Use of Hydrogen Peroxide and UV to Degrade GTC in VL/EID Liquid Waste, Uganda experience

Joel Peter Opio

Lab System Branch,

CDC-Uganda

July 2024

Presentation Layout

- National guiding Documents on liquid waste management
- National Lab network
- Central Public Health Laboratories (CPHL)
- VL and EID Centralized testing Volume
- Waste Burden (Solid & Liquid)
- Alternative Liquid Waste Management Method

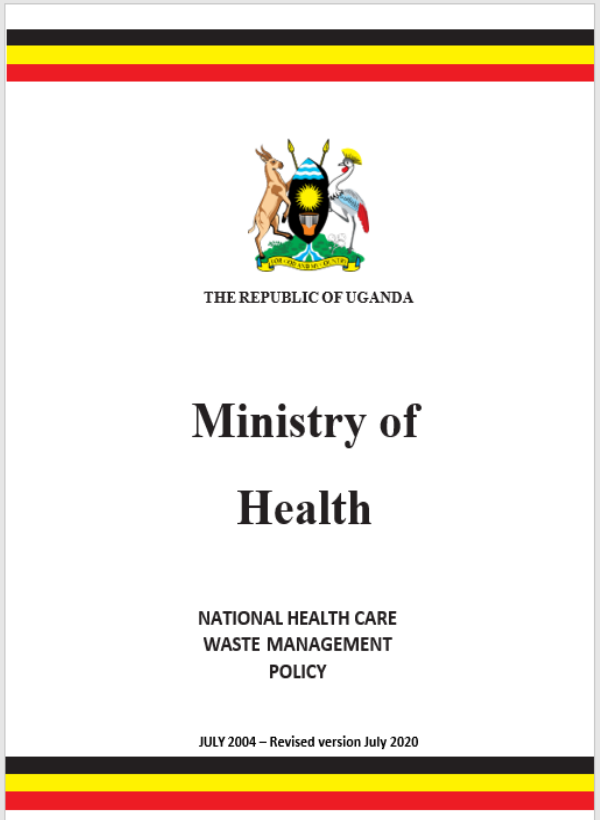
National Healthcare Waste Management Documents

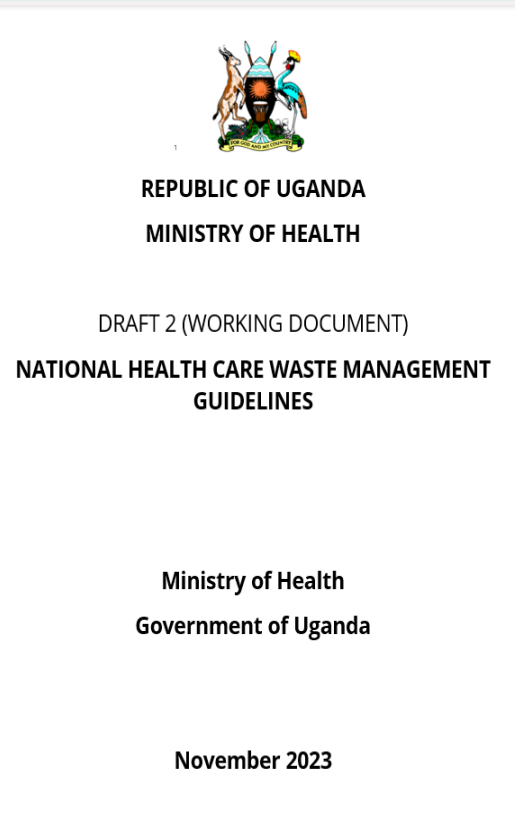
1. National policy for Healthcare waste management policy.

- Since 2004, currently under review by MoH.
- **"POLICY OBJECTIVES 5.3.4:** *To ensure that liquid chemical waste and potential wastewater from isolation wards are treated separately*".

2. **National implementation guidelines for Healthcare waste.**

- Under review my MoH.
- **Effluents**: *Effluents and more particularly, effluents from isolation wards and medical diagnostic laboratories, should be considered as hazardous liquid waste that should receive specific treatment before being discharged into the sewerage/drainage system*





The documents don't provide specific procedures for treatment of GTC in liquid waste

