A REPORT

OF

MERCURY LEVELS IN SELECTED HOTSPOTS IN NIGERIA

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List of Acronyms

UNEP	United Nation Environmental Protection Agency
UNEP GC	United Nation Environmental Protection Agency Governing Council
INC	Intergovernmental Negotiating Committee
Dip Con	Diplomatic Conference
SRADev	Sustainable Research and Action for Environmental Development
NGO	Non Governmental Organisation
ZMWG	Zero Mercury Working Group
ng/m^3	Nano-grams per cubic meter (ng/m3)
ATSDR	The Agency for Toxic Substances and Disease Registry (ATSDR)
FEPA	Federal Ministry of Environment and Protection Agency
BCRCC	Basel Convention Coordinating Centre for the African Region
CEMA	Customs & Excise Management Act
EPA RfC.	Environmental Protection Agency reference dose
DEQ	Department of Environmental Quality
PBB	Poly brominated Biphenyls
SWM	Solid Waste Management
TLS	Transfer Loading Station
EEE	Electrical and Electronic Equipment
WEEE	Waste of Electrical and Electronic Equipment
WF	Work face
BFR	Bromide Flame Retardant
PVC	Polyvinyl Chloride
PBDEs	Poly brominated diphenyl ethers
CRT	Cathode Ray Tube
BAN	Basel Action Network
OECD	Organization of Economic Cooperation Development
LASEPA	Lagos State Environmental Protection Agency
NESREA	National Environmental Standard Regulatory and Enforcement Agency
UCH	University College of Ibadan
UNILAG	University of Lagos
SOPs	Standard Operating Procedures
LASUTH	Lagos State Teaching Hospital
LUTH	Lagos University Teaching Hospital
CAPDAN	Computer and Allied Products Dealers Association of Nigeria
LAWMA	Lagos Waste Management Agency
PIT	Project Implementation Team
NDA	Nigerian Dental Association

1.0 BACKGROUND

Mercury and its compounds are toxic substances which can have adverse effects on human health and the environment. Despite the risks due to mercury, Africans have very low awareness of this toxic substance which is used in soap; cosmetics; antiseptics; paints; pesticides; pharmaceutical products; human and veterinary products; and even in dental fixtures. Outdated mercury process and production equipment are still dumped into the developing countries, including Africa.

In February 2009, the UNEP Governing Council (UNEP GC) decision to start developing a global legally binding instrument on mercury (Decision 25/5). *An Intergovernmental Negotiating Committee (INC) was formed, under UNEP, to start formal deliberations in June 2010, leading to a legally binding Treaty on mercury on or before February 2013. The text for the future Minamata Convention on Mercury was agreed to on 19 January 2013, in Geneva.* The diplomatic conference (Dip Con) where the treaty was adopted and opened for signature took place in Japan in October 2013. ZMWG is therefore putting in place preparatory work for developing countries to ratify and implement the Mercury Treaty nationally. This legally binding instrument would help control the use and handling of mercury and mercury compounds. It will help prevent and minimize dumping to developing countries in the guise of exports of factory equipment used in manufacturing processes of mercury. A legally binding instrument on Mercury would benefit Nigeria more if Nigerians would agree on common position on specific issues of relevance to its ratification and implementation.

Although the Nigeria government and some NGOs have been committed to the success of this process since inception to date (*from INC1-5*), Government has not given sufficient priority to the assessment of the national mercury situation in order to raise awareness of policy makers of the extent of mercury pollution with the ultimate goal of developing management options for domestic mercury sources and identifying key components for a national mercury reduction plan. Towards facilitating the entire national process for quick ratification of the Mercury Treaty by decision makers, NGOs are playing several roles in the Nigeria process by assisting government officials and the various Ministries in taking the steps necessary for Nigeria to ratify the treaty.

2.0 INTRODUCTION

Mercury has been ranked third in the list of toxic substances (ATSDR 2012). Being assessed as a toxic substance to ecosystem, wildlife and human (UNEP 2002 & 2013), it affects nervous system and functioning of brain, especially of children. The toxic effects on human, wildlife and the ecosystems cannot be overemphasized as available in many literatures. In view of the adverse health impacts due to mercury exposure and its impacts on ecosystem and environment, in order to reduce and phase out global mercury use, “Minamata Convention on

Mercury," was in-acted by over 140 countries in early 2013 and as today 100 countries including Nigeria have already signed it (UNEP 2013), with Gabon topping the latest signatory.

SRADev Nigeria is a professional, non-governmental think-tank in environmental health acting as a catalyst, advocate, educator and facilitator to promote the wise use and sustainable development of the environment. It have in the past six (6) years been involved in programmes and projects towards raising awareness on the need to eliminate mercury use in products and formally launched a national campaign in this regard in 2010. This project focus is informed by the need to contribute to the paucity of information and data through quantitative analysis using Lumex mercury air sampler.

This present study was aimed to quantitatively determine the ambient mercury level of selected hotspots like dental clinics/hospitals, open landfills, universities laboratories (chemistry labs), incinerators, electrical/electronic wastes (e-wastes) etc. for policy advocacy purpose and awareness raising to support ratification of treaty by 2015.

> Box 1: **Perception of Healthcare Workers on Mercury exposure in workplace in Lagos**
> In an earlier study carried out in Nigeria on Establishing Framework for Mercury Free Healthcare in Nigeria, about (97.5%) of the respondents in LASUTH agreed to know the equipment in use that contains mercury in their hospitals such as the thermometer and Sphygmomanometers but many of the Medical personnel knowledge of approximate quantity of mercury in instrument were generally very low *(SRADev Nigeria, 2012).* Also, on the study of: The Impact Assessment of Electronic Waste Handlers and Livelihood in Lagos computer village, it was observed that majority of the EEE traders are literate and unaware of the environmental health impact of heavy metals contain in e-waste, almost 100% of the respondents acknowlegded having one or two ill-health symptoms in the handling and diassembling electrical and electronic equipment *(SRADev Nigeria, 2010).*

3.0 DESCRIPTION OF SOME MERCURY HOTSPOTS IN NIGERIA

3.1 *MERCURY FROM WASTE DUMPSITES/LANDFILLS*

Hazardous waste is waste that poses substantial or potential threats to public health or the environment. It is known that such releases contain a wide range variety of potential carcinogens and potentially toxic chemicals that represent a threat to public health (Fredlee et al., 2003). Sufficient number of individuals near dumpsites would experience an average increased cancer risk, at least 1 in 1000 (Fredlee et al., 2003).

When rain water infiltrates landfills it dissolves organic and inorganic material, forming a toxic leachate that collects at the base of the landfill. Like all metals, mercury dissolves easily in the acidic leachate. Any mercury in leachate could discharge to sewers system or surface water. Available data show that mercury in groundwater can exceed drinking water standards from

older, unlined landfills, but is less likely to leach into groundwater from landfills that are lined and use leachate collection systems.

The delivery and crushing activities at the dumpsite from transfer stations, deposited, compacted and covered with fill material can cause the release of the mercury from the products. Inorganic mercury in the landfill is converted by bacteria living there into a more toxic form, called organic or methylated mercury. Researchers have measured one organic mercury compound, dimethyl mercury, from gas destined for landfill venting at levels 1,000 times higher than what has been measured in open air (Lindberg, 2001).

Nigeria has 36 States and a Federal Capital Territory with increasing in population, urbanization and industrialization including globalization, therefore the challenge of solid waste management (SWM) in the Country has increased and even now complex. Generally, the average rate of generation is estimated as 0.5kg/capital/day. Lagos State is known to house one of the largest dumpsite possibly in Nigeria. There are a total of five approved dumpsites in the State but only two are functioning properly presently which are the Olushosun and Solous 3. The rate of waste generation in Lagos (with estimated population over 10 million in 2012) is 9,000 tonnes/day (Lagos State Waste Management Authority, LAWMA), while Ibadan the capital of Oyo State, the rate is 4,513 tonnes/day with a population of 1,338,659 according to the 2006 census and Abuja the FCT of Nigeria has the rate of waste generation of 492.8 tonnes/day.

As a general rule, sorting of non-hazardous waste from the hazardous ones and extracting of as many metals as possible especially copper, nickel, lead, and mercury before incinerating and land filling should be recommended.

3.2 MERCURY FROM TRANSFER LOADING STATION (TLS)

A transfer station is a building or processing site for the temporary deposition of waste. Transfer stations are often used as places where local waste collection vehicles will deposit their waste cargo prior to loading into larger vehicles. Researchers estimate that the amount of mercury lost during collection, storage, compacting and transfer activities may be comparable to what's lost at the working face. During routine truck unloading at a transfer station, it was found mercury concentrations ranging from 30 to 90ng/m^3. Background levels averaged 10ng/m^3 mercury during non-active periods at a transfer station-suggesting prior mercury contamination. When fluorescent bulbs were intentionally added to the pit at the transfer station, mercury concentrations reached 500ng/m^3 (Lindberg, 1999b). This level exceeds the EPA Reference concentration (RfC) of 300ng/m^3.

Waste transfer station is not common in Nigeria the only State that has a waste transfer station is Lagos State and there are only two transfer loading stations in the State. As at the time of this report only one of the TLS functioning is the Simpson TLS in Lagos Island local government.

3.3 MERCURY FROM INCINERATORS

It has been studied that when wastes are incinerated they became concentrated. They are concentrated in the ash and released to the air from the stack. Of all the trash that enters the incinerator, 30% remains as ash at the end of the process. Incinerators can vaporize mercury where some of it is turned to methylmercury and enters the food chain. Incinerators include garbage incinerators, medical-waste incinerators, as well as crematoria.

According to the EPA, medical waste is the fourth leading source of mercury emissions after dioxins in the US. Heavy metals may be dispersed over a wide area, settling on the food we eat and the water we drink. Even very small amounts of mercury can do significant damage. One gram of mercury per year (that's just 1/28th of an ounce) is enough to contaminate all the fish in a lake with surface area of 20 acres so that the fish are unsafe to eat. Today, more than 90% of WEEE is land filled, incinerated or shredded without any pre-treatment. It was found in many countries like Japan, Korea, England that residents living <1 km from municipal waste incinerators were found to have higher rates of stomach, colon, liver and lung cancer than those living further away.

There is paucity of information on the Nigeria's anecdotal figure on standard incinerators available. In Lagos State only one functioning incinerator was identified at Oshodi Waste transfer loading station (managed by LAWMA), this is the Ecoda Medical Waste Treatment Facility, a steam-based thermal process for treating medical wastes before being sent to the landfill. In Ibadan also, the only functioning incinerator located at UCH, Ibadan is used for treating medical or others hazardous wastes produced from the hospital. Generally, what is known to be practiced in Nigeria is the open burning of medical wastes.

3.4 MERCURY FROM WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE)

Waste electrical and electronic equipment (WEEE) is a diverse waste set, mercury, cadmium and chromium VI (hexavalent chromium) and Lead are all of concern both because of their toxicity and leaching potential, and their persistence in the environment. Electronic and electrical products have a significant impact on the environment when they are manufactured, when they are used and when they reach the end of their life and are discarded. Nigeria and other African countries like Ghana are known to be at the receiving end of more of the toxic EEE 'dumped' onto its markets mainly due to less developed policy and regulations.

The global man-made release of mercury to the atmosphere is approximately 2000-3000 tonnes per year. It is estimated that of the yearly world consumption of mercury 22% is used in

EEE (AEA, 2004). Mercury is basically used in thermostats, sensors, relays and switches (on printed circuit boards and in measuring equipment and discharge lamps). These equipments are in turn used to manufacture other variety of appliances. Leaching of mercury takes place when certain electronic devices, such as circuit breakers are destroyed. Toxic and hazardous materials are present in IT and telecom products too are imported into Nigeria. Nigeria, as a Party to the Basel Convention, is obliged to control the importation of used electronics when they are deemed as hazardous.

According to a Basel Action Network (BAN 2005) study, in conjunction with Basel Convention Coordinating Centre for the African Region (BCRCC) Nigeria, Nigeria imports about 500,000 used computers annually through the Lagos port alone. Only 25% of the imports are functional while the remaining 75% are junks. *45% of electronic shipments from all over the world enter Lagos, and most of the imported items that are tested as non-functional get discarded almost immediately as e-waste. They end up in dumpsites where they are eventually burnt. Also survey revealed that about 30 million cell phones in use in Nigeria, more than 20 million older models and non-functional.* To date, such imports have not for the most part been totally controlled in accordance with the Basel Convention but their exist presently a legal instrument on management of e-waste at the national level **"Electrical and Electronic Sector Regulation on E-waste Management"** by the National Environmental Standard Regulatory and Enforcement Agency (NESREA) passed into law.

