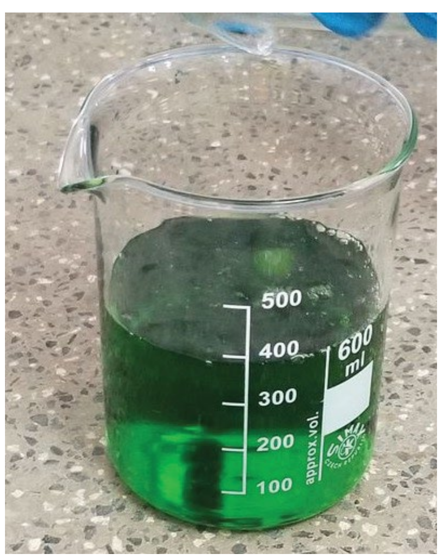


Figure 9: Color after combining solutions

Note: This combined solution of copper sulfate and sodium thiosulfate must be used within 5 minutes of mixing and is not shelf stable.

D. Add sodium thiosulfate/copper sulfate solution to the main batch of GTC waste effluent and stir.

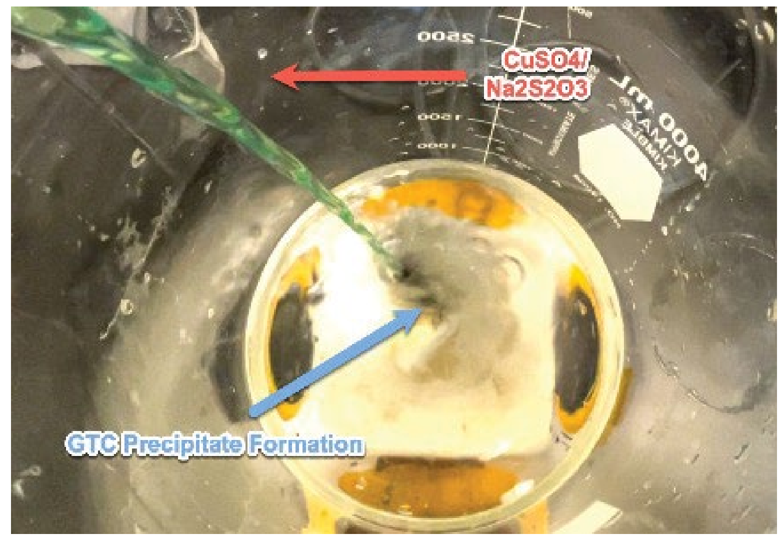


Figure 10: Adding chemical reagent to waste to precipitate GTC

After adding the chemical reagents to the effluent waste, the solution must be allowed to settle so that the precipitate is at the bottom of the container.

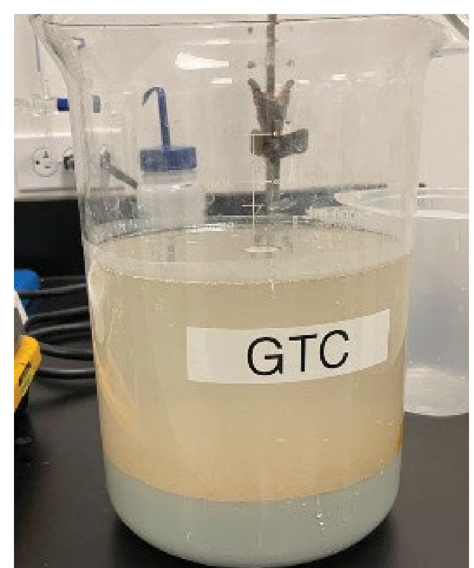
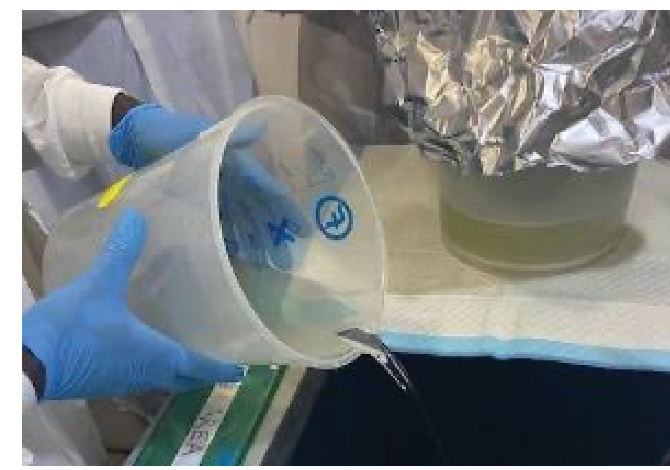


Figure 11: Precipitate settled to the bottom of a container

Adding this green solution to the waste effluent initiates the precipitation reaction to remove the GTC.

Note: Document the color change to the solution.

E. Settle and decant
Allow the solution to settle overnight. See Figure 12 above. Decant supernatant and dispose of it.



Decanting supernatant into the sink

Figure 12: Decanting supernatant into a sink

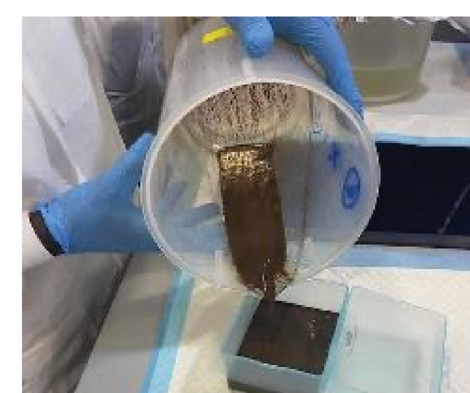


Figure 13: pouring precipitate into a separate container. In this case, the precipitate is a dark color.