The national Specimen Transportation and Results Network through the Hubs system

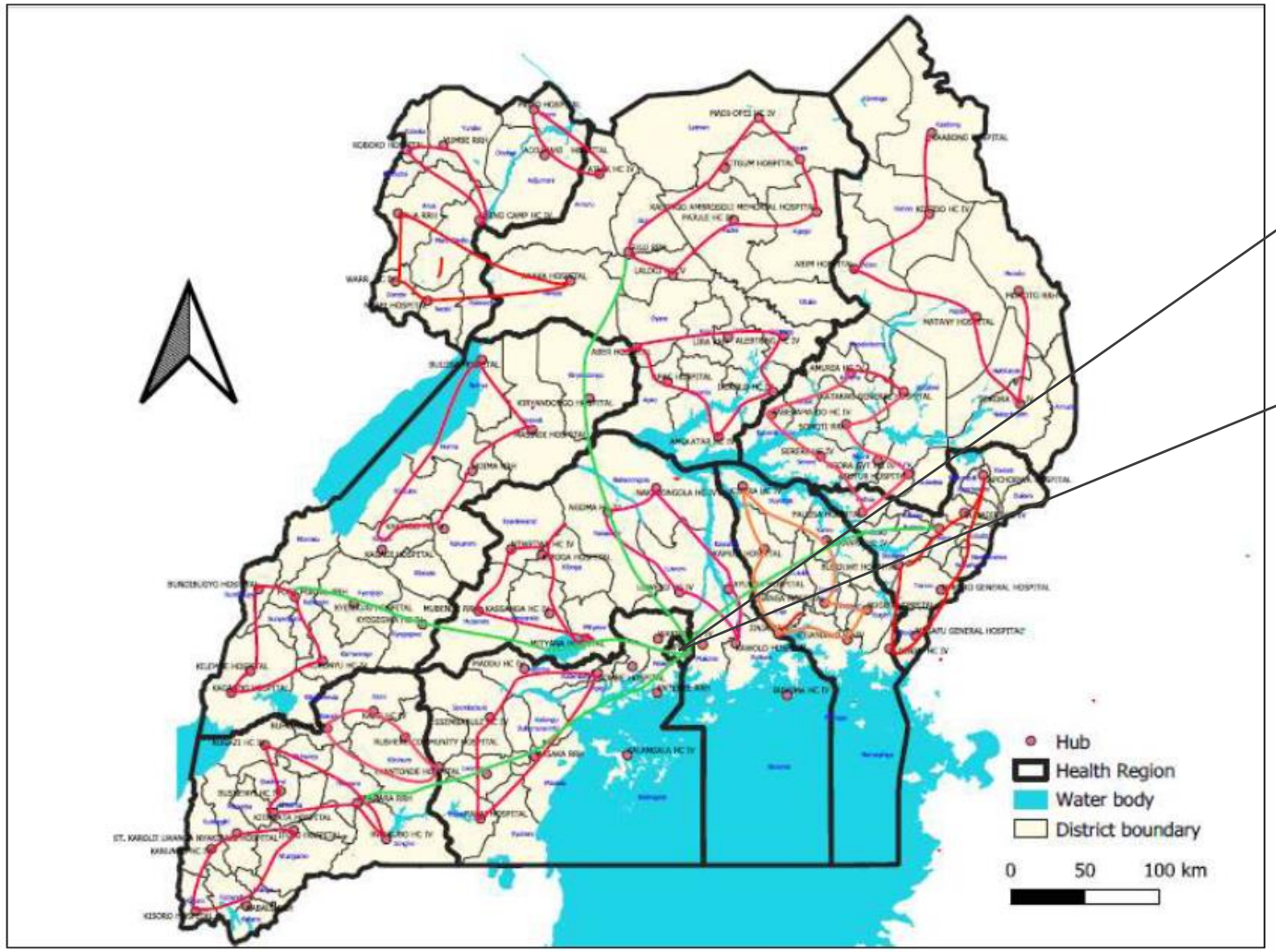
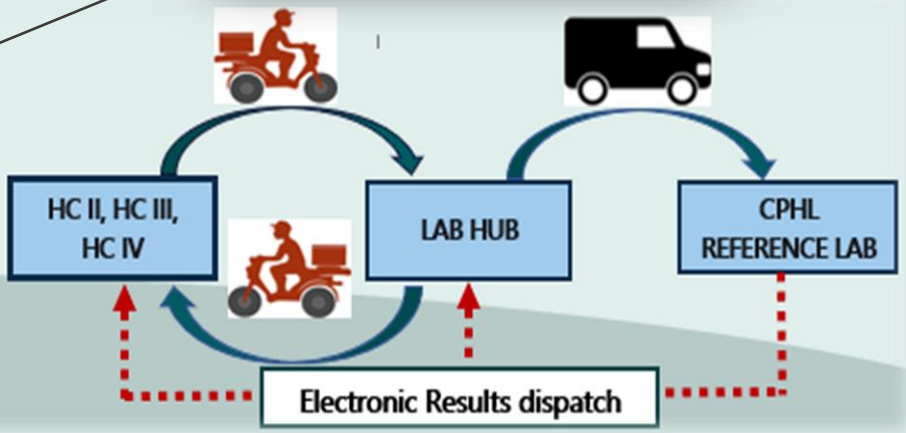


Fig 3: The National Health Lab hub and Sample Transport Network revised to include trunk vehicles, where no Posta services are available.

CPHL



Central Public Health Laboratories (CPHL)

- CPHL is located about 10kms from Kampala City.
- CPHL comprises of the:
  - National VL, EID & HIVDR Lab – (Accredited to ISO 15189),
  - National Microbiology Reference Lab – (Accredited to ISO 15189),
  - National Equipment Calibration Laboratory – (Accredited to ISO 17025)
  - Sickle cell & malaria Reference Lab,
  - PT panel preparation Lab & National biorepository, among others
- Generates over 1000 Kgs of waste daily

