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Environmental sensitization of BMLW of Anthropocene epoch: in developing township: Bhubaneswar, India

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Abstract : The Health carewaste (HCW) disposal is social and legal accountability of individuals in addition to maintain sustainable health and reducenosocomial infection of human and theecosystem. Medical wastes disposal are prioritized in EP Act-1986 onwards to improve methods of minimization categorization, quantification, segregation,handling and collection, onsite transport and storage accompanied by treatment and disposal. In management of HCW, the liquid waste contains only 5% of total wastes generated in form of chemicals, heavy metals, excrata and radioactive elements. Protocols about HCLW disposal are dissimilar depending on the size, people and economy of the people in a city and its laws but the risk of exposure is constant for healthcare managers, stake holders and workers.The authenticated and scientific Common Biomedical liquid Waste Treatment (CBLWT) procedure is not available till date.The present study is an approach for categorization, handling and management of liquid wastes of different health care units in a 70 years developed old city, Bhubaneswar along east coast of India. The physico- bio-chemical study of the liquid waste generated from HCU's has been studied and the concentration of physical characters such as pH, electrical conductivity, TSS,turbidity, DO, BOD, COD etc. are observed which is generated from different health care units by using different chemical procedures. The concentration of nonmetals, metals, metalloids and rare earth elements are found by XRF spectroscopy and their possible nosocomial health-care associated infections (HAI's) and their effects are investigated. The different treatment procedures of management of CBLWTare discussed before discharge to local drains. The identification of possible heavy metals/.metalloids/ REE's are found and hospital-acquired infections are identified and the pre-treatment procedure has been tried before disposing the HCLW to the local drains.

Key words : Waste. HCU's, Bio-medical wastes, BMLW, Hospital

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Fig 1: Index map of Hospitals in the study area

Introduction:

The status of major health care units in the Bhubaneswar, the capital of Odisha, has 5 government hospital, seventeen dispensaries, more than twenty nursing homes and one hundred eleven private hospitals and number of veterinary units including Homeopathic, Ayurvedic and veterinary hospitals. There are about thirty pharmaceutical companies at Bhubaneswar, out of which only fourteen companies follow BMWM practices Saif Md. 2015[1]. **Fig -1**.HCU waste generated during 2010 and 2011 from Hospital sector were 278MT and 287.4MT. The different common hazardous medical wastes are Hg, Dioxins, Furans and Co-Planar PCBs, Cytostatic drugs, Corrosive/toxic liquid chemicals, radionuclides and nano particulate matters etc.All waste constituents created at health care units (HCU's), like large or small hospitals, poly clinics, physician's workplaces, dental practices, blood banks, veterinary hospitals/clinics, medical researchcenters and laboratories. The concept of health care waste was initialized by World Health Organization (WHO) Geneva meet, June 2007, to achieve safe and sustainable management of health-care waste and the federal bodies should finance for creation, legalize and maintain health care management system. The health care units generate≈10-25% hazardous (infectious, toxic and radioactive) and rest 85% is general (benign waste)in India, BMWM Rules, 1998[2] and 2016[3] amendment 2018[4]and WHO guidelines 2004[5] and WHO HCU guide lines amendments 2018[6].

Fig 2: The biomedical waste directly left to a local drain behind a hospital

The wastes created by way of physical, chemical, and microbiological menaceaffecting the people working in health sector,Basu M. et al, 2012[7],Dutta et al., 2018[8], Gupta M et. al., 2018[9].The Bio Medical Waste (BMW) generated as solids and liquids in the process of pathological diagnosis, management,research and preventive health care initiatives of patients/animals are lethal. The most neglected part is the liquid medical wastes generated from health care sector which has adverse impact on the biome by contaminating the surface and ground water.The average daily waste generated from hospitals of developed countries 0.5Kg/ person/ bed and under developed countries is@0.2Kg/person/day. Global average total BMW generated per year is 330000 MT/year (WHO's report). In management of Biomedical liquid waste (BMLW-1998), contains only 5% (from 1% sharps, 3% chemical &pharmaceuticals and 1% radioactive and others) of total wastes generated.

