Centralized Management and Disposal of Molecular Liquid Waste from HIV Viral Load PCR Laboratories Supported by USAID in Nigeria.

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Centralized Management and Disposal of Molecular Liquid Waste from HIV Viral Load PCR Laboratories Supported by USAID in Nigeria: A Pilot Study

Keywords: Molecular Liquid Waste Management, Guanidine Thiocyanate, HIV Viral Load, PCR Laboratories.

INTRODUCTION

HIV Viral Load (HVL) monitoring is an indicator of HIV/AIDS management success. Globally, more than 30 million HVL tests are performed annually. Molecular Liquid Waste (MLW) generated from HVL testing contains Guanidine Thiocyanate (GTC), which is toxic to humans, animals and the ecosystem if untreated properly. Many countries face the challenge of improper management and disposal of MLW. We present outcomes of a piloted centralized management and disposal of GTC-containing MLW in PCR Laboratories (PL) in Nigeria between July 2021 and November 2022.

METHOD

Seeking a scalable and sustainable solution to MLW in PL in Nigeria, the US Agency for International Development (USAID), between March 2021-November 2022, piloted centralised MLW disposal in its supported PL in three states (Nigerian Institute for Medical Research, Lagos, University of

PCR LABORATORY	LOCATION AND STATE	PCR EQUIPMENT PLATFORM
Nigerian Institute for Medical Research (NIMR)	Yaba, Lagos State	Roche COBAS 68/8800
Chukwuemeka Odumegwu Ojukwu University Teaching Hospital (COOUTH)	Awka, Anambra State	Abbott M2000
University of Uyo Teaching Hospital (UUTH)	Uyo, Akwa Ibom State	Abbott M2000

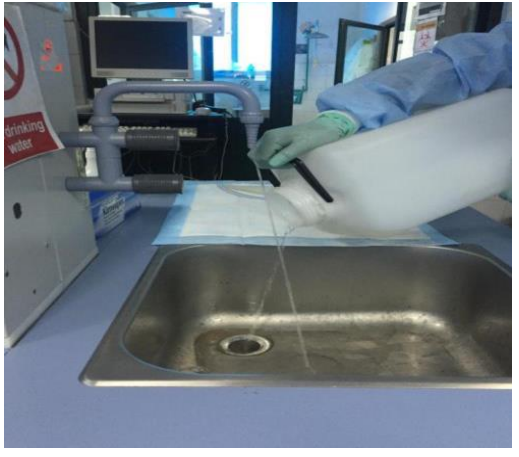
Background-1/2

- According to World Bank, global waste may reach nearly 3.4 billion tonnes in 2050, a 70 % increase from 2016 levels
- HIV Viral Load (HVL) monitoring is a treatment success indicator and marker for HIV/AIDS management outcomes
- Globally, millions of HVL tests are performed annually
- This may have resulted in growing waste management challenges in many countries, especially in developing middle-income countries
- Nigeria has analysed over 6.0m VL samples across 17 PCR Labs from 2021 till date

https://www.worldbank.org/en/news/press-release/2018/09/20/global-waste-to-grow-by-70-percent-by-2050-unless-urgent-action-is-taken-world-bank-report

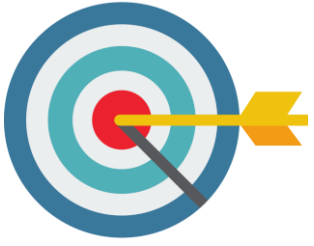
Background-2/2

- Liquid waste generated from HVL & EID testing contains hazardous Guanidine Thiocyanate (GTC), which is an RNA isolation and protein solubilization agent
- It is toxic to humans, animals and the environment if untreated properly
- Many countries are faced with the challenge of proper management and disposal of MLW due to lack of policy framework, or implementation and enforcement, infrastructure and shortage of technical expertise
- A study in 2021 reported that 9 of 11 (81.2%) African countries surveyed did not have a waste management framework and waste management program in place
- The study also reported four countries pour down the drain HIV VL testing liquid waste
- Nigeria was in a similar situation until 2021