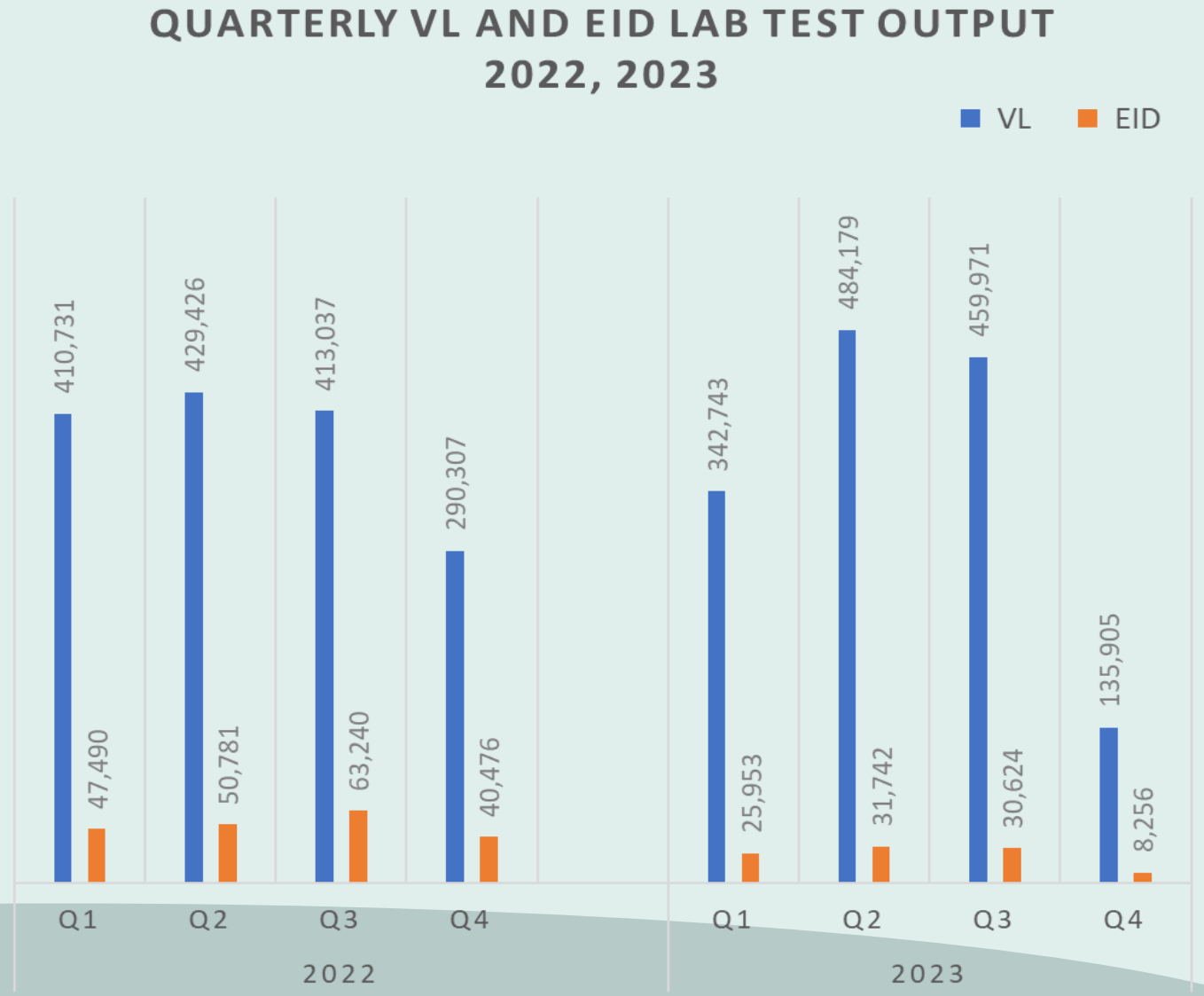
ISO 15189 Accredited VL/EID & HIVDR Lab

VL and EID Centralized testing Volume

Tests over **1.5 million** VL & EID tests annually

VL and EID Molecular Platforms

Equipment	Number
Roche Cobas 8800	2
Abbott Alinity	7
Hologic	3



Waste Burden (Solid & Liquid)

1 Solid waste

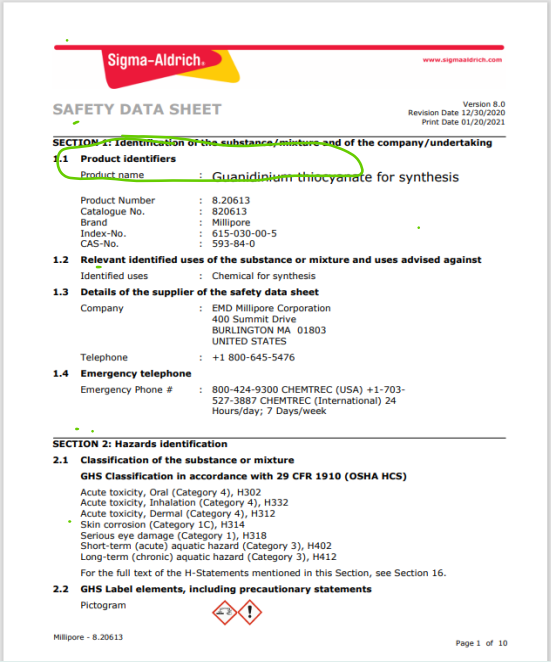
- Increased VL/EID waste generation due scale-up in 2018.
- About 12 tones per month

2 Liquid Waste

- About **100,000 total** liters per month.
- **12,000** liters from VL/EID platforms/month

3 Guanidinium thiocyanate

Material Safety Data Sheet (MSDS)



Sigma-Aldrich.