Above all, only the Lagos State government, in an attempt to contain the indiscriminate disposal of electronic wastes is making some conscious effort to engaged the services of a consultant through LASEPA to establish a waste recycling facility in preparation to mopping up all obsolete and faulty electronic equipment within the metropolis, but as the time of this project, not much of achievement in this regard could be documented.

3.5 MERCURY IN DENTAL AMALGAM

Dental amalgam is a restorative material that contains approximately 50% mercury in the elemental form, silver 30% and 20% other metals such as tin, copper & Zinc (Hardy, James E 1998; SDPI, 2013). Dental amalgams are also called silver fillings and it has been used in for over 160 years and is widely preferred because it's inexpensive, ease of use, best settling material and most importantly it is resin free which make it less allergic than composite fillings. These fillings gave off mercury vapors and its amount depends upon cavity size, tooth characteristics, composition, age of amalgam, time taken for filling, the number of fillings, temperature of ingested food/drinking liquids and the activities like chewing & grinding of teeth (VACMP, 1998; BIO 2012). Estimated average absorption of mercury concentration vapors from dental fillings vary from 3,000 to 17,000 ng Hg (Clarkson 1988; Skare and Engqvist 1994). As mercury vapor, it is taken up via the lungs, and 80% of it is absorbed.

The complex pathways of dental mercury may include amalgam waste (generated by drilling out a previous filling) going to the wastewater system; the excess material carved from a new amalgam filling; the removal of teeth containing amalgam; unused amalgam going to solid waste; mercury emissions directly to the air; the traps, filters and other devices in dental clinics designed to remove mercury from the wastewater; and various waste disposal alternatives
Deleterious health effect on children and women of child-bearing age, the dangers of fetal and infant exposure to mercury via maternal dental amalgam have likewise been scientifically established. The Estimated Hg input, Kg Hg/year in use and disposal of dental amalgam fillings from the Nigeria National data base (FMENV) is 25,518.6 while the total mercury entering the air, water, land, by-products and impurities and general wastes due to dental amalgam are 510.4, 8,472.2, 0.0, 918.7 and 4,899.6 respectively (FMENV data).

In many higher income countries, dental use of mercury is now declining. Many others, Sweden, Denmark, Norway and Finland have implemented measures to greatly reduce the use of dental amalgams containing mercury in line with the “phase-down” recommendation of the Minamata convention.

4.0 PROJECT JUSTIFICATION

Nigeria is a party to many Multilateral Environmental Agreements (MEAs) including Basel, Stockholm and Rotterdam. The country is also very active in regional and sub-regional activities in the area of environment. It participated very actively in the INC process (as African Bureau Representative) and other INC African processes.

Mercury has been ranked third in the list of toxic substances (ATSDR 2012), it affects nervous system and functioning of brain, especially of children. Federal Ministry of Environment using the UNEP "Toolkit for identification and quantification of mercury releases“ reveals that virtually all the sectors use mercury in Nigeria. Although some studies have shown that Mercury both from intentional and unintentional sources continued to be released into the air as a contaminant in solid and liquid waste streams unsustainably and this is of great concern causing various health related problems. But very little statistics is available on a national scale about mercury use and its emissions.

Generally, *there is no comprehensive national law on mercury management in Nigeria*. The existent national legislations relevant to chemicals management are too general, fragmentary and not specific to mercury. These laws in piecemeal merely provides standard for some environmental media, actions and regulations that control releases from environmental sources that contain mercury, products that contain mercury and other standards, actions and programmes relevant to mercury which fall short the present focus of the Mercury Treaty.

Therefore, the success of this mercury study will aid the harmonization of the chemical management system in the country on several fronts; it would help in the synchronization of national legislation, the Mercury Convention and other international and regional agreements whose contents may be related. This project focus is informed by the need to contribute to the paucity of information and data on mercury exposure in Nigeria. It will enable awareness raising to support the country's ratification of Mercury Treaty by 2015. Identification of mercury hotspots in some Nigerian cities will give status report of Mercury products use in Nigeria. It will enhance and strengthened national framework for Compliance and Enforcement and a harmonized inter-agency coordination approach to the Treaty ratification and implementation.

5.0 METHODOLOGY

This is an exploratory study involving 4 parts which are:

1) Literature review of related materials
2) Interview/Consultation
3) Field work on mercury measurement (air sampling using Lumex sampler)
4) Visual Observation

5.1 EQUIPMENT AND MATERIALS USED

- Lumex Mercury Analyzer RA-915+ (Mercury Analyzer),
- Mobile Pocket Weather Tracker
- Geographical Positioning System (GPS) Device

5.2 STUDY LOCATIONS

The selected project locations were Lagos, Ibadan and Abuja FCT of Nigeria should provide a fundamental representation of the current ambient mercury level in their chosen hotspots in the country. Purposive sampling method was used to choose sampled identified hotspots based on the following criteria:

- Mercury must be known to be used/in-use or discharged in the said location/facility
- Permission to access said location/facility must be guaranteed especially the private dental clinics and waste dumpsites.
- Sites (Incinerators, TLS and landfills etc) must be legally authorized to be used for such activities

5.3 SAMPLING AREA/POINTS

1. Dental facilities: dental clinics both government general hospitals, teaching institutions and private dental clinics
2. Waste dumpsites/landfills and Transfer loading stations
3. Incinerators/Medical waste treatment facility
4. University Science Laboratories and chemical store rooms

Section 6.0 below provides a detail description of the exact sampling points and locations employed.

5.4 PROJECT IMPLEMENTATION /METHOD

a. **Preparatory Work:** This involved data gathering through literature review, visits to identified hotspots in different states with letter of collaboration and sensitization on the project's objectives, consultation with identified stakeholders (e.g. Ministry of Environment, Ministry of Health, e-waste traders association – *CAPDAN,* local government, LAWMA, Nigerian Dental Association NDA, Dental professionals in identified dental clinics/hospitals). This was done to allow access to the facility and designing the data collection schedules and itinerary etc.
SRADev Monitoring team was constituted in December, 2013. This was followed by short trip to Dar Es Salam, Tanzania for a 2-day hands-on training exposure on the use and operation of the Lumex instrument.

Consultative meetings were held with relevant stakeholders' with a view to gaining their support and inclusiveness in the project. Acquaintance visits and reconnaissance survey were made to identified hospitals (private and public), dental clinics, universities, incinerators sites, waste dump sites/landfills etc. When necessary, information was collected through telephonic contacts and interviews of key personnel at the sites. The monitoring teams also made some relevant visual observations; about ventilation system, waste generations, handling and disposal practices at the visited sites. This aspect was undertaken between December 2013 and February 2014.

Fieldwork: Mercury was monitored in air using the instrument, **Lumex Mercury Analyzer RA-915+** (Mercury Analyzer). Operational and maintenance guidelines, as described in the Lumex User's Manual were thoroughly followed throughout the fieldwork. For quality assurance, Lumex test cell was run using the internal check standard cell prior to each measurement. Annual calibration of the instrument was done and certified by Lumex, Inc.

Mercury concentrations were measured in all location on a clear dry weather during daytime. Sampling points for dental clinics/hospitals were purposively (i) operative dentistry sections/wards/rooms, (ii) adjacent corridors/waiting lobbies/reception area (iii) open air outside the clinic (ambient). At waste dump sites, measurement was done in different locations around the dumpsite/landfill. At incinerators or school laboratories settings (enclosed location), measurements was done in different area within the facility and then the open air.

In all, three (3) measurements were taken at one sampling point and the mean with standard deviations determined and reported. All measurements at a visited site were recorded on specially designed/formatted data sheets. Workplace **exposure standards** are

subject to exposure time duration (8 working hours) and expected to be higher than the environmental exposure standards. It is to be noted that the observed mercury contamination in air at the visited sites and reported in the present study are only snap values (with maximum exposure time less than 15 minutes) at the time of measurements. The field work investigation was carried out between March – August 2014.

b. **Results, Data Analysis, discussions:** Results were analysed using descriptive statistics and the discussions of the results were done using USA EPA reference concentration in air, 300 nano-gram per meter cube (ng/m^3). This is because this level is considered to be safe even among the vulnerable groups (children), to breathe the air for 24 hours, 365 days for 70 years at 300 ng/m^3 mercury in air without adverse effect on health (ATSDR, 2012; TEMPR, 2013).

6.0 IDENTIFICATION OF SAMPLING LOCATIONS

6.1 SAMPLING LOCATIONS FOR DENTAL CLINIC/HOSPITALS IN IBADAN

The sampled dental clinics in Ibadan were two government general hospitals and three private dental clinics. The government general hospitals were University College Hospital (UCH) located along Queen Elizabeth road in Ibadan north local government (*07.4449 N, 003.89432 E*). UCH is known to be largest teaching hospital in West Africa with about 501 Dentists**.** Dugbe Government Dental Centre located along Bank road in Ibadan North-West local government (*07.08825 N, 003.87380 E*).

The private hospitals are: **Ire-Ayo Dental Clinic**, located along Adamasingba road in Ibadan North Local government (*07.88821 N and 003.77384 E*); **TOS Dental Clinic** is located along Sango road in Ibadan North Local government (*07.4339 N and 003.89432 E*) and **Smile Dental Clinic** on Oluwole way, off Bodija road in Ibadan North Local government (*07.44490 N and 003.89432 E*).

Figure 1: Lumex sampling at the fathom and Prosthetic Laboratories in UCH

Figure 2: Lumex sampling at the Smile Dental clinic and Ire-Ayo dental clinic

6.2 SAMPLING LOCATIONS FOR DENTAL CLINIC/HOSPITALS IN LAGOS STATE

The sampled dental clinics in Lagos were four government general hospitals (include two University Teaching hospitals) and four private dental clinics.

The government general hospitals were **Lagos State University Teaching Hospital** (LASUTH), is located at Ikeja local government of Lagos (*06.55956 N, 003.37096 E*). **Lagos University Teaching Hospital** (LUTH), is located at Idi-Araba in Mushin local government. **Eko General Hospital** is located along Broad Street in Marina, Lagos Island local government area (*06.44678N, 003.39795 E*) while **Gbagada General Hospital** is at hospital road, Kosofe local government.

The private dental clinics/hospitals sampled are:

First Consultant dental clinic, is located in Ilupeju in Mushin local government area (*06.57068 N and 003.25501 E*). **Havillah dental clinic**, is located in Anthony village of Kosofe Local government area, **Schubbs dental clinic** is located along Milverton road in Lagos Island local government area, while **Faces n Braces dental clinic** is located in Park View Estate of Ikoyi in Lagos Island local government area of Lagos state.

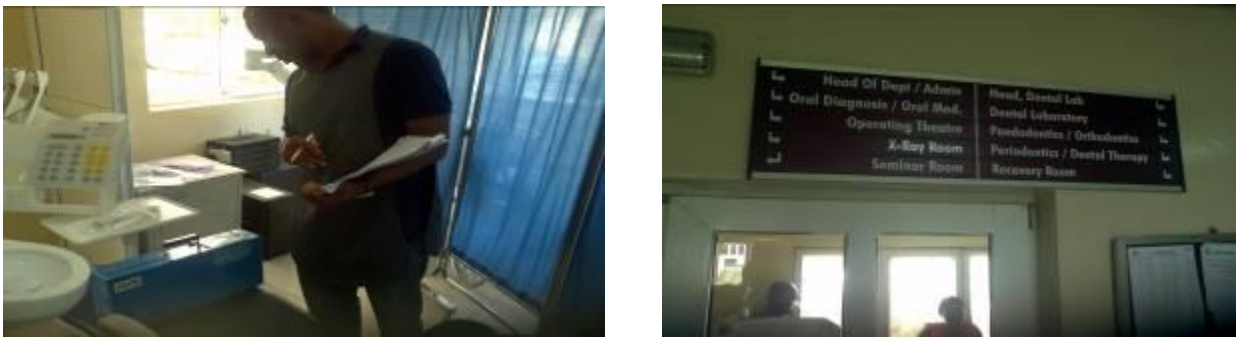


Figure 3: Lumex Sampling at LASUTH

6.3 SAMPLING LOCATIONS FOR DENTAL CLINIC/HOSPITALS IN ABUJA FCT

The sampled dental clinics/hospitals in Abuja were six public (government) dental clinics/hospitals and five private dental clinics/hospitals.