Centralized GTC Liquid Waste Implication

- GTC-containing waste can only be effectively treated using a high-capacity rotary kiln incinerator, which is expensive to procure and maintain
- Incinerators are inherently energy inefficient with high water content wastes
- High amount of fuel must be burned to maintain combustion temperatures to destroy liquid waste
- Much of that energy is spent simply to boil off the water so that the organic portion of the waste will burn
- Burning of large quantities of fuel entails the generation of excessive greenhouse gases (primarily carbon dioxide)



Centralized GTC Liquid Waste Treatment

Several molecular waste treatment methods have been proposed such as Activated Charcoal, cement factory or centralized waste management

Each GTC treatment methods offers merits and demerits

Centralized waste management involves moving waste to a central disposal plant due minimal infrastructure at testing points

This reduces cost of setting up, maintaining several incinerators, and provision of power supply and human resources for their operations

USAID Pilot Intervention (n=3)

- To ensure efficiency and safety in the handling and disposal of the laboratory liquid waste in conformity with international best practices, USAID environmental regulations and local laws, the USAID Nigeria embarked on a pilot of centralized liquid waste disposal in three supported PCR laboratories in three states between March 2021-November 2022

The laboratories are:

- Nigeria Institute of Medical Research (NIMR), Yaba, Lagos state,
- University of Uyo Teaching Hospital (UUTH), Uyo, Akwa Ibom state
- Chukwuemeka Odumegwu Ojukwu University Teaching Hospital (COOUTH), Awka, Anambra state

Centralized Waste Management Implementation Processes

01

Laboratory and waste disposal facilities assessments to estimate the laboratory operation capacity, and volume of waste generated per time to determine the number of tanks for temporary storage

02

Assessment of disposal plant for environmental compliance and standards per USAID guidance and national environmental protection agency

03

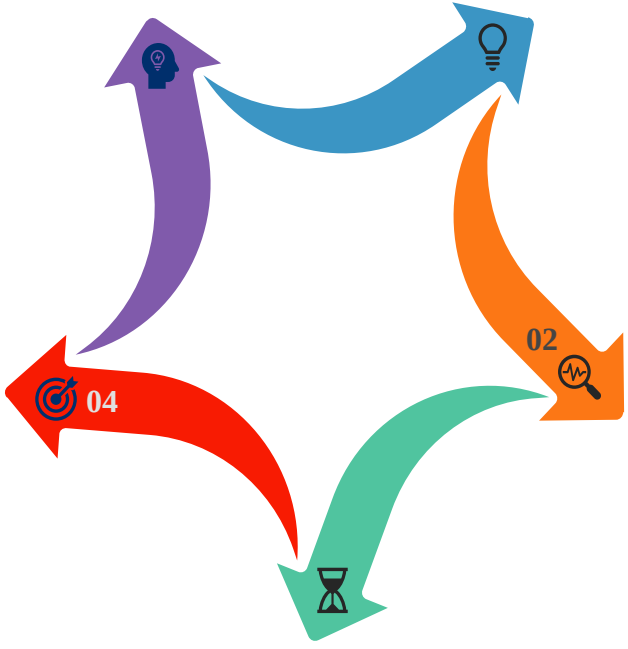
Development of an action plan for placement of 1000 litres collection tanks to ensure personnel and environmental safety within and around Laboratories