www.sigmaaldrich.com

SAFETY DATA SHEET

Version 8.0
Revision Date 12/30/2020
Print Date 01/20/2021

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifiers

Product name : Guanidinium thiocyanate for synthesis

Product Number : 8.20613
Catalogue No. : 820613
Brand : Millipore
Index-No. : 615-030-00-5
CAS-No. : 593-84-0

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Chemical for synthesis

1.3 Details of the supplier of the safety data sheet

Company : EMD Millipore Corporation
400 Summit Drive
BURLINGTON MA 01803
UNITED STATES

Telephone : +1 800-645-5476

1.4 Emergency telephone

Emergency Phone # : 800-424-9300 CHEMTREC (USA) +1-703-527-3887 CHEMTREC (International) 24 Hours/day; 7 Days/week

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)

Acute toxicity, Oral (Category 4), H302
Acute toxicity, Inhalation (Category 4), H332
Acute toxicity, Dermal (Category 4), H312
Skin corrosion (Category 1C), H314
Serious eye damage (Category 1), H318
Short-term (acute) aquatic hazard (Category 3), H402
Long-term (chronic) aquatic hazard (Category 3), H412

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Millipore - 8.20613

Page 1 of 10

The Liquid Waste Burden Cont……

12,000 liters translates into about 120 drums of water to illustrate

- Ferried every 2 weeks by an external service provider at the cost of USD 2000 per collection.
- The service provider disposes the waste at the military facility.
- Final disposal site at the military facility is highly restricted thus unknown to the central lab
- Disposal such volumes can't be ignored

The liquid waste is stored in an underground containment tank

Alternative Liquid Waste Management Method

The quest for control of final disposal of GTC containing liquid waste and the cost associated to its disposal prompted us to look for a sustainable solution.

The Objectives

- Destroy cyanide in the liquid waste generated by VL/EID testing platforms.
- Gain control of the final disposal and avoid reliance on an external entity including possible litigation as a result inappropriate management.
- Cut down on the increasing costs dependent on the oil prices and service providers

Justification

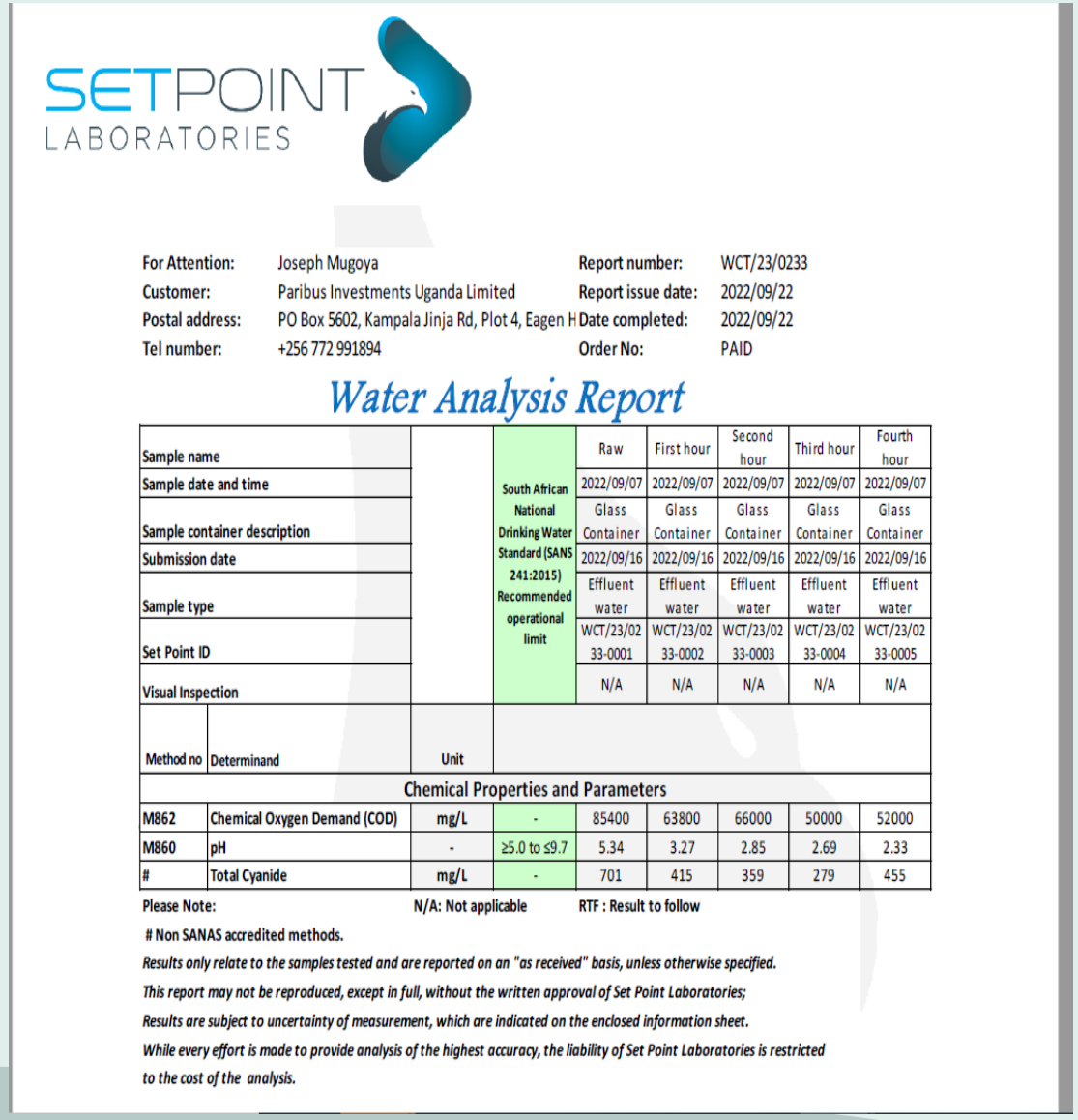
- The quantity of the liquid waste generated (400 liters **per day**), and risk of GTC as highlighted in the MSDS for VL/EID reagents required attention.