The public clinics were: *National hospital*, located on Independence Avenue, Plot 132 Central District (Phase II), Garki; *Wuse General hospital*, zone 3, Abuja; *University of Abuja Teaching hospital* (UNABTH) on hospital road, Gwagwalada; *Federal High Court Dental Clinic* located on Abia house road, Off Shehu Shagari way; *Federal Staff Dental Clinic* located at the Federal secretariat, Phase 1, Abuja and *National Assembly Dental Clinic* located within the National Assembly complex, Three Arm Zone, Maitama.

Private clinics sampled in Abuja were: *Limi Hospital*, located at Plot 541, Constitution Avenue, Airport Road, Central Area District; *QH Specialist Dental Clinics*, located on 2nd floor Suite C3, Sysak Plaza, Off 1st Avenue, Gwarimpa; *Urbane Dental Clinic*, located at No 5 Ilorin street, Area 8, Garki; *Ideal Dental clinic*, located at CEDDI PLAZA, 264 Tafawa Balewa Way, CBD and *Regal Dental Clinic*, located at Suite 6, Hilltop Plaza,Plot 2189, House 13, Gwani street, Zone 4.

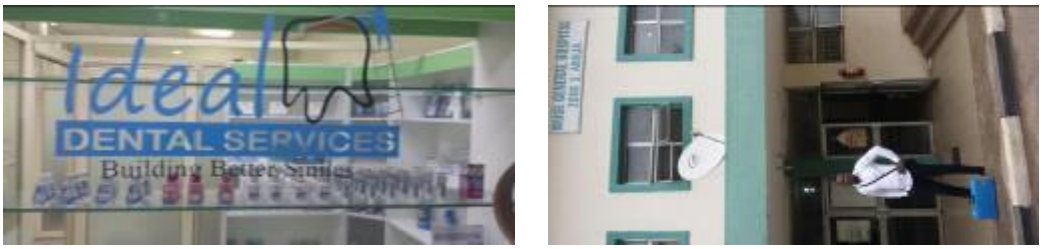


Figure 4a: Lumex Sampling at Ideal Dental Services and Wuse General Hospital in Abuja

Figure 4b: Lumex Sampling at National Hospital in Abuja

6.4 SAMPLED LOCATIONS FOR WASTE DUMPSITES IN IBADAN

There are four major dumpsites/landfill in Ibadan in which three were sampled for the purpose of this study. The three chosen sites namely **Lapite dumpsite** ***(****07.88827 N and 003.87984 E)*, which is located at the extreme end of Moniya of Akinyele local government area of Ibadan with land mass of 22 acres. **Afofunra/Aba Eku** *(07.82289N, 003.88749 E)*, is an open landfill in 25 acres of land that is located at the extreme end of Akanran village after Amuloko in Ona Ara local government area of Ibadan and **Akowo dumpsite** *(07.82298 N and 003.93743 E)*, an open landfill in 50 acres of land that is located at 11-12km after Apete of Awotan village in Ido local government area.

Figure 5: Lumex Sampling at Lapite and Afofunra/Aba Eku Sites in Ibadan

6.5 SAMPLED LOCATIONS FOR WASTE DUMPSITES IN LAGOS STATE

There are five approved dumpsites in total in the State but only two (Olushosun and Solous 3) were functioning and accessible as at the time of this project. The waste includes infectious medical wastes, toxic industrial solid wastes and domestic wastes, all co-mixed together most of the time. This practice of co-disposal of toxic and hazardous materials with the other refuse increases the likelihood of exposure to toxic and hazardous mercuric compounds.

Olushosun dumpsite is located in Ojota/Ikeja local government, and is possibly the largest dumpsite in Nigeria, which was originally on the outskirts of Lagos metropolis but is now within a developed locality of the metropolis and surrounded by residential, commercial and industrial neighbourhoods due to rapid urban development. The geographical coordinates of the sampling points are *06.51484 N and 003.39930 E, 06.59280 N and 003.37947 E, 06.59354 N and 003.37637 E.*

Solous landfill is situated at Igando in Alimosho Local Government Area of Lagos State. It commenced operation since 1996. As at 2008, estimated household survey, Alimosho was 309,347 with annual waste generation of 773.37 tones. The geographical coordinates of the sampling points are *06.61738N and 003.34057E, 06.56344N and 003.25261E, 06.56360N and 003.25401E.*

Simpson Transfer Loading Station is located in Sura area of Lagos Island Local Government Area. It commenced operations in March, 2009 and receives waste from Lagos – Island, Eti – Osa, Ajah, Surulere, Mainland, Orile, Ojo, Ogudu, an its environ. The geographical coordinates of the sampling points are *06.45675N and 003.40324, 06.45875N and 003.40323E*.

Figure 6: Lumex Sampling at Transfer Loading Stations

Figure 7: Lumex Sampling at Olusosun and Solous Sites

6.6 SAMPLED LOCATION FOR DUMPSITES IN ABUJA

The only waste dumpsite sampled in Abuja is the Gosa waste dumpsite located in Gosa village, serves as the central refuse dump for all the household and industrial waste in the capital city and undoubtedly the biggest in the city. It is a 90 hectares of land dumpsite located within the Abuja Municipal Area Council located in a far away bush, off Jabi road in Idu Industrial Layout about 30kilometers off the express road is under the management of Abuja Environmental Protection Board (AEPB). As at the time of the monitoring visit, this site was noticed to have been abandoned completely and it's now converted to a large farmland for growing maize.

6.7 SAMPLED LOCATION FOR INCINERATORS/MEDICAL WASTE TREATMENT FACILITY

There is only one functioning incinerator in Ibadan *(06.59598 N and 003.67881 E)* located in University College Hospital (UCH) Ibadan that was sampled during the study. The **Based Thermal ECODA Processor** ***(****06.59598 N and 003.67881 E)* located on Oshodi/Mile 2 Expressway, Oshodi Local Government Area is used for treating medical waste before being sent to landfill was also sampled.

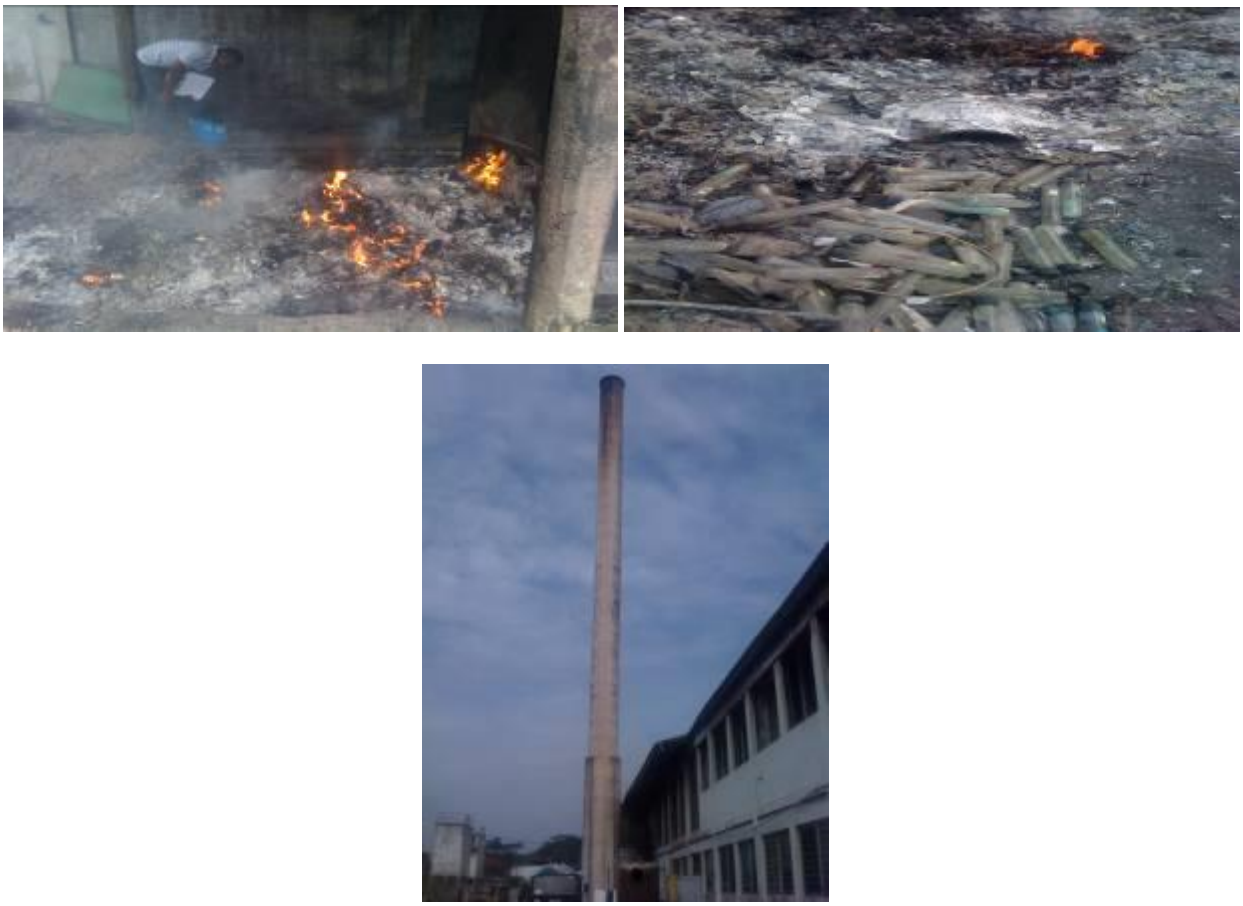


Figure 8: Lumex Sampling at UCH Incinerator Site

Figure 9: Lumex Sampling at Oshodi ECODAS Medical Waste Incinerator Site

6.8 SAMPLING LOCATION FOR WEEE (E-WASTE) IN LAGOS

The Ikeja Computer Village *(06.59384 N and 003.34185 E, 06.59404 N and 003.34099, 06.59350 N and 003.34152. 06.59435 N and 003.33950 E*) and Ikeja GSM Village (*06.58688N and 003.33850E, 06.58790N and 003.33840E, 06.58576N and 003.33345E*) of Lagos state were also sampled since majority of the cell phones and obsolete computers that circulate Nigeria filters

through these markets and also the dealers, technicians, peasants, waste-pickers, recycler that are directly exposed to this e-waste are readily available.

Figure 10: Lumex Sampling at Ikeja GSM Village and Computer Village Sites

6.9 SAMPLING LOCATION FOR UNIVERSITY LABORATORIES AND CHEMICAL STORE ROOMS

In Ibadan the chemical laboratories and chemical store rooms *(07.39846N and 003.30480E, 07.4494N and 003.9430E)* of chemistry department of University of Ibadan, Oyo state were sampled. While in Lagos, the laboratories and chemical stores (*06.58688N and 003.63850E, 06.51492N and 003.40075E, 06.51432N and 003.40072E, 06.51484N* and 003.39933E) chemistry department of University of Lagos (UNILAG) were sampled.

Figure 10: Lumex sampling at UNILAG and Univ. of Ibadan Chemical laboratory sites

7.0 RESULT FINDINGS AND DISCUSSION

The data were collated and analysed by states, source categories, structure of institution and finally by mercury source categories.

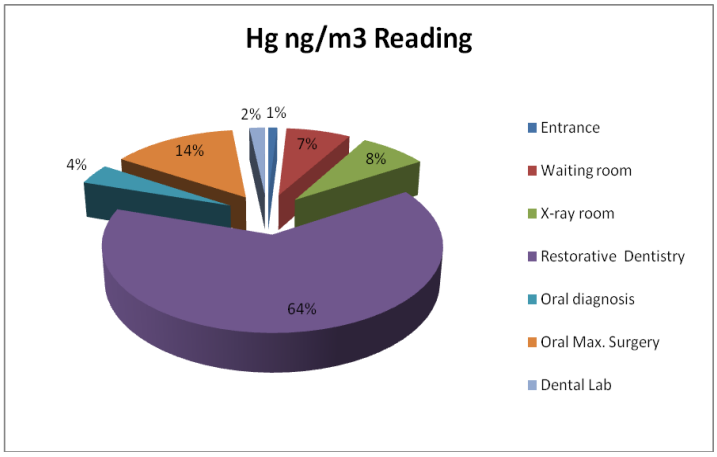
7.1 MERCURY LEVELS IN LAGOS STATE DENTAL CLINICS/HOSPITALS

Table 1: Indoor reported mercury levels (ng/m^3) at different sampling point at LASUTH, Lagos.