Review of Literature:

According to WHO, the Population of India is 12-13 billions, life expectancy at birth 66years among thelower middle income group (World bank), with 15.1% Per capita total health expenditure was @$157 dollars during the year 2014 (WHO).NIOSH, the National Inst. for Occupational Safety and Health has reported that total medical waste generated through all (HCU's) of the globe was 5.9MMT from 16billion injections/year and 2Million needles/day out of which nonhazardous wastes are 5.01MMT.The rest 0.89MT is unsafe waste and contain hazardous and contagious wastes.The management protocol for wastes of health care units exists, but liquid waste generated from HCU's and their treatment and disposal to common drains (**Fig 2**)is the foremost aberrant issues for the hospital authorities, Biswal et al 2013[2].

Various BMLW kits are available depending upon the size HCU's and volume of liquid waste generated. KelliDoneley M, 2001[11],Wiafe S.et al., 2016[12].The rate of BMLW waste generated in Ethiopia s 1.79 ± 0,57 Kg/person/day, out of which 52% was nonhazardous and rest hazardous. Another study in Adisabba Hospital reveals 1.6Kg/bed/day Haile D. et al., 2008[13]. A study of a super-specialty hospital, New Delhi reveals that doctors and nurses were aware about the legal aspects of HCU's management rules, 2016 but other health workers are lagging behind. Bhattar, S., et al.,2018[14].Selvraj K., et al., 2013[15]reported that BMW in a south Indian city was disposed untreated, 61%, treated deep burial, 5.7%, incinerated 23.8% and rest by open burning.which include BMLW, Patnala S et al.,2017[16], has reported that the health care liquid waste (HCLW) generated in a hospital at Belgaon was 16500 m^3/month. The health care waste HCW spawned in India was 484.271 MT in 2013; 416.824 MT in 2012; and 415.429MT in 2011. The highest generating BMW states are Karnataka, Maharashtra and Kerala which generated BMW @of 83.614MT, 65.66MT and 47.224 MT respectively in the year 2013 as per PTI, New Delhi | Published on April 21, 2015.

LadlenaLamba, 2016[17]have reported that HCU's should minimize generation of BMLW generated from Laboratories, Cancer units, Infectious Hospitals, operation theatres, laboratories, radiology units, ICU's, Maternity wards, etc. The levels of knowledge and awareness of efficient BMW generation, threats, legislation and management among the HCU in Jaipur Dental College is deficient so regular monitoring and training are required at all levels. About 8.645 numbers of Taiwan's HCU workers were surveyed in 1999,andestablished that > 54.8% of them had the needle prick injuries where the needles were used for hepatitis B or C, syphilis or HIV infection patients, .

Sharma et al 2013[18]WHO has reported that there were 32% Hepatitis B infections created by use of contaminated syringe in 2000., About 18% up to 64% from 22countries adopt improper medical waste disposal management/methods of BMW management in 2002 as per WHO's report, Medical Waste Disposal Definitive Guide.html. Manasi S, 2017[19]has reported about 13,037 HCU's in India are violating BMW management rules 1998.The UN Basel Convention (NAIROBI/GENEVA, 1st March (UNEP)) refers health care wastes are dangerous next to nuclear wastes. The effect of solid wastes is localized whereas liquids from HCU's is mixed with local drains, contaminates groundwater, local water bodies and all water bodies connected nearby. Gilbert et al 2002[20],YadavannavarM.C.,2010[21], Ananthachari et al, 2016[22], Saha et al 2017[23], internal doctors (≈20%) in hospitals has less knowledge of classification, color coding of HCU wastes and many staffs(≈50%) haveno knowledge of HCUWM but conversant with special disposal of expired drugs, contaminated gadgets and appliances.

Biomedical wastes:

WHO handbook[15] on safe management of wastes from health-care activities is called "The Blue Book, started from 1999, "The Blue Book-2014" reports different methods for safe disposal of BMW and BMLW, GOI-2016(**Fig – 3**)stating modern environmental pollution control gadgets, measures, and detection procedures.**Hospital wastes** are all wastes of hospitals which may be biological / or non-organic trashes that is rejected and not projected for future use which comprises of 85% in India. **Bio-medical** waste are generated during diagnosis, treatment or immunization of humans/animals or in research works or in the production/ testing of biological constituting rest 15%, and included categories appended in Schedule I,[4].