- Characterization confirmed presence of cyanide in the liquid waste and other stubborn materials (recalcitrant).

- The analysis of the samples was done in an accredited lab called Set point, South Africa.

Justification Cont……..

- The initial tested conduct indicated presence of **total cyanide levels in the range of 400mg/l - 700mg/l**.
- This is way above the NEMA recommended maximum levels of 0.1 mg/l
- In addition, there was contamination due to minerals such as: chromium, selenium, manganese, Nickel and Titanium in micrograms, which can be a threat if bioaccumulated in the environment.



SETPOINT LABORATORIES

For Attention:	Joseph Mugoya	Report number:	WCT/23/0233
Customer:	Paribus Investments Uganda Limited	Report issue date:	2022/09/22
Postal address:	PO Box 5602, Kampala Jinja Rd, Plot 4, Eagen H	Date completed:	2022/09/22
Tel number:	+256 772 991894	Order No:	PAID

Water Analysis Report

Sample name			South African National Drinking Water Standard (SANS 241:2015) Recommended operational limit	Raw	First hour	Second hour	Third hour	Fourth hour
Sample date and time				2022/09/07	2022/09/07	2022/09/07	2022/09/07	2022/09/07
Sample container description				Glass Container	Glass Container	Glass Container	Glass Container	Glass Container
Submission date				2022/09/16	2022/09/16	2022/09/16	2022/09/16	2022/09/16
Sample type				Effluent water	Effluent water	Effluent water	Effluent water	Effluent water
Set Point ID				WCT/23/02 33-0001	WCT/23/02 33-0002	WCT/23/02 33-0003	WCT/23/02 33-0004	WCT/23/02 33-0005
Visual Inspection				N/A	N/A	N/A	N/A	N/A
Method no	Determinand	Unit						
Chemical Properties and Parameters								
M862	Chemical Oxygen Demand (COD)	mg/L	-	85400	63800	66000	50000	52000
M860	pH	-	≥5.0 to ≤9.7	5.34	3.27	2.85	2.69	2.33
#	Total Cyanide	mg/L	-	701	415	359	279	455

Please Note: N/A: Not applicable RTF : Result to follow

Non SANAS accredited methods.

Results only relate to the samples tested and are reported on an "as received" basis, unless otherwise specified.

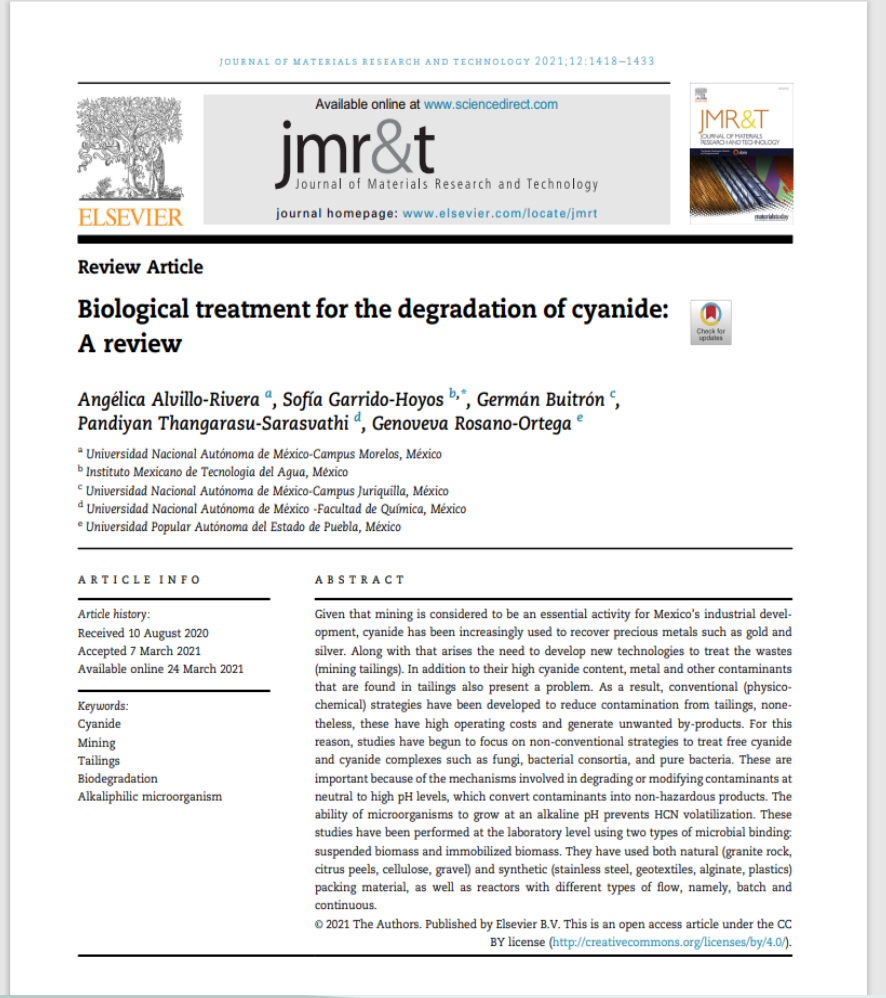
This report may not be reproduced, except in full, without the written approval of Set Point Laboratories;