S/N	SAMPLING POINT	READINGS Hg ng/m^3
1	Entrance	23
2	Waiting room	164.3
3	X-ray room	172.3
4	Restorative Dentistry	1434
5	Oral diagnosis	90.67
6	Oral Maxillo. Surgery	318
7	Dental Lab (prosthetic or prosthodontics lab)	40

Source: SRADev Nigeria, (2014)

Figure 11: A pie chart showing an Indoor mercury levels (ng/m^3) of different sampling point at LASUTH, Lagos



Source: SRADev Nigeria, (2014)

From table 1 and Figure 11 above, it could be observed that the mercury level from restorative dentistry is almost four times higher and in oral maxillofacial surgery unit is a little above recommended air level that could breathed for 24 hours, 365 days for 70 years at 300 ng/m^3 mercury in air without adverse effect on health (ATSDR, 2012; TEMPR, 2013) respectively.

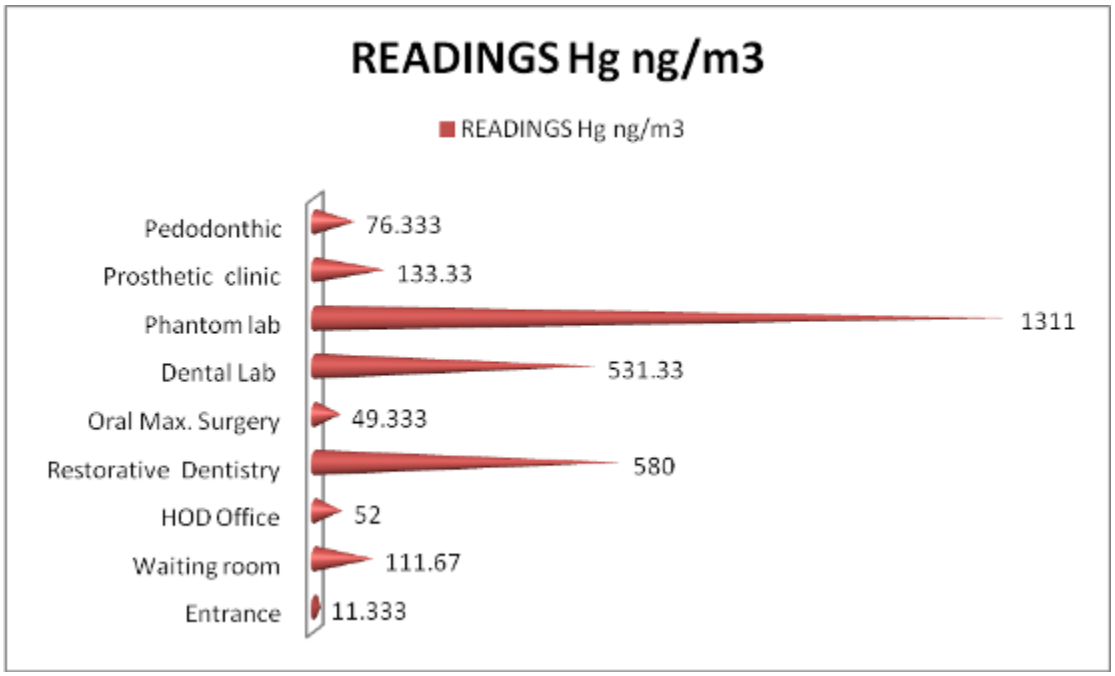
Table 2: Indoor reported mercury levels (ng/m^3) at different sampling point at LUTH, Lagos

S/N	SAMPLING POINT	READINGS Hg ng/m^3
1	Entrance/outside	11.333
2	Waiting room	111.67
3	HOD Office	52.00
4	Restorative Dentistry	580.0
6	Oral Max. Surgery	49.333
7	Dental Lab (prosthetic or prosthodontics lab)	531.33
8	Phantom lab	1311.0

9	Prosthetic clinic	133.33
10	Pedodonthic	76.333

Source: SRADev Nigeria, (2014)

Figure 12: A bar chart showing an Indoor mercury levels (ng/m^3) of different sampling point at LUTH, Lagos

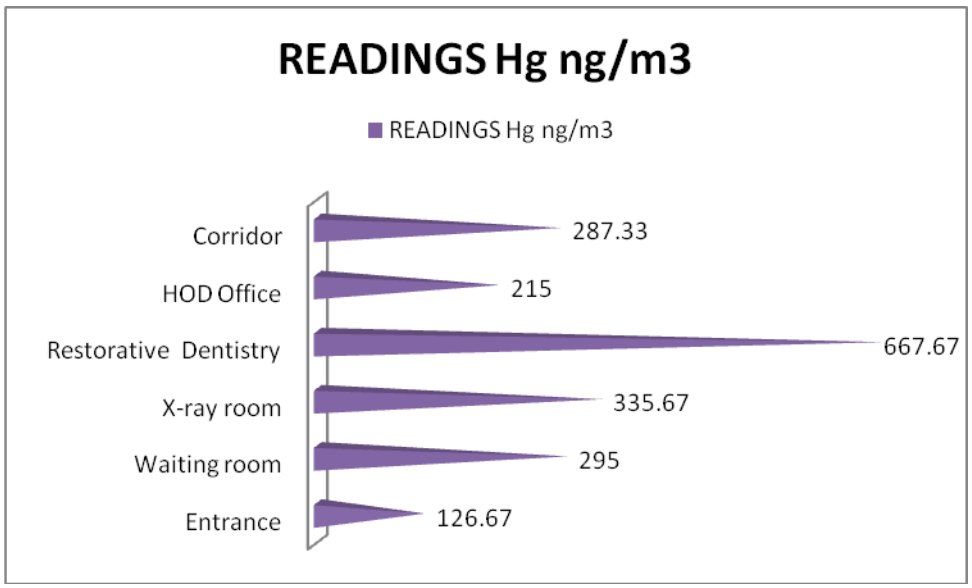


Source: SRADev Nigeria, (2014)

It could be observed from figure 12 above that the mercury level from the phantom laboratory (were dental students undergo practical teaching) is highly contaminated with mercury vapour. It is more than 300% higher than the ambient air recommended level. It is basically due to the activities that takes place there i.e student dentist training room. Concentration in restorative and oral maxillofacial surgery sections are also high and almost doubles the recommended level. This finding compare with the high levels observed at LASUTH, indicating that mercury amalgam activities are still well used in restorative and phantom lab sections of teaching hospitals and general hospitals in Lagos State.

At the Eko General Hospital (figure 13), the concentration at different unit was due to the activity that occurred there. The restorative dentistry unit that was 100% higher than recommended level is where amalgam posterior fillings take place regularly.

Figure 13: A bar chart showing an Indoor mercury levels (ng/m^3) of different sampling point at Eko General Hospital, Lagos



Source: SRADev Nigeria, (2014)

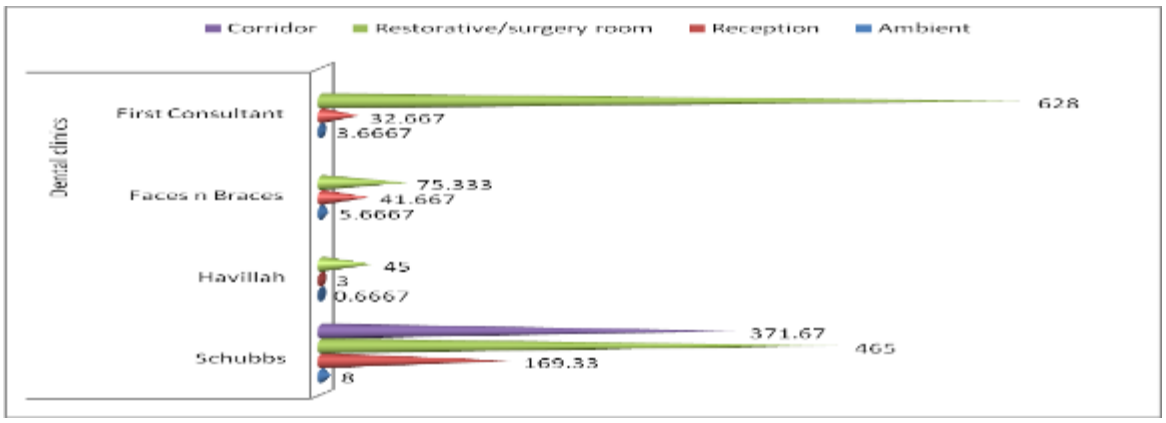
7.2 MERCURY LEVELS IN PRIVATE DENTAL CLINICS SAMPLED IN LAGOS STATE

Table 4: Indoor reported mercury levels (ng/m^3) at different Private Dental Clinics sampled in Lagos state

S/n	SAMPLING POINT	Dental clinics			
		Schubbs	**Havillah**	**Faces n Braces**	**First Consultant**
1	Ambient/outside air	8	0.6667	5.6667	3.6667
2	Reception	169.33	3	41.667	32.667
3	Restorative/surgery room	465	45	75.333	628
4	Corridor	371.67	-	-	-

Source: SRADev Nigeria, (2014)

Figure 14: A bar chart showing indoors mercury levels (ng/m^3) of different Private Dental Clinics sampled in Lagos state



Source: SRADev Nigeria, (2014)

Of the four private dental clinics sampled in Lagos state, *Schubbs* and *First consultant clinics* are having higher concentration of ambient mercury level indicative of dental amalgam use in the clinics, which is above recommended level for healthy lifestyle. Levels on the corridors of *Schubbs* were also seen to be high due to series of restorative/operative laboratories observed adjourning the corridor, a situation which also puts at risk all visitors, workers etc within the facility.

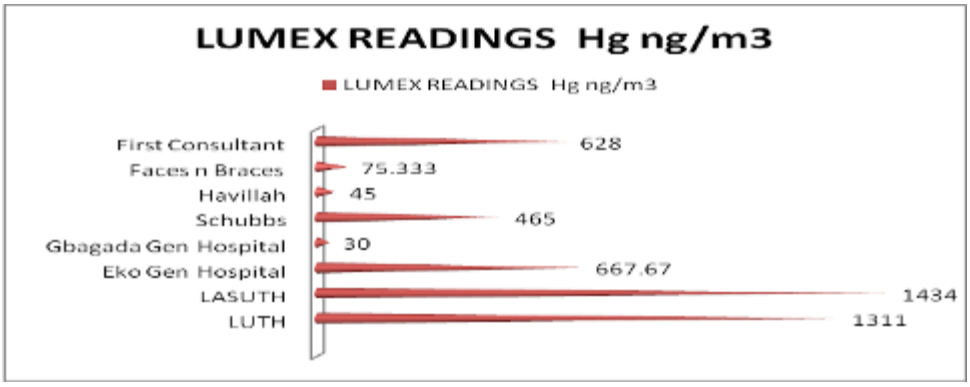
Table 5: Indoor reported mercury levels (ng/m^3) at different General Dental Hospitals sampled in Lagos state

s/n	**SAMPLING POINT**	**DENTAL CLINICS**			
		LUTH	LASUTH	EKO GENERAL HOSPITAL	GBAGADA GENERAL HOSPITAL
1	Entrance	11.333	23	126.67	3
2	Waiting room	111.67	164.3	295	26
3	Restorative Dentistry	580	1434	667.67	30
4	Oral Max. Surgery	49.333	318	-	-
5	Dental Lab (prosthetic or prosthodontics lab)	531.33	40	-	-
6	X-ray	-	172.3	335.67	-
7	Phantom lab	1311	-	-	-

Source: SRADev Nigeria, (2014)

From the above, it could be seen that all the restorative dentistry units of the four general hospital sampled in Lagos have indoor mercury level above the recommended level except the *Gbagada general hospital* which was much lesser. *LASUTH* had the overall average mean indoor mercury level followed by LUTH.

Figure 15: A chart showing indoors mercury levels (ng/m^3) of different dental clinics (Hg ng/m^3)) in Lagos state



Source: SRADev Nigeria, (2014)

From the above comparison of the different indoor mercury level in selected health facilities in Lagos state, LASUTH and LUTH have the highest indoor mercury level of 1434Hgng/m^3 and 1311Hgng/m^3 respectively which are far above the recommended level. They are both Teaching dental hospital and also government owned general hospitals. It could be seen that 62.3% of the sampled facilities has indoor mercury level above the recommended standard which is 300ng/m3 for 24 hours, 365 days for 70 years of mercury in air without adverse effect on health (ATSDR, 2012; TEMPR, 2013) respectively.