The different categories of waste in India areYellow, red, white and blue. The other wastes can nonhazardous general wastescontaining wet, dry and construction wastes of HCU' and the last type is categorized as other wastes which includes batteries, E-wastes and radioactive wastes, Nano wastes as per Atomic Energy Act-1962. The HCU wastes, causative organisms and transmission vehicles are given in **Table 1**

Table 1: The possible infections , causes, carriers and contamination by different HCLW

Dis-functions	Type of diseases	Causes	Carrier	Source
Stomach flu	Diarrhea/ abdominal pain/ vomiting /	Viruses/bacteria/ parasite/fungus	Faeces/liquid waste/ vomit	https://apps.who.int/iris/\ bitstream/handle /10665
Respiratory infections	Common cold/ Epiglottitis /Sinusitis /URI(respiratory infection)/Asthma/pertusis	Bacteria/virus	Inhaled secretions/slob ber	https://epi.publichealth.nc.gov/cd/diseases/respiratory.html
Eye infection	keratitis/Vitritis /Conjunctivitis	Bacteria/virus/fungus	Eye secretions	https://www.webmd.com/eye-health/eye-infection-symptoms-
Genital rash	Genital warts / blister-liksores /STDs gorrheaon	Bacteria/yeast/virus	Genital secretions	https://www.healthline.com/health/herpes-simplex
Skin problems	Cellulitis/Erysipelas/chicken pox/ringworms	Bacteria/virus/parasitic/fungus	pus	https://www.healthline.com/health/skin-infection
(AIDS)	Damage immune system	Virus(Human immune deficiency virus)	Blood/Sexual secretions/body fluids	https://www.webmd.com/hiv-aids
Hide porter's disease	Cutaneous anthrax/Pulmonary antrax/Gastrointestinal antrax	Bacillus anthracis	Skin secretions	https://www.who.int/csr/resources/publications/anthrax_
Viral hepatitis A	Acute liver failure	Hepatitis A virus	Faeces	https://www.vaccines.gov/diseases/hepatitis_a/index.
Viral hepatitis B and C	Liver cancer	Hepatitis B and C virus	Infected blood and body fluids	
Candidaemia	Septicshock/low blood pressure	Candida albicans	Blood	http://www.candidaovergrowth.co/candidemia-treatment

Objective of study:

Health care unit liquid wastes (HCULW) are major chunks for water pollution in big cities. Liquid wastes fromHealth care units (HCU's) include all medical establishments, research units, health-related laboratories and even domestically health care generations, liquids from dialysis units, insulin and injections. The direct liquid waste disposal to local drains**(Fig -2)** can contaminate the water supply system, ground water, rivers , drainage channels and nearby water bodies, Incinerated liquid wastes contain chlorine which is air pollutant as (dioxins and furans), bioaccumulation of heavy metals (mercury, lead, and cadmium) and all has

detrimental effect on health sector.Besides, a lot of research and advances need to be done in the field of developing environmental friendly medical devices for BMLW disposal systems for a greener and cleaner environment.

It is seen from the past studies that the liquid waste from hospitals in India is unattended and not given priorities though its impact is unsafe to hospital inmates and the surrounding water and the environment by reducing the DALY's rate. In the present Anthropocene Epoch particularly in 21st century, hospitals are growing like mushrooms keeping pace with the demographic growth within the cities, townships and NAC's in comparison to rural settlements. They are unplanned and not equipped with adequate BWM systems. Particularly the harmful liquid wastes generated are directed to the municipal sewage line or roadside drains directly without any treatment so that it is polluting the surface water, groundwater and affecting the environment.