Results are subject to uncertainty of measurement, which are indicated on the enclosed information sheet.

While every effort is made to provide analysis of the highest accuracy, the liability of Set Point Laboratories is restricted to the cost of the analysis.

The Intervention

- The literature review indicated that Cyanide could get eliminated by advanced oxidation approaches involving:
  - *Ozonation/UV,*
  - *Hydrogen peroxide/UV*
  - Incineration
  - Plasma arc,
  - Bioremediation



JOURNAL OF MATERIALS RESEARCH AND TECHNOLOGY 2021;12:1418–1433

Available online at www.sciencedirect.com

jmr&t Journal of Materials Research and Technology

journal homepage: www.elsevier.com/locate/jmrt

ELSEVIER

Review Article

Biological treatment for the degradation of cyanide: A review

Angélica Alvillo-Rivera [a], Sofía Garrido-Hoyos [b,*], Germán Buitrón [c], Pandiyan Thangarasu-Sarasvathi [d], Genoveva Rosano-Ortega [e]

[a] Universidad Nacional Autónoma de México-Campus Morelos, México
[b] Instituto Mexicano de Tecnologia del Agua, México
[c] Universidad Nacional Autónoma de México-Campus Juriquilla, México
[d] Universidad Nacional Autónoma de México -Facultad de Química, México
[e] Universidad Popular Autónoma del Estado de Puebla, México

ARTICLE INFO

Article history:
Received 10 August 2020
Accepted 7 March 2021
Available online 24 March 2021

Keywords:
Cyanide
Mining
Tailings
Biodegradation
Alkaliphilic microorganism

ABSTRACT

Given that mining is considered to be an essential activity for Mexico's industrial development, cyanide has been increasingly used to recover precious metals such as gold and silver. Along with that arises the need to develop new technologies to treat the wastes (mining tailings). In addition to their high cyanide content, metal and other contaminants that are found in tailings also present a problem. As a result, conventional (physicochemical) strategies have been developed to reduce contamination from tailings, nonetheless, these have high operating costs and generate unwanted by-products. For this reason, studies have begun to focus on non-conventional strategies to treat free cyanide and cyanide complexes such as fungi, bacterial consortia, and pure bacteria. These are important because of the mechanisms involved in degrading or modifying contaminants at neutral to high pH levels, which convert contaminants into non-hazardous products. The ability of microorganisms to grow at an alkaline pH prevents HCN volatilization. These studies have been performed at the laboratory level using two types of microbial binding: suspended biomass and immobilized biomass. They have used both natural (granite rock, citrus peels, cellulose, gravel) and synthetic (stainless steel, geotextiles, alginate, plastics) packing material, as well as reactors with different types of flow, namely, batch and continuous.

The Intervention Cont…..