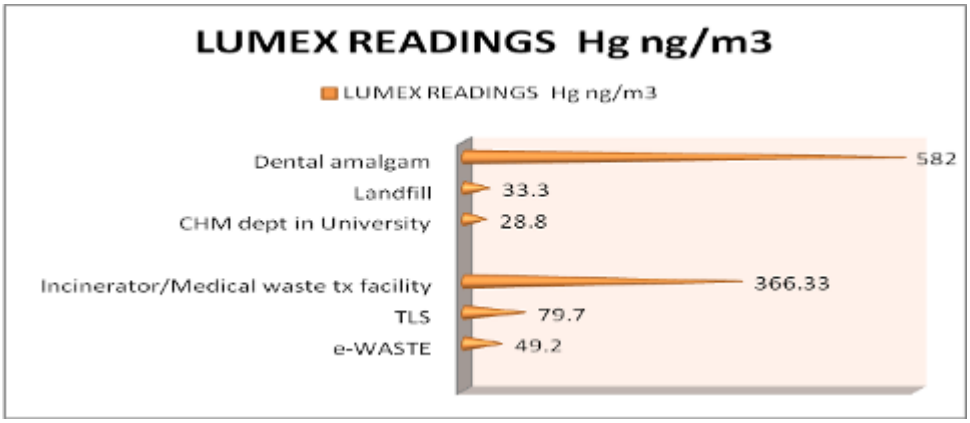
7.3 MERCURY LEVELS FROM SOURCE CATEGORY (WASTE DUMP/LANDFILLS, INCINERATOR, WEEE LOCATIONS, LABORATORIES) IN LAGOS

Table 6: Showing the result of Lumex readings for average Mercury emission from source categories (Hg ng/m^3) in Lagos state

SITE	MERCURY EMISSION SOURCE CATEGORIES				
	e-WASTE	**Transfer Loading Stations (TLS)**	**Incinerator/Medical waste treatment facility**	**Landfill**	**CHM dept in University**
A	Computer village	Simpson	Oshodi (Ecoda Med waste treatment)	Olushosun	Organic lab (Unilag)
Reading in ng/m^3	63.7	79.667	366.33	18.667	16.667
B	GSM Village	-	-	Solous	Inorganic lab (Unilag)
Reading in ng/m^3	34.667	-	-	48	41

Source: SRADev Nigeria, (2014)

Figure 16: A bar chart showing indoors mercury levels (ng/m^3) of different average mercury emission across all sources in Lagos state



Source: SRADev Nigeria, (2014)

Mercury levels and emissions across all sources of both indoor and outdoor sampled in Lagos as shown in the figure 16 above, shows that dental amalgam has the highest consistent mercury emission during application or removal from fillings. This is followed by incinerator/medical waste treatment facilities.

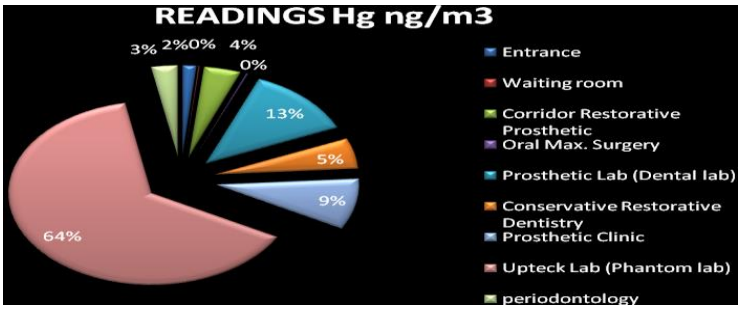
7.4 MERCURY LEVELS IN DENTAL CLINICS/HOSPITALS IN IBADAN, OYO STATE

Table 7: Indoor reported mercury levels (ng/m^3) at different sampling point in UCH Ibadan

S/N	**SAMPLING POINT**	**READINGS Hg ng/m^3**
1	Entrance	146
2	Waiting room	17
3	Corridor Restorative Prosthetic	401.3
4	Oral Max. Surgery	22
5	Prosthetic Lab (Dental lab)	1203
6	Conservative Restorative Dentistry	524.15
7	Prosthetic Clinic	866.7
8	Upteck Lab (Phantom lab)	6189
9	Periodontology	284

Source: SRADev Nigeria, (2014)

Figure 17: A pie chart showing indoors mercury levels (ng/m^3) of different sampling point in UCH



Source: SRADev Nigeria, (2014)

Mercury levels obtained indicate that the phantom laboratory at UCH is 20 times higher than the standard recommended level. This alarming levels presents public health risk as it was further confirmed that actual practical work was last carried out in the laboratory 6 months ago due to the long university strike. This implies that much higher levels would be recorded during normal academic period. The conservative restorative unit, its corridor, prosthetic laboratory and prosthetic clinic were also all above recommended air levels significantly, more than half (55%) of the sampled sites at UCH are high risk locations for mercury contamination.

Mercury levels recorded at Dugbe General Hospital, another government owned dental hospital indicates entrance/outside (1.3%), waiting room (26%) and restorative operative room (365.33%). It was observed that emission from UCH is much higher compared to that of Dugbe general hospital, although the indoor emissions from restorative dentistry of the two hospitals compare favorably and are above recommended standard of safety.

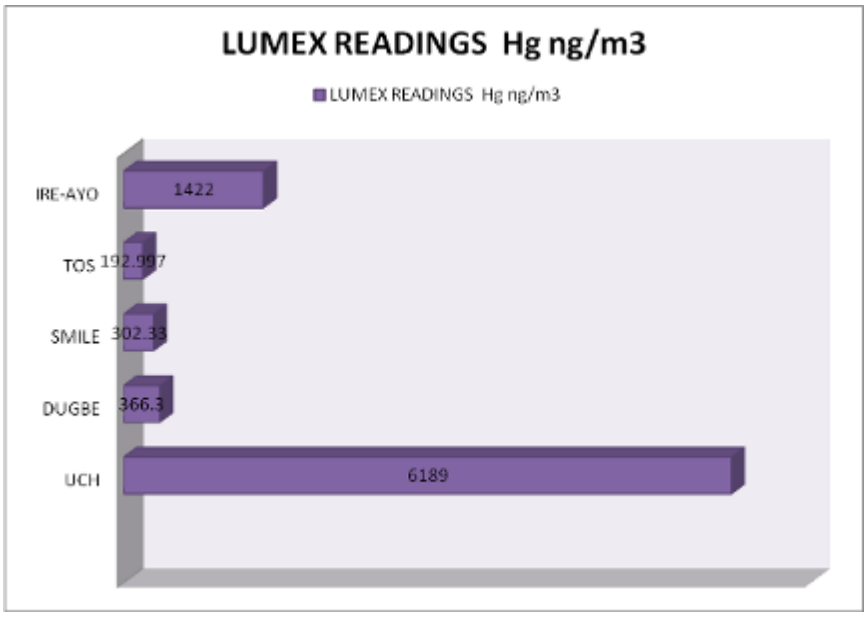
7.5 MERCURY LEVELS IN PRIVATE DENTAL CLINICS IN IBADAN

Table 8: Indoor reported mercury levels (ng/m^3) at different Private Dental clinics sampled in Ibadan

S/N	SAMPLING POINT	DENTAL CLINICS		
		SMILE	***TOS***	***IRE-AYO***
1	Ambient	10.333	4.6667	11.7
2	Reception	81	5.3333	68.667
3	Restorative/surgery room	212	183	1339

Source: SRADev Nigeria, (2014)

Figure 18: A bar chart showing indoors mercury readings for diff. dental clinics (Hg ng/m^3) in Ibadan



Source: SRADev Nigeria, (2014)

In all the five dental clinics sampled in Ibadan , 80% of the clinics indoor mercury emission are higher than recommendable safety standard of 300ng/m^3, with UCH and Ire-Ayo having 6189ng/m^3 and 1422ng/m^3 which are about 20.6 and 4.7 times higher than the safety standard respectively. The high level recorded for Ire-Ayo is substantiated by the manual usage of pestle and mortar for mixing the amalgam observed during the visit to the clinic. This practice is however outdated considering its attendant mercury emission rate.

7.6 MERCURY LEVELS FROM OTHER SOURCE CATEGORIES IN IBADAN

TABLE 9: Showing the result of diff. mercury (ng/m^3) emission source categories in Ibadan

	MERCURY EMISSION SOURCE CATEGORIES		
SITE	*Incinerator/Medical waste treatment facility in UCH*	*Dump site/Landfill*	*Chemistry laboratory in University*
A			
Reading in ng/m^3	2748.3	43.77667	121.67

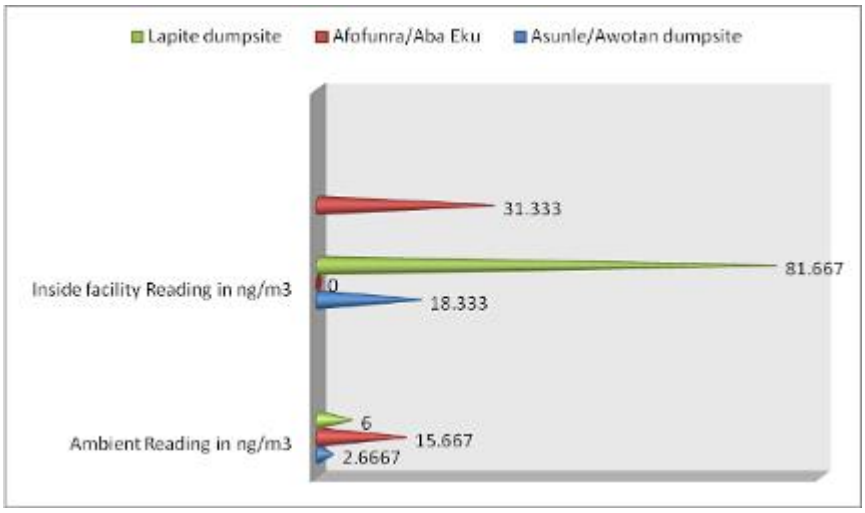
Source: SRADev Nigeria, (2014)

TABLE 10: Showing the result for diff. mercury (ng/m^3) emission at dumpsites in Ibadan

	MERCURY EMISSION AT DUMPSITES		
SITE	A	B	C
	Asunle/Awotan dumpsite	***Afofunra/Aba Eku dumpsite***	***Lapite dumpsite***
Ambient Reading in ng/m^3	2.6667	15.667	6
Inside facility *Reading in ng/m^3*	18.333	31.333	81.667

Source: SRADev Nigeria, (2014)

Figure 19: A bar chart showing indoors mercury readings for different mercury (ng/m^3) emission at dumpsites in Ibadan



Source: SRADev Nigeria, (2014)

The result indicates that all the three waste dumpsites in Ibadan are presented with very low mercury emissions as was also observed for dumpsites in Lagos. The reason for the low values in those sites as observed could be mainly due to high aeration occurring over a very large expanse of open land space sufficiently dispersing any emissions produced from the sites and also work activities such as turning, grading, off-loading etc were not much as at the time of the sampling.

7.7 MERCURY LEVELS FROM DENTAL CLINICS/HOSPITALS IN ABUJA FCT

Table 11: Indoor reported mercury levels (ng/m^3) of different Dental hospitals (government owned) in Abuja

S/N	SAMPLING POINT	DENTAL CLINICS					
		National hospital, Abuja	Wuse (Zone3) General hospital	University of Abuja Teaching hospital	Federal high Court Dental clinic	Federal staff dental clinic (federal secretariat)	National Assembly Dental clinic
1	Entrance	2	2	36	2.7	17.3	6.3
2	Waiting room	28.3	40.333	172.33	227.67	54	66.7
4	Restorative Dentistry	579.33	91	634	298.67	438.3	239.3
5	Oral Max. Surgery	17.667	-	215.33	-	-	-
6	Dental Lab (prosthetic or prosthodontics lab)	20	-	260.7	-	64.7	187
7	Registration room	-	70	-	-	-	-
8	Pedodonthic	-	-	634	-	-	-

Source: SRADev Nigeria, (2014)

In all the different government-owned Dental hospitals sampled in Abuja, higher levels continued to be repetitive in all the restorative dentistry sections as shown in the table 11 for *National hospital* (579.33), *University of Abuja Teaching Hospital* (634), *Federal high court dental clinic* (298.67), *Federal staff clinic at Federal secretariat* (438.3) and *National Assembly Dental clinic* (239.3) which are in most cases higher compared to the USA EPA reference levels of 300ng/m^3. The very low value (91) recorded for *Wuse general hospital* and perhaps other government clinic/hospitals was as a result of no activity taken place at the operative dentistry for a very long time due to the long period of doctors nationwide strike ongoing at the time of visit, however skeletal operation was observed at the national hospital and others but still below normal operation. Notwithstanding, 50% of them still have vapor mercury emissions above the safety dose limit in their restorative clinic/wards.