04

Advocacy and sensitization meetings with management of Laboratories

05

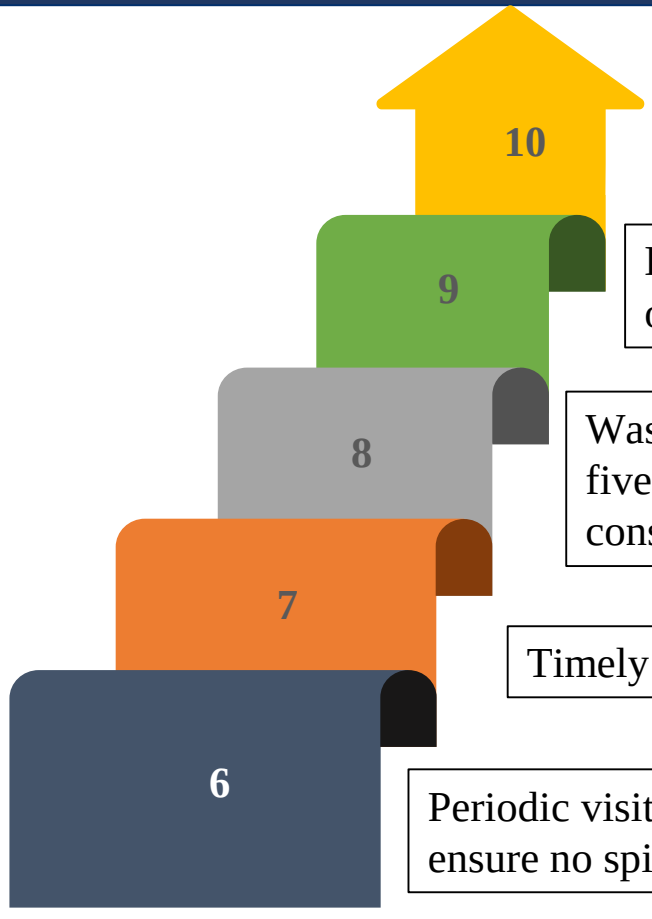
On-site training for laboratory staff and waste handlers



Centralized Waste Management Implementation Processes

5. Regular follow up with the labs to determine if their tanks are three-quarters full
4. Provision of biohazard tapes to cordon off the area from unauthorized persons
3. Deployment of tote tanks and connection with the needed accessories for liquid waste collection.
2. Engagement of waste management vendors for evacuation
1. Development and deployment of tools for documentation and reporting of waste generated

Centralized Waste Management Implementation Processes



This ensured that all active components in the liquid waste were destroyed and that no residue comes out from the process

Disposal was with a special-purpose incinerator at a temperature of between 1,000 – 1,200 degrees Celsius

Waste was moved to Boskel Nig Ltd Port Harcourt in three cycles of five months each using specialized trucks that are marked with conspicuous biohazard signages

Timely retrieval of the filled tote tanks before they get to a critical level

Periodic visits to the labs for physical checks of the tote tanks and pipes to ensure no spillage or over filling

Tote Storage Tanks in two PCR Labs (UUTH & COOUTH)

Fig 1. Tote Storage Tanks at COOUTH Awka and UUTH Uyo PCR Laboratories

Molecular Waste evacuation processes

Fig. 2 .Molecular Waste Evacuation Process. How it happened at each of the PCR Labs.

Waste Discharge at the Private Sector Managed Incinerator

Fig. 3. Waste Discharge at the disposal plant

Private Sector Managed Incinerator

TREATMENT PROCESS

- At the client base, the liquid waste was mechanically transferred into Boskel's evacuation tanks using pumps.
- On arrival to Boskel's facility, the liquid waste was pumped into the holding tank
- The treatment plant was energized and brought to optimal treatment temperature of 950-1050°C. This treatment plant is the rotary kiln incinerator.
- The liquid waste was sent into the treatment chamber by gravity through tubes, the flow rate was controlled and monitored according to a predetermined rate.
- The liquid waste was mixed with compressed air in order to create even distribution into the treatment chamber.
- The contaminants in the liquid waste were destroyed in the treatment chamber.
- The hot flue gases are swept into the secondary combustion chamber and Quench scrubber to reduce the temperature of the air and also to condense water in the particles.
- The flue gases moves into a Cyclone, dust and other particles are removed after which, it was passed through an activated Charcoal bed for final cleaning
- The clean air was emitted into the surrounding through the stack, while the sludges from the Quench scrubber and Cyclone are fixed in concrete matrix.

Fig. 4. Final Stage of Molecular waste Incinerator at over 1,000 degree Centigrade

Air Quality & Effluent Water Monitoring Post-Treatment

S/NO	PARAMETERS	RESULTS	NUPRC LIMIT	FMEnv LIMIT
		Incinerator Area		
1	SO_2 ($\mu g/m^3$)	0.11	-	26
2	H_2S (mg/m^3)	0.00	-	-
3	CH_4 (mg/m^3)	52.5	-	-
4	NO_2 ($\mu g/m^3$)	22.8	0.2 (1-hr Mean)	75.0-113
5	CO ($\mu g/m^3$)	0.01	30 (1-hr Mean)	22.8
6	CO_2 (ppm)	234	-	-
7	NH_3 (mg/m^3)	0.30	-	-
8	TSP($\mu g/m^3$)	102	150-230	250
9	VOC (mg/m^3)	0.10	-	-
10	Temp(^0C)	28.7	-	-