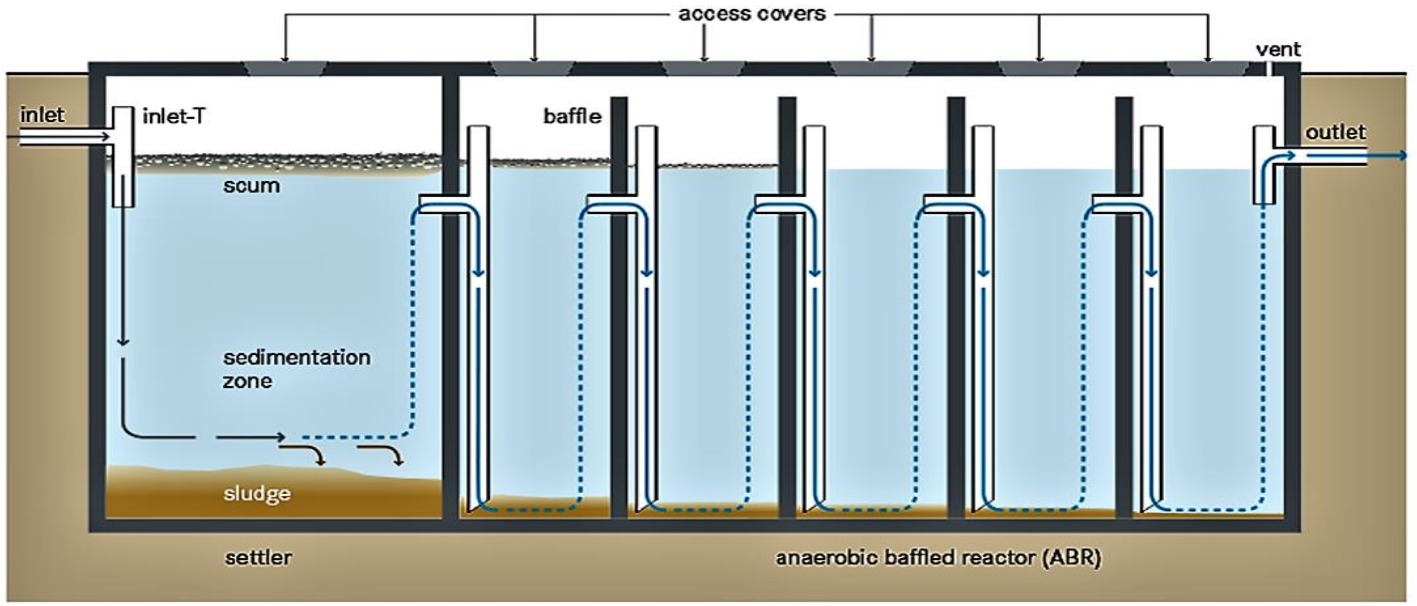
Ozonation/UV

- Involves a big and often complicated kit particularly in ozone generation.
- Require air compressors, air filters, cooling water, need for a lagoon

system designed to cover most needs in disinfection and treatment in versatile environments and industries such as large breweries, pharmaceutical production and process manufacturing.

RENA Vivo C-series

The C-series is our highest capacity ozone system of the Vivo range, designed to solve complex treatment challenges such as break-down of pharmaceutical residues and complex substances. It is a perfect solution for ensuring large flows and volumes of high quality process water supply. It is delivered with an integrated oxygen generator or external oxygen supply.



The Intervention Cont……

Hydrogen peroxide /UV

- Selected as the method of choice.
- The requirements for set up are less elaborate compared to the other methods.
- Can be accommodated in small space,

LabClean Machine (Enviolet™)

Hydrogen peroxide/UV Method - Key Elements

1. Strategy

- Breakdown the nitrile bond in cyanide
- This is the bond which is central to cyanide toxicity & resilience in GTC.
- When this bond is broken, the byproducts are friendly

2. Set up

- Lab clean plus accessories
- Cyanide testing kit
- Ph tester
- Temperature Meter
- Hydrogen Peroxide
- Fume Hood

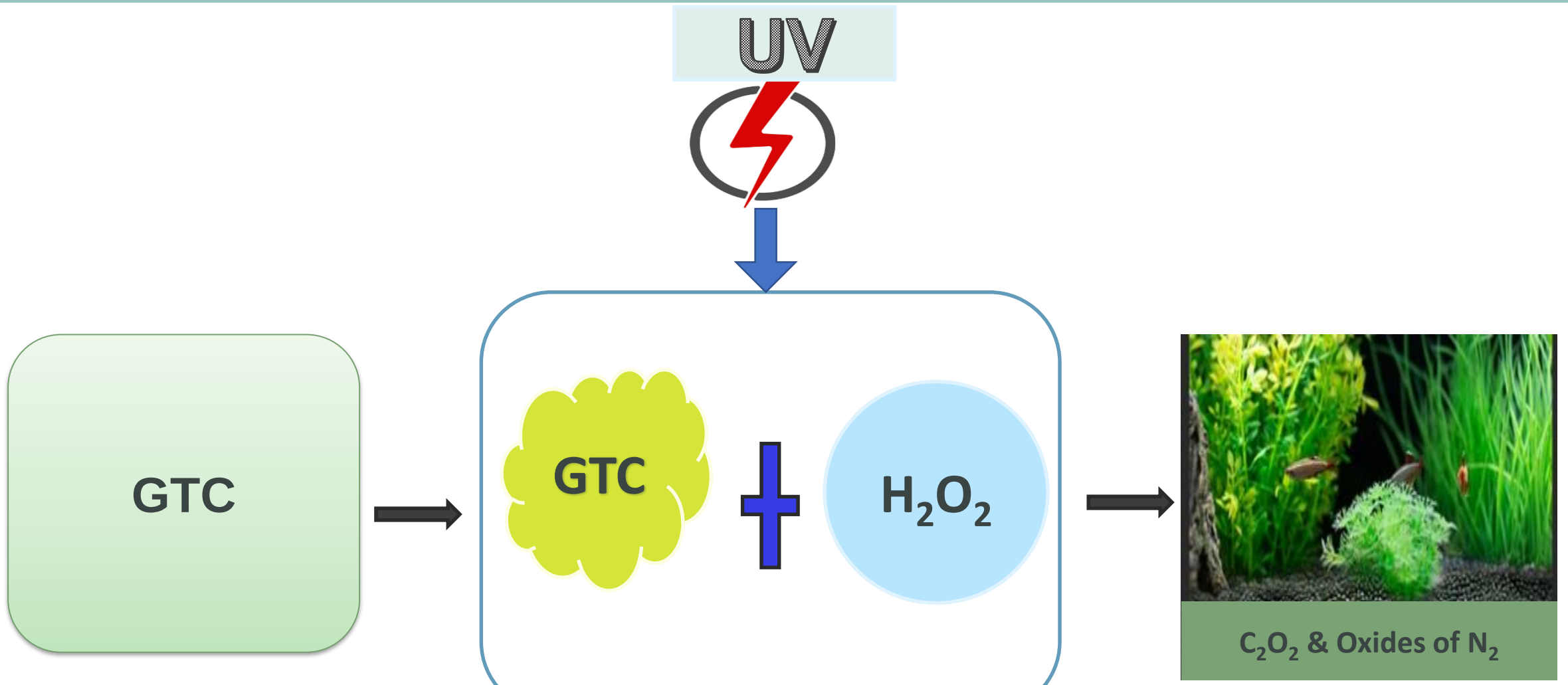
3. Procedures

- GTC waste is treated with Hydrogen peroxide in presence of UV Light at ambient temperature and pH for a period of 1-2 hrs. The process is performed under a fume hood to exhaust any hazardous emissions that may have been released inadvertently.
- Checks are carried out to establish that cyanide is degraded to undetectable levels