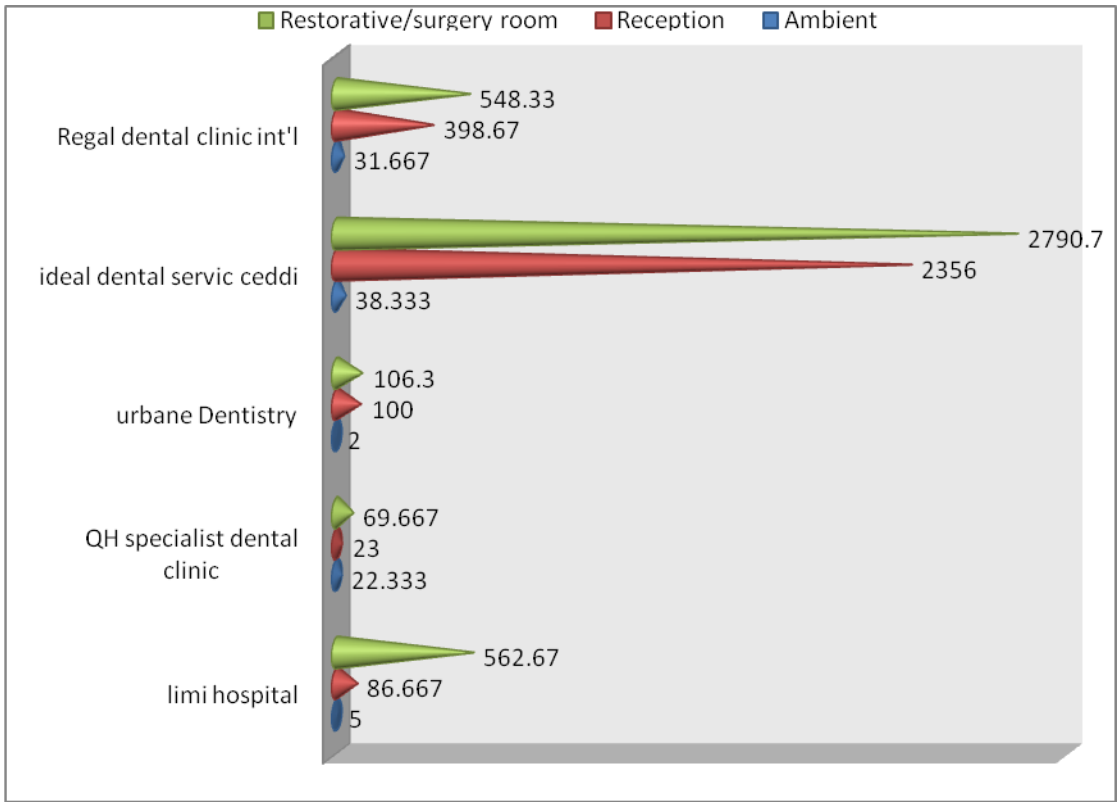
7.8 MERCURY LEVELS FROM PRIVATE DENTAL CLINICS SAMPLED IN ABUJA FCT

Table 12: Indoor reported mercury levels (ng/m^3) of different Private dental Clinics in Abuja FCT.

S/N	SAMPLING POINT	Dental clinics				
		Limi hospital	QH specialist dental clinic	Urbane Dentistry	Ideal dental clinic	Regal dental clinic int'l
1	Ambient	5	22.333	2	38.333	31.667
2	Reception	86.667	23	100	2356	398.67
3	Restorative/surgery room	562.67	69.667	106.3	2790.7	548.33

Source: SRADev Nigeria, (2014)

Figure 20: A bar chart showing the result of Lumex readings of average mercury (ng/m^3) of different Private dental Clinics sampled in Abuja FCT.

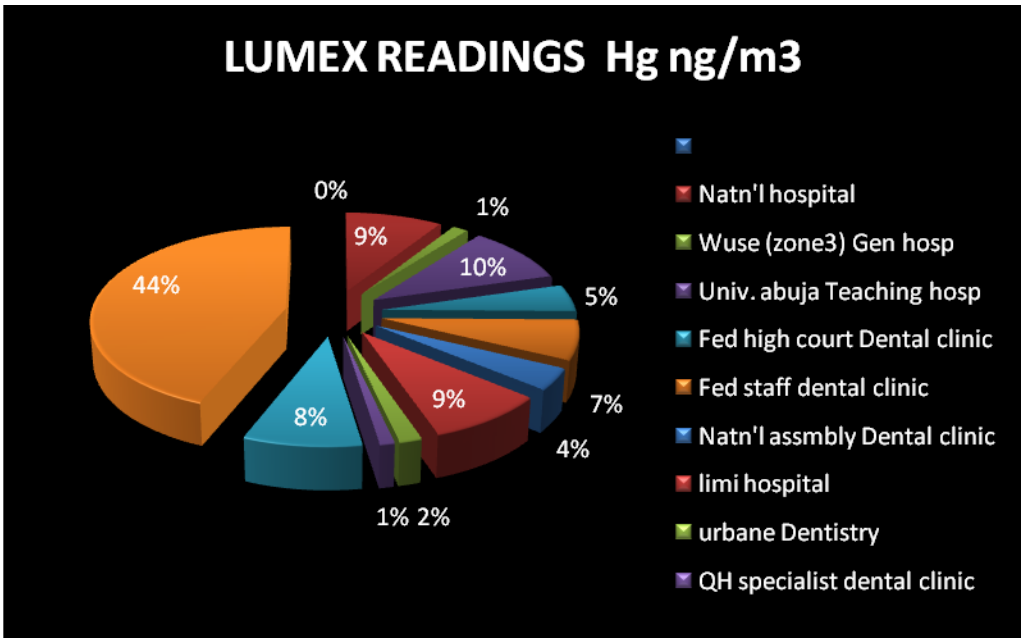


Source: SRADev Nigeria, (2014)

From the total number of private dental hospitals sampled in Abuja 60% of them have vapor mercury emission above safety limit. The case of *Ideal dental clinic*, was extremely alarming with as high levels of 2356-2790.7ng/m^3 in both the restorative surgery area and the waiting/reception lobby. Monitoring team observed that this clinic was located right at the underground basement of CEDDI plaza (a very popular shopping complex in Abuja) were there

are no window outlets or any form of aeration, the facility runs on full air-condition system at all times of operation which is observed to be responsible for the accumulated mercury vapour within the clinic. The readings are as high as nine times above the reference safety limit of 300ng/m^3. Significantly, two hospitals (*QH Specialist dental hospital* and *Urbane dental Clinic*) with levels ranging from 23-106.3ng/m^3 were operating under lower mercury levels. These low levels were further confirmed by the management claiming they never use dental amalgam anymore and for a long time.

Figure 21: A Pie chart showing the result of Lumex readings of average mercury (ng/m^3) of diff. dental clinics in Abuja FCT.



Source: SRADev Nigeria, (2014)

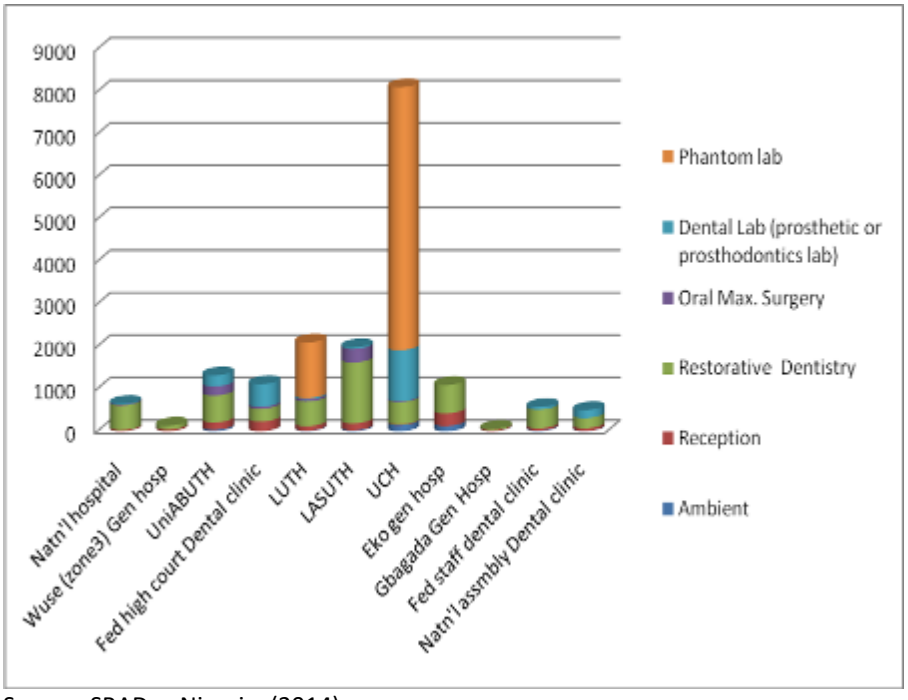
From the above comparison of the different indoor mercury level in selected health facilities in Abuja FCT, *Ideal dental clinic* and *University of Abuja teaching hospital* have the highest indoor mercury level of 2790.7Hgng/m^3 and 634Hgng/m^3 respectively which are far above the recommended level. The former is a privately owned dental clinic while the latter is a Teaching Dental institution also government owned hospital. It could be observed that 55.6% of the sampled clinics has indoor mercury level above the recommended standard which is 300ng/m^3 for 24 hours, 365 days for 70 years of mercury in air without adverse effect on health (ATSDR, 2012; TEMPR, 2013) respectively.

7.9 MERCURY LEVELS FROM ALL GENERAL HOSPITALS (GOVERNMENT OWNED) SAMPLED IN NIGERIA

Table 13: Indoor reported mercury levels (ng/m^3) of different General hospitals Sampled in Nigeria

S/N	SAMPLING POINT	DENTAL CLINICS										
		National hospital	Wuse (zone3) General hosp	Univ.Abuja TH	Fed high court Dental clinic	LUTH	LASUTH	UCH	Eko general hosp	Gbagada Gen Hospital	Fed. staff dental clinic	Natn'l assembly Dental clinic
1	Ambient	2	2	36	2.7	11.3	23	146	126.67	3	17.3	6.3
2	Reception	28.3	40.333	172.33	227.67	111.67	164.3	17	295	26	54	66.7
3	Restorative Dentistry	579.33	91	634	298.67	580	1434	524	667.67	30	438.3	239.3
4	Oral Max. Surgery	17.667	-	215.33	49.333	49.3	318	22	-	-	-	
5	Dental Lab (prosthetic or prosthodontics lab)	20	-	260.7	531.33	31.33	40	1203	-	-	64.7	187
6	Phantom lab	-	-	-	-	1311	-	6189	-	-	-	