Method of Analysis : Physico-Chemical Analysis is by Standard Method(APHA 2005)21st Edition

S/NO	PARAMETERS	RESULTS	NUPRC LIMIT (Fresh Water)
1	pH	6.13	6.5 – 8.5
2	Temperature (^0c)	25.1	Ambient ± 2°C
3	Conductivity(µs/cm)	9	-
4	Total Suspended Solids(TSS)	2	30
5	Total Dissolved Solids(TDS)	4	2000
6	Salinity as chloride (mg/l)	3	400
7	Biochemical Oxygen Demand (BOD)	0.39	30
8	Chemical Oxygen Demand (COD)	0.58	10
9	Nitrate,NO_3^- (mg/l)	0.03	-
10	Phosphate PO_4. (mg/l)	0.08	-
11	Sulphate , SO_4^{2-} (mg/l)	0.00	-
12	Hydrogen Sulphide ,H_2S (mg/l)	<0.01	-
13	Dissolved Oxygen , DO (mg/l)	6.2	≥ 5.0
14	Vanadium , V (mg/l)	<0.01	-
15	Zinc , Zn (mg/l)	0.010	1.0
16	Chromium, Cr (mg/l)	<0.001	0.05
17	Cadmium , Cd (mg/l)	<0.001	-
18	Mercury , Hg (mg/l)	<0.001	0.006
19	Lead , Pb (mg/l)	<0.001	0.05
20	Total Iron , Fe (mg/l)	<0.001	1.0
21	Barium , Ba (mg/l)	<0.001	1.5
22	Copper , Cu (mg/l)	<0.001	1.5
23	Manganese , Mn (mg/l)	0.038	-
24	Nickel , Ni (mg/l)	<0.001	0.07
25	Arsenic , As (mg/l)	<0.001	-
26	Total Petroleum Hydrocarcon, TPH (mg/l)	<0.001	-

Fig. 5. Average Flue Gas & Effluent Water Test Results

Table 1. Results of Centralized Waste

PCR Lab	Location & State	PCR Equipment Platform	# of Equipment	Total No of VL Samples Tested	No. of tanks Installed (1000) Ltrs	Total Waste Vol Evacuated (Ltr)/Lab	No of Cycles
NIMR	Yaba Lagos State	Roche COBAS 68/8800	2	242,014	4	4,300	3
COOUTH	Awka Anambra State	Abbott M2000	5	148,012	4	4,400	3
UUTH	Uyo Akwa Ibom State	Abbott M2000	4	335,354	10	10,800	3
Total				**725,380**	**18**	**19,500**	**9**

Five Major Lessons Learnt

- During the study period the collection, transportation and disposal did not encounter any problems as required permits from the regulatory agencies and authorities were secured
- The plastic holding containers are made from high-density polyethylene plastic and encased in a metal exoskeleton to mitigate the risk of breaking in the event that the container is dropped
- Measures 1&2 above ensured that there was no negative environmental impact because of transporting from 3 PCR Labs to a central facility in Port Harcourt for treatment.
- Overall, the waste treatment was handled correctly, and in compliance with local international safety and regulation requirement standards.
- Cost-benefit Analysis Outcome: It costs average of **$3.23** to dispose a kg of liquid waste compared to average of **$5.28** cost of hazardous waste disposal.

Additional Activities Post-Pilot

Expanded to Federal Medical Centre Jalingo, Taraba state PCR Lab; increasing the number to four labs

About **36,630** Liters of liquid waste have been moved and disposed in 6 cycles per lab between 2021 and May 2024

Used GeneXpert EID cartridges in POC EID testing sites also covered

Recommendations

Piloted Centralised molecular waste management and disposal is a safer, scalable, and sustainable alternative for the management PCR laboratory liquid waste

Integration of more PCR laboratories in the country into the existing arrangement will reduce costs of waste management

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- Nigeria FMOH Medical Laboratory Services Division (MLSD)
- National Agency for the Control of AIDS (NACA)
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- Boskel Nigeria Limited

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