The precipitate is Copper Thiocyanate (CuSCN). The precipitate may be in the following forms:

1. Paint-like consistency
2. Pudding-like consistency if moisture is allowed to evaporate over several days
3. Dry/brittle material if baked. The thickness will vary based on using a shallow versus deep pan. Material may still be pudding-like in consistency

The CuSCN-containing precipitate can be disposed of by:

Mixing with solid infectious waste that will be incinerated
Mixed with cement for encapsulation
Sent to a cement kiln for incineration
Mix with sawdust to a paste-like consistency and incinerate

Mix with charcoal dust to a paste-like consistency and incinerate
Mixed with paint for use as a smoothing agent. (about 10% of precipitate by volume while still wet works well)

Mixed with paint for use as a smoothing agent. (about 10% of precipitate by volume while still wet works well)

GTC Waste Precipitation Helper

The GTC Waste Precipitation Helper can be utilized to assist in determining the exact amount of precipitation chemicals that are required when the GTC concentration is known as a result of performing the Titration Protocol on pages 70-80 of this guidance document. Data that needs to be entered includes the "Effluent Waste Batch Volume" and "Concentration of GTC."

Precipitation Method Helper			Step
Effluent Waste Batch Volume	5.0 L		
Concentration of GTC	50.0 g/L		
STEP1: Dissolve Copper Sulfate (CuSO4) in water		Copper Sulfate Information	1
528	g of CuSO4 required		
3693	ml of water in which to dissolve the CuSO4		
Step 2: Dissolve Sodium Thiosulfate (Na2S2O3) in water		Sodium Thiosulfate Information	2
528	g of Na2S2O3 required		
1583	ml of water in which to dissolve the Na2S2O3		
Step 3: Combine Solutions from step 1 and step 2		Combine Solutions	3
Will turn green. Solution is only stable <3 minutes. Use quickly!			
Step 4: Add solution from step three to effluent waste			4
Add contents of reagent to effluent waste and stir		Precipitate GTC from waste	
This should turn white/green/pink depending platform with formation of precipitate.			
Step 5: Settle and Decant			5
Allow to settle overnight and decant water from precipitate Water can be disposed of down the sink in some locations Precipitate can be sent to a cement kiln, bagged and disposed into a landfill, or sold as a reagent to other users (paint companies)			

WASTE DISPOSAL MULTI CRITERIA ANALYSIS TREATMENT OPTION MATRIX - GTC LIQUID WASTE AND CARTRIDGES

- **Methods:** Lists the current disposal options in alphabetical order that are being considered and researched to date as part of this project.
- **Factors to be considered in the selection of a disposal option (This is not an exhaustive list):**

  - **Availability:** The degree to which a waste disposal option is accessible, operable, or obtainable within a country.

  - **Cost*:** Each option must be assessed for costs that could include material, labor, and treatment/disposal costs. Examples of factors associated with costs are provided below*.

  - **Complexity:** Some disposal options may be considered complex as they will require a higher skillset by the personnel performing the disposal method.

  - **Environmental Hazard:** Impacts to the environment would include air, water and land.

  - **Human Toxicity:** Impacts to human toxicity dovetail with environmental hazards. There may be short term public health impacts that occur during the treatment of a waste stream.

  - **Regulatory Compliance:** Many countries have evolving regulations/licensing requirements that could apply to the activities described here. It is important for the producers of waste to review regulatory requirements and discuss them with the appropriate authorities for the disposal of the GTC-containing waste streams as there could be costs associated with obtaining a license.

  - **Worker Hazard:** There will be varying occupational hazards associated with each of the methods of disposal that will require specific protective equipment for staff.

*** Factors to consider for cost include but are not limited to:**

Fee for service	Equipment operating costs
Fee for transport	Labor
Fee for consumable	Personal Protective Equipment
Fee for treatment equipment	Final disposal if there is an end product

Information on these factors will continue to evolve as countries implement solutions. This information is to be entered in a “Country Cost Table” (section VII below) to assist with completing the decision matrix.

Waste Disposal Multi Criteria Analysis Treatment Option Matrix - GTC Liquid waste and Cartridges

Select the Matrix scheme below to enter values

Method	Availability	Cost	Complexity	Environmental hazard	Human Toxicity	Regulatory Compliance	Worker Hazard	Total Score
Cement Inertization[a]								
Cement Kiln[*b]								
Cement Kiln - Waste mixed with charcoal or sawdust[c]								
Hi Temp Incinerator[*d]								
Hi Temp Incinerator with charcoal or sawdust[e]								
Precipitation[f]								
Trans Boundary Movement[g]								

* Disposal option for cartridges

Note: Scoring scale is 1 to 5 (1 = Least favorable / 5= Most favorable). Scoring is subjective.

Comments

a. Currently limited to small volumes of liquid <20 liters as cement/liquid mixture will weigh 20 kg/ 44 lbs.
b. Some but not all cement kilns have introduced material handling equipment to process 5-, 10-, or 20-liter containers of GTC waste (liquid or cartridges. This needs to be confirmed with the cement kiln vendor if available in the country.
c. Use of ground charcoal or charcoal dust and sawdust will incur additional costs (materials and labor). This may not be required by cement kilns, but it does provide calorific value to the process.
d. Operators must determine the method of introducing GTC liquid waste, which is usually non-flammable, into the incinerator. Fluid injection systems could make the management of such liquids easier but require specific equipment and training of staff for proper operation.
e. As with cement kilns, use of ground charcoal or charcoal dust and sawdust will incur additional costs (materials and labor). The appropriate ratio/mixture of liquid to ground charcoal or charcoal dust/sawdust will also need to be determined.
f. Cost of chemicals will need to be determined based upon the amount of liquid to be processed.
g. Use this method when storage of waste is not an option as well as no in country disposal method is deemed acceptable

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