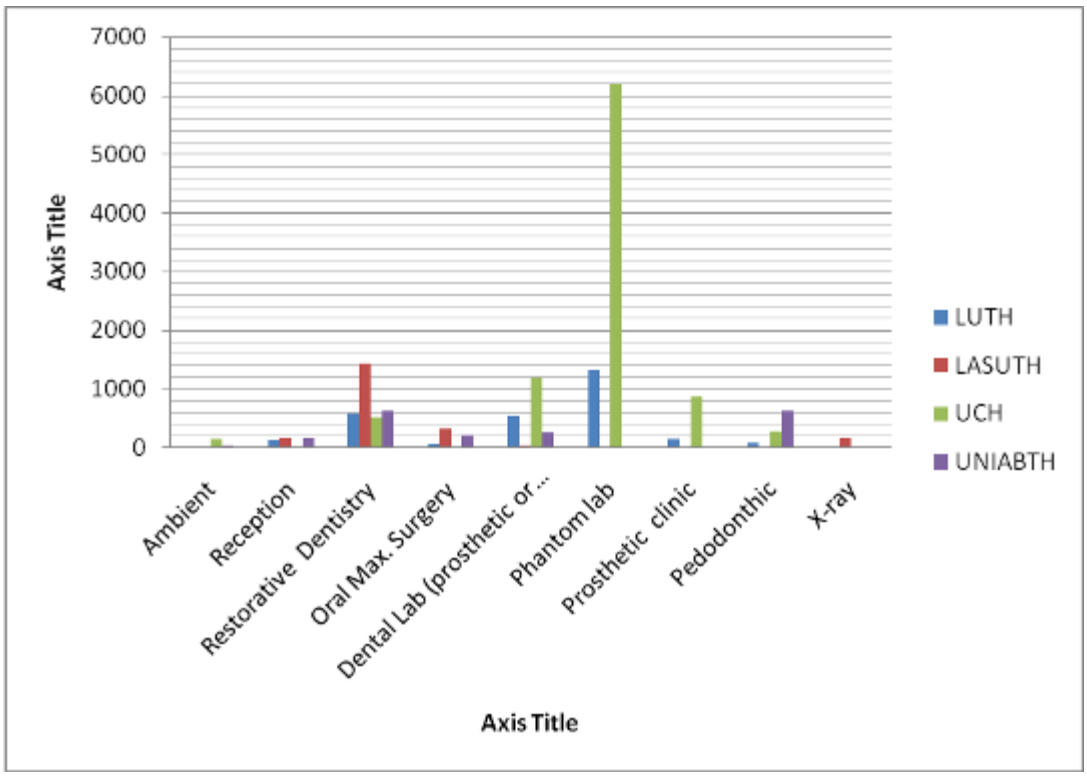
Figure 22: A bar chart showing the result of Lumex readings of average mercury (ng/m3) of diff. General hospitals Sampled in Nigeria



Source: SRADev Nigeria, (2014)

From the above comparison, *UCH* has the highest level mercury vapor emission in dental amalgam, followed by *LASUTH* and *LUTH*. The emission in UCH is 6189ng/m^3 which is 20.6 times higher than the safety limit. The three general hospitals with the highest emissions are government dental institutional teaching hospitals. It was observed generally that in all the three states sampled, government hospitals still operate heavily on the use of dental amalgam despite their high knowledge of the mercury free alternatives existing in the country. This is as a result of the need to train dental students, outdated incinerators facility (as was observed in UCH), the economic status of those requesting dental amalgam treatment etc. On the other hand, private clinics were observed to be shifting away from the use of amalgam to safer alternatives.

Figure 23: A bar chart showing the result of mercury (ng/m3) of different Dental Teaching Institutions sampled in Nigeria



Source: SRADev Nigeria, (2014)

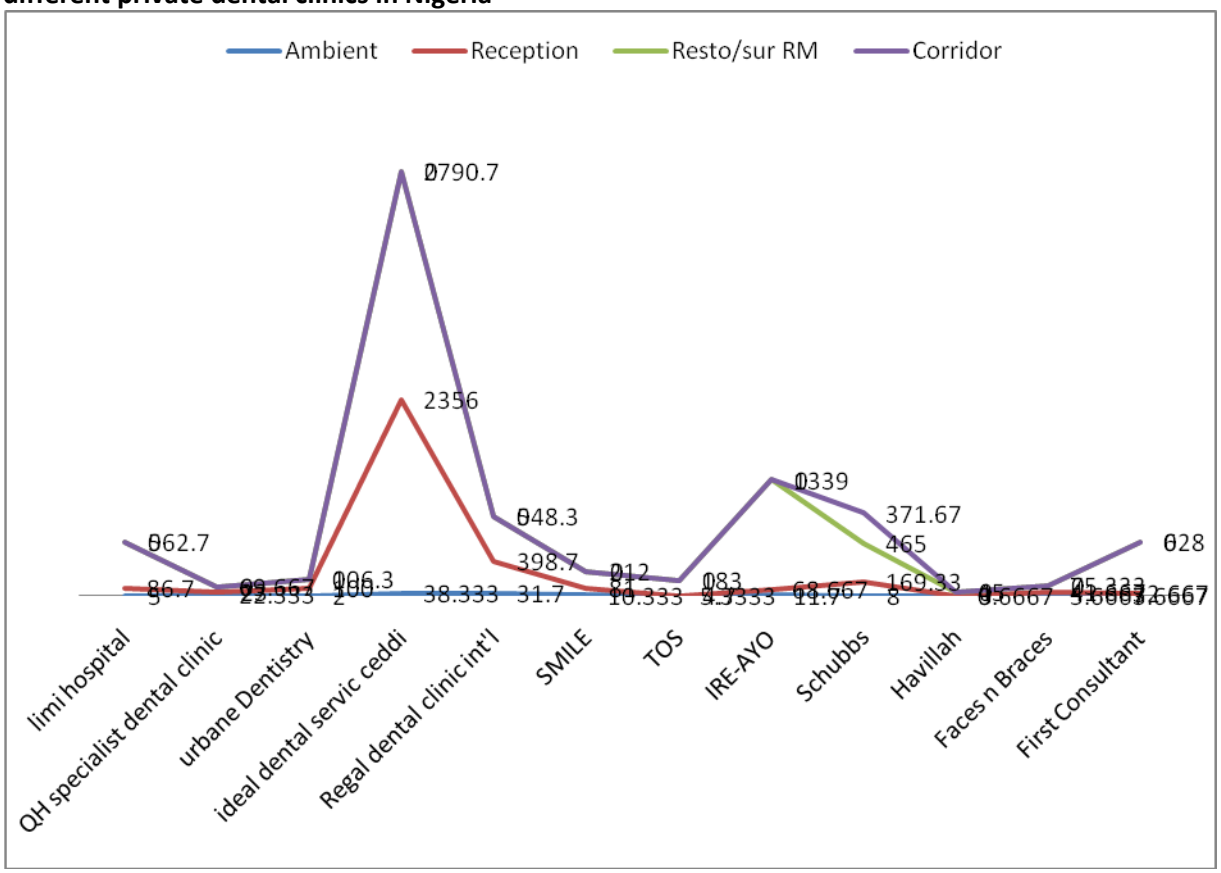
In the comparison of the four dental teaching institution sampled (figure 23), *University College Hospital Ibadan* has the highest emission from the phantom unit of the clinic. The emission value is 6189Hgng/m^3 which is about 2063% increment from the safety limit, next to this value is 1434Hgng/m^3 from Lagos state University Teaching Hospital and closely followed is *Lagos University Teaching Hospital* with emission of 1311Hg ng/m^3, *University of Abuja teaching hospital* having the least emission. The emission from the four hospitals is higher than the set safety limit standard.

8.0 MERCURY LEVELS FROM ALL PRIVATE DENTAL CLINICS IN NIGERIA

Table 14: Indoor reported mercury levels (ng/m³) of all private dental clinics sampled in Nigeria

s/n	SAMPLING POINT	Dental clinics											
		Limi hospital	QH specialist dental clinic	Urbane Dental clinic	Ideal dental services	Regal dental clinic	Smile	TOS	IRE-AYO	Schubbs	Havillah	Faces n Braces	First Consultant
1	Ambient	5	22.333	2	38.333	31.7	10.333	4.7	11.7	8	0.6667	5.6667	3.6667
2	Reception	86.7	23	100	2356	398.7	81	5.333 3	68.667	169.33	3	41.667	32.667
3	Restoratory /Surgery RM	562.7	69.667	106.3	2790.7	548.3	212	183	1339	465	45	75.333	628

Figure 23: A line graph showing the result of Lumex readings of average mercury (ng/m3) at different private dental clinics in Nigeria



Source: SRADev Nigeria, (2014)

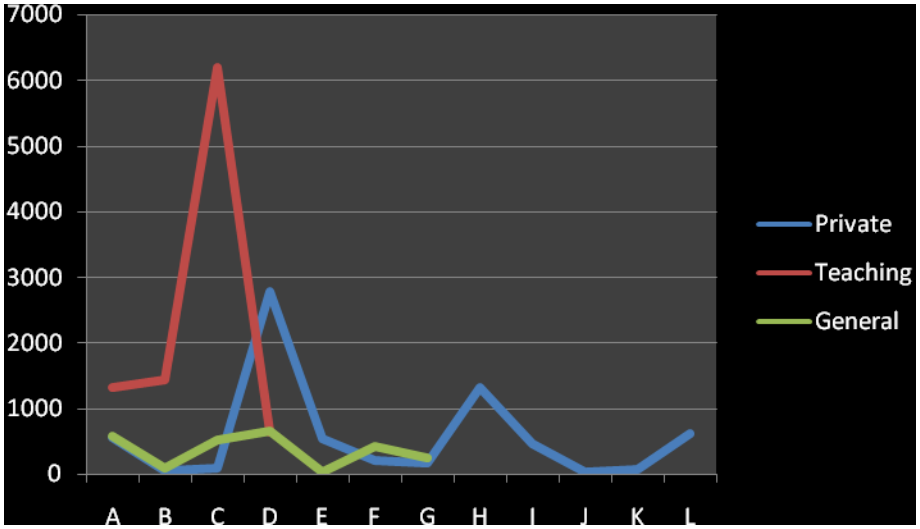
Twelve private dental clinics were used for this study as shown above, 50% of these clinics have high vapor mercury emission with Abuja based dental clinic (Ideal dental Clinic) having the highest emission from the restorative dentistry and waiting area of the clinic. The emission

from the surgery room is nine times above the safety limit, which is about 930% increment. Another clinic in these categories is *Ire-Ayo dental clinic* in Ibadan with emission of 1339Hg ng/m^3 and increment of 446% above the safety limit. While the third private clinic with high emission is *First consultant clinic* based in Lagos state.

Table 15: Mercury levels at visited clinics in Lagos, Ibadan and Abuja FCT, Nigeria

S/n	**Samples by hospital category**	**No of samples (n)**	**Mercury Levels in air ng/m^3**		**Above Standard *(300ng/m^3) No (%)**
			Mini.	Max.	
1	Dental teaching institutions	4	634.0	6189	4(100) **%**
2	General Hospitals	7	30.0	667.7	4 (57) **%**
3	Private Dental Clinics	12	75.3	2790.3	6 (50) **%**
	Total	23			14(61) **%**

Figure 24: A bar chart showing the result of Lumex of average mercury (ng/m^3) emission across dental hospitals in Nigeria



Source: SRADev Nigeria, (2014)

In the comparison of the three categories of dental clinic studied, monitoring data at the 23 dental clinics/hospitals of the 3 cities (Lagos, Ibadan and Abuja) shown in table 15 above, 61% of the sites indicated mercury vapours indoor levels above the USA EPA reference level of 300ng/m^3 the Teaching institutions have the highest mercury vapor emission from dental amalgam most likely due to the use of liquid mercury and non-mechanical mixing of mercury amalgam making..

Table 16: Mercury levels at visited sites in Lagos, Ibadan and Abuja FCT, Nigeria

S/n	Samples by hospital category	No of samples (n)	Mercury Levels in air ng/m^3		Above Standard *(300ng/m^3) No (%)
			Min.	*Max.*	
1	Dental teaching institutions	*4*	*634.0*	*6189*	*4(100) %*
2	General Hospitals	*7*	*30.0*	*667.7*	*4 (57) %*
3	Private Dental Clinics	*12*	*75.3*	*2790.3*	*6 (50) %*
4	Incinerator	*2*	*366.3*	*2748*	*2 (100) %*
5	Dumpsite (landfills)	*6*	*18.3*	*81.7*	*0 %*
6	E-waste	*2*	*11*	*79.7*	*0 %*
7	TLS	*1*	*50.6*	*79.7*	*0 %*
	Total	*34*			*16(48) %*

Source: SRADev Nigeria, (2014)

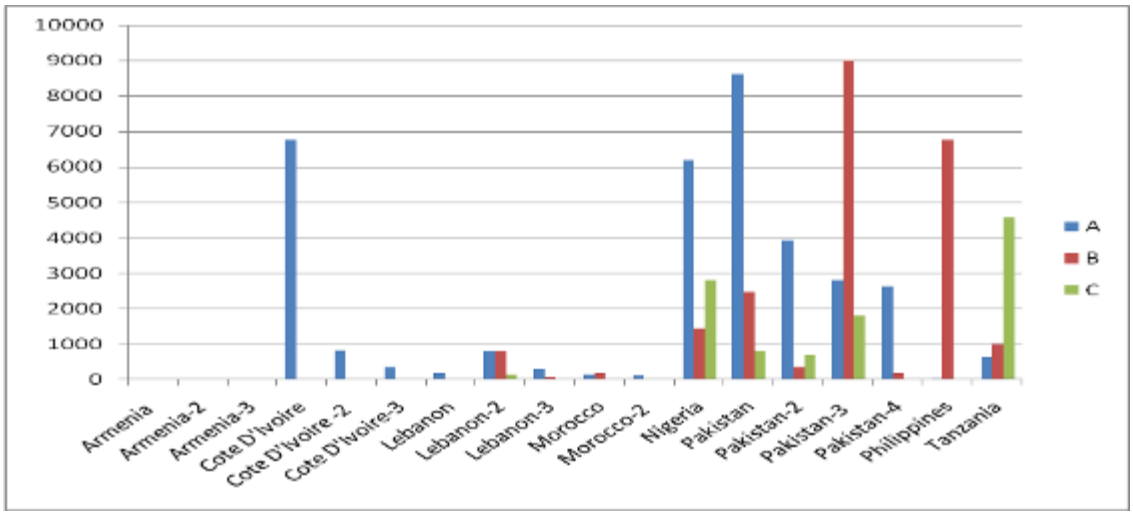
From monitoring data of all the 34 sites sampled in Nigeria, all four teaching hospitals and all the two medical waste incinerators were found to have mercury vapours above the reference level of 300ng/m^3 , indicating very high contamination of the air around those facilities, significantly as well, more than half (57%) of the seven (7) government owned general hospitals, and half (50%) of the 12 private dental clinics also show high mercury vapour contamination above the reference level of 300ng/m^3.