4. Outcome

- Results from the accredited - Set point a sub subsidiary of Wear Check, South African based lab reveled that the total cyanide present in the treated product was below **0.07mg/l**
- The concentration is way below the NEMA acceptable standard for disposal which is **0.1mg/l**

The Hydrogen Peroxide/UV Method Cont…



VL/EID Liquide waste

Labclean

Final product safe to support life

The Hydrogen Peroxide/UV Method Cont…

Results

Table 2.1 Constituents' properties and parameters of the wastewater

Parameter	Units	Waste water effluents	Maximum Permissible Limit*
Surfactants (mg/L)	mg/L	2748	15
Ammonia Nitrogen	mg/L N	<0.10	
Chemical Oxygen Demand (COD)	mg/L	40750	70
Chloride	mg/L	12957	250
Conductivity	mS/m@ 25°C	3490	1000
Fluoride	mg/L	0.31	2
Free chlorine	mg/L	<0.10	
Free Cyanide	mg/L	<0.05	0.1
Nitrate & Nitrite Nitrogen	mg/L N	<0.10	10
Oil & Grease	mg/L	3329	10
Orthophosphate	mg/L P	0.12	5
pH		4.89	5.0 -8.5
Phenols	mg/L	<0.01	0.5
Sulphate	mg/L	<3.00	500
Total Cyanide	mg/L	368	0.1
Total Suspended Solids	mg/L	104	50
Silver (Ag)	µg/L	2.44	0.5
Aluminium (Al)	mg/L	<0.15	0.5
	mg/L	4.00	0.1

WEAR CHECK
Condition Monitoring Specialists

Gauteng Water Laboratory
Wireless Cape Water Laboratory
Head Office

For Attention: Joseph Mugoya
Customer: Paribus Investments Uganda Limited
Postal address: PO Box 5602, Kampala Jinja Rd, Plot 4, Eagen Ho
Tel number: +256 772 991894

Report number: WAT/23/1327
Report issue date: 2023/04/26
Date Completed: 2023/04/26
Order no: COD

Certificate Of Analysis

Sample name			TWW	WW 1	WW 2		
Sample date			2023/02/25	2023/02/25	2023/02/25		
Sample container description			Glass Bottle	Glass Bottle	Glass Bottle		
Submission date			2023/04/14	2023/04/14	2023/04/14		
Sample type			Water	Water	Water		
Set Point ID			WAT/23/1327 0001	WAT/23/1327 0002	WAT/23/1327 0003		
Visual inspection			N/A	N/A	N/A		
Method no	Determinand	Unit					
Chemical Properties and Parameters							
M460	pH	-	2.73	4.06	5.03		
#	Total Cyanide	mg/L	<0.07	<0.07	<0.07		

Please Note: N/A: Not applicable RTF: Result to follow *Sub-contracted Analysis

Non SANAS Accredited methods.
Results only relate to the samples tested and are reported on an "as received" basis, unless otherwise specified.
This report may not be reproduced, except in full, without the written approval of Set Point Laboratories.
Results are subject to uncertainty of measurement, which are indicated on the enclosed information sheet.
While every effort is made to provide analysis of the highest accuracy, the liability of Set Point Laboratories is restricted to the cost of the analysis.

Comment:

Nthudzeni Mabidi
(Report Compiler)

Moses Letaka
Technical Signatory

Tests marked "Non SANAS Accredited methods", as well as any comments, opinions or interpretations expressed in this report are not

Treated Product

- In addition to proving that cyanide was degraded to undetectable level, the treated waste was analyzed for presence of unintended intoxicants oxidation products .
- Lab results indicated none

Method of Analysis

Analysis of the sample done using the FTIR scanning method.

Results of Analysis

The mean analysis values are as below,

Test/Parameter	Results	
	SAMPLE A GE 526/2023	Min. Score 850
FTIR SCREENING	Human skin	703
	PVAL, Polyvinyalcohol	658
	Protein (Human Hair)	623, 609
	Titanium Dioxide (Rutile)	616, 609
	Polyacrylamide-1(non-Ionic)	604, 589
	Polyacrylamide-2 (low Carboxyl Content)	591

Remarks

1. The scores were lower than the minimum score (850) indicating that the above functional groups (reactive) were very low or didn't match the given sample.
2. Results relate to samples analyzed and are reported as on received basis.

Acknowledgements

1. NHLDS-MoH-Uganda
2. PEPFAR
3. CDC-Uganda
4. CDC Atlanta – ILB
5. Paribus Investments
6. Setpoint Laboratories, South Africa
7. Makerere University
8. Government Analytical Lab

Thank you