Table 17: Comparing Indoor Mercury (ng/m^3) Levels in Nigeria and other countries monitored by ZMWG *(source: SDPI report 2014)*

S/N	Reported Levels			
	Country	**Site A**	**Site B**	**Site C**
1	Armenia	12	10	14
2	Armenia-2	4.4	NIL	NIL
3	Armenia-3	4	NIL	NIL
4	Cote D'Ivoire	6759	NIL	NIL
5	Cote D'Ivoire -2	806	NIL	NIL
6	Cote D'Ivoire-3	337	NIL	NIL
7	Lebanon	163	10.3	NIL
8	Lebanon-2	787.8	797.1	134.8
9	Lebanon-3	291.4	46.5	NIL
10	Morocco	131.6	170.4	25.4
11	Morocco-2	104.2		
12	**Nigeria**	**6189**	**1434**	**2790.7**
13	Pakistan	8627	2453	791
14	Pakistan-2	3930	333	714
15	Pakistan-3	2798	9003	1800
16	Pakistan-4	2631	179	NIL
17	Philippines	20	6760.9	NIL
18	Tanzania	615	986	4588

Source: SRADev Nigeria, (2014)

Figure 25: A bar chart showing comparing Indoor Mercury (ng/m^3) Levels in Nigeria and other countries monitored by ZMWG



Source: SRADev Nigeria, (2014)

From the chart above it could be observed that among the 8 countries and 18 sites involved in the indoor Mercury Levels (ng/m^3) monitored by ZMWG, Nigeria is the 4th country with the highest indoor vapor mercury level after Pakistan, Philippines and Cote D'Ivoire and 5th highest among all site in the 18 countries studied so far.

TABLE 18: SHOWING THE SUMMARY OF THE CHARACTERISTICS OF ALL SITES SAMPLED

S/n	Category	Location	Highest average Hg (ng/m^3)	Observation	Recommendation
1	Dental amalgam	Schubbs (P)	465	-fully air-conditioned but poor atmospheric ventilation -i.e wind speed 0.0m/s - dental amalgam used last was about six month -mostly alternatives -composite was used on the day of sampling	
2	Dental amalgam	Havillah (P)	45	-highly aerated and ventilated -i.e wind speed 0.5m/s - dental amalgam used last was about six month -mostly alternatives -work was not going on	
3	Dental amalgam	Faces n Braces (P)	75.3	-mildly aerated and ventilated - dental amalgam used last was about six month -mostly alternatives -work on alternatives was done on day of sampling	
4	Dental amalgam	First consultant (P)	628	- poor atmospheric ventilation -i.e wind speed 0.0m/s - dental amalgam was used a day prior to the sampling -use of dental filling is based on patient request -	

5	Dental amalgam	TOS (P)	183	highly aerated and ventilated -i.e wind speed 0.5m/s -mostly alternatives -work was not going on	
6	Dental amalgam	IRE-AYO (P)	1339	-small private clinic -don't have amalgamator rather use mortar and pestle for mixing -average number of 3 patients per week -though well ventilated -amalgam was used prior to the sampling	
7	Dental amalgam	SMILE (P)	212	-mildly aerated and ventilated - dental amalgam used last was about six month -mostly alternatives -work on alternatives was done on day of sampling	
8	Dental amalgam	Regal dental clinic int'l(P)	548.3	- poor atmospheric ventilation -i.e wind speed 0.2m/s - dental amalgam was used a day prior to the sampling -use of dental filling is based on patient request	
9	Dental amalgam	ideal dental service(P)	2790.7	-located underground -fully air-conditioned but poor atmospheric ventilation -i.e wind speed 0.0m/s - dental amalgam used at patient request	
10	Dental amalgam	urbane Dentistry	106.3	-mildly aerated and ventilated - dental amalgam used last was about six month -mostly alternatives -work on alternatives was done on day of sampling	
11	Dental amalgam	QH specialist dental clinic(P)	69.7	-highly aerated and ventilated - dental amalgam used last was about 2 months ago -mostly alternatives -work on alternatives was done on day of sampling	
12	Dental amalgam	Limi hospital(P)	562.7	-poorly ventilated - dental amalgam used last was about 1 year ago -mostly alternatives -work on alternatives was done on day of sampling	
13	Dental amalgam	Natn'l hospital (G)	579.33	-permanent dentist, a pregnant woman -poorly ventilated - dental amalgam used last was about 1 year ago -mostly alternatives -alloy filling used about 3 months ago	
14	Dental amalgam	Wuse (zone3) Gen hosp (G)	91	-amalgam was used 3 weeks prior to the sampling - work was not going as at the time of the analysis because doctors were on strike -well ventilated	
15	Dental amalgam	Fed high court Dental clinic (G)	298.67	-amalgam was used a week ago -doctors were on strike at the time of this sampling -mildly aerated	
16	Dental amalgam	Eko gen hosp(G)	667.7	-lack cross ventilation -amalgam use almost everyday -work was not on-going as at the time of the sampling	
17	Dental amalgam	Gbagada Gen Hosp(G)	30	-highly ventilated and aerated -amalgam is used often at patient request	

				-amalgam was used 2 weeks prior to the sampling	
18	Dental amalgam	Fed staff dental clinic (G)	438.3	-mildly ventilated -work was not on-going as at the time of this sampling -amalgam is used at patients request	
19	Dental amalgam	Natn'l assmbly Dental clinic (G)	239.3	-mildly ventilated -work was not on-going as at the time of this sampling -amalgam is used at patients request	
20	Dental amalgam	LUTH (T)	1311	student doctors' practical room, contains phantoms -mercury highly exposed during practicals -mildly ventilated ie windows locked up -room used 2 weeks before sampling	
21	Dental amalgam	LASUTH (T)	1434	-mildly ventilated -work was on-going as at the time of this sampling -amalgam was used same day -average number of patient per day is 7 -most times 4 dentists on ground	
22	Dental amalgam	UCH (T)	6189	-student doctors' practical room, contains phantoms -mercury highly exposed during practicals -poor ventilation i.e room locked up -Room last used prior to the sampling was six months ago	
23	Dental amalgam	UNIABUTH (T)	634	-amalgam was used a month ago prior to the sampling -usually amalgam is between 2-3 times a week -doctors on strike	
24	Incinerator/Medical waste tx facility	Oshodi	366.33	-incinerator not working -Ecoda medical waste treatment as a substitute -vapor from the steam of treated waste highly polluted	
25	Incinerator/Medical waste tx facility	UCH	2748.3	-the air stack about 50 feet high -fumes emitting at the base fireplace of the incinerator highly contaminated	
26	CHM dept in University	UNILAG	41	-labs well ventilated and aerated -chemical containers well covered and neatly labeled and arranged. -analysis a week prior to the sampling	
27	CHM dept in University	Univ of Ibadan	121.67	-labs well ventilated and aerated -chemical containers well covered and neatly labeled and arranged. -analysis was not going on, students were on holidays	
28	Waste dumpsite	Solous	48	-receives between 200-220 trucks a day -an open space of land -highly aerated and ventilated -there was burning - recycling activities ongoing	
29	Waste dumpsite	Olushosun	18	-receives between 400-450 trucks a day -50 acres, an open space of land -highly aerated and ventilated -there was opening burning -recycling activities ongoing	
30	Waste dumpsite	Awotan/Asunle	18.333	-Expanse 50 acres of land, - an open space, highly aerated	

31	Waste dumpsite	Afofunra/Aba Eku	31.333	-Expanse 25 acres of land, an open space, highly aerated - recycling activities ongoing	
32	Waste dumpsite	Lapite dumpsite	81.7	-Expanse 22 acres of land, an open space, highly aerated -recycling activities ongoing	
33	e-WASTE	GSM village	79.667	Little cramp shops, basically disassembling, reassembling, melting and soldering of GSM phones, mildly ventilated	
34	e-WASTE	Computer village	63.7	-Little cramp shops, -basically disassembling, reassembling, melting and soldering of computers and laptops, -mildly ventilated rooms	
35	TLS	Simpson	79.667	-well ventilated -there I increase of mercury level during turning, off-loading and loading of waste	

Source: SRADev Nigeria, (2014)

CONCLUSION AND RECOMMENDATIONS

Sampled data at 14 dental clinics, 61% of those sites indicated indoor mercury vapors levels above the USA EPA reference level of 300ng/m^3. Relatively higher in the mercury vapors levels in dental hospitals was the teaching institution which was also observed and reported by ZMWG. Followed from the results above were the results from private dental hospitals. Noticeably from outdoor categories was the emission from incineration and steam based medical waste treatment facility which value was higher than other outdoor and far above recommended safe limit by the US EPA. It can be concluded in this report that most dental clinics/hospital and incinerators/medical waste treatment facilities in Nigeria essentially are very high risk environments for mercury vapour emissions and as such pose serious health risk to workers and the general population. Most likely these very high mercury vapors levels are due to the use of liquid mercury and non-mechanical mixing for mercury amalgam making.

From the study it was observed that many of the dental clinics lack proper ventilation within the facility which prevent the escape of mercury vapor thus high concentration also inappropriate handling of mercury/mercury amalgam, mercury containing wastes, lack of awareness regarding health hazards of mercury to human health and its impact on the environment.

From this report, comparatively it can be concluded that other environments like waste dumpsites and transfer loading stations, school chemical laboratories, WEEE (e-waste) workshops air environments do not pose any alarming risk of mercury contamination to its workers, students or the general public except in situation of direct contact with mercuric materials by an individual.

Recommendations

In order to reduce the continued risk of mercury exposure to public health as observed, we strongly recommend the following:

- Dentists should enlighten patients on the importance of non-mercury dental fillings over amalgam

- Legal framework of dental amalgam elimination formed, implemented and followed up to the latter.
- Highly ventilated environment (cross ventilation, exhaust fans) should be used for dental practices and operations.
- Standard operating procedures (SOPs) for mercury handling collection, transport and use, be developed and implemented and be dully followed by dentists and other mercury handlers.
- The use of manual handling and mixing of amalgam should be highly be discouraged and penalized.
- Capsulated mercury amalgam use and mechanized mixing be promoted and encouraged, as these effectively and substantially reduce mercury waste, its releases/emissions to the environment.
- The current curriculum at dental colleges and teaching institutions be reviewed and revised to include mercury toxicity and hazards, mercury specific occupational and health safety, mercury releases and emissions control, environmentally sound mercury waste management, non-mercury dental fillings and alternate material and capsulated mercury amalgam & mechanized mixing technologies.
- Mercury specific legislation, including national emissions/releases standards should formulated and made available to public.
- Media publicity should be made available through the television, radio, street electronic billboards etc.
- Promotion of ART and use of best environment friendly technologies be encouraged.
- Promoting mercury-free alternatives for dental restorations
- The government should discourage insurance policies and programmes that favour dental amalgam over mercury-free alternatives for dental restorations.
- The practice of un-sound and environmentally unfriendly incineration methods should be discouraged nationwide.

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