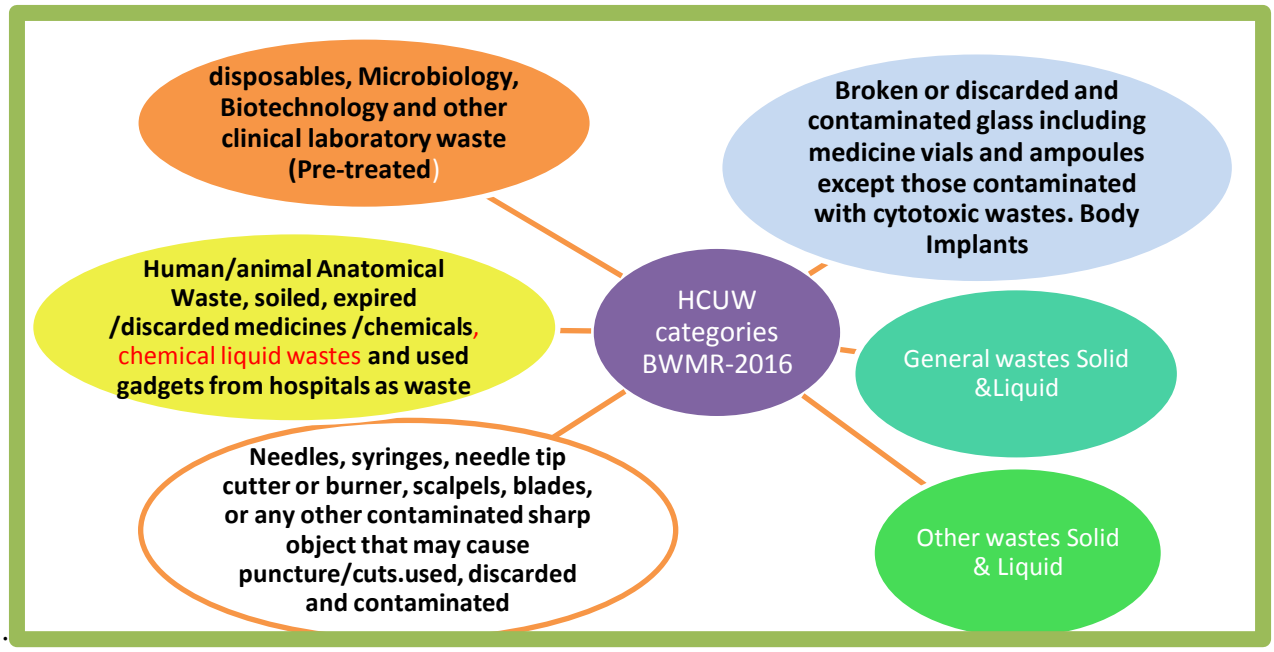

Fig 3: BMWM Rules, India 2016:Six categorizesof the BMW generated from the HCU's

The non-burn technology and ETP has been introduced in Odisha by OPSCB from 2013. The developing townshipBhubaneswarhas the worst apathyin BMLWM being a 70 year old city, in Odisha, India and stressed upon overviewing:

i. Finding sources of wastewater in the healthcare facility of Bhubaneswar.
ii. To assess the existing generation and management practice of healthcare wastes in selected government health centers at Bhubaneswar, Odisha.
iii. Identifying the physic-chemical components of the liquid waste generated from HCU's, like hospitals, Nursing homes, clinics and their varieties like allopathic, ayushHCU's.
iv. Studied of harmful physical components present in the liquid discharge from the different Health care units
v. Describingphysiognomies and hazards linked with these liquid wastewater
vi. Describing the treatment and final management options for thesewastewater.

Present study aims at diagnosing the harmful healthcare liquids, identification, reduction and management before flushing to natural drainage system and finally to adjacent riverDaya, in OdishaMishra S. P. 2017[42].

Methods

The present research is important as it targets at a stress-free, reasonable, accessible and hands-on cynosure for designers, architects, managers and stakeholders of Health care units who need to treat the medical waste of his hospital or dispensing unit.

i. Identify sources and hazards of wastewater from different sources.
ii. Identify appropriate methods collection, treatment and disposal of these BMLW
iii. Finding the physical, chemical and biological character of the BMLW's like pH, EC, Turbidity, SPM, DO, BOD, COD,. And coliforms present if any.
iv. The Spectro photometer-169 and Flame Photometer -128 to find the presence of alkali and alkaline earth metals present in liquid waste of the health care units.
v. XRF spectroscopic studies have been conducted to identify harmful heavy metals like Lead (Pb), Cobalt (Co), Cadmium (Cd), Zinc (Zn), Copper (Cu), Manganese (Mn), Chromium (Cr), Arsenic (As), Nickel (Ni), Iron (Fe), Fluoride (F), and Mercury (Hg) if any and their conc.
vi. Describe the facilities available for wastewater management in the health care units.
vii. Discussing the possible alternatives to expand BMLW management of in those units.

Previous researchers of waste management were focusing exclusively on municipal and solid BMWbut BMLD wastes have received scant attention. Analysis of biomedical waste urges treatment of harmful ingradients and to make it portable before allowing to runoff in local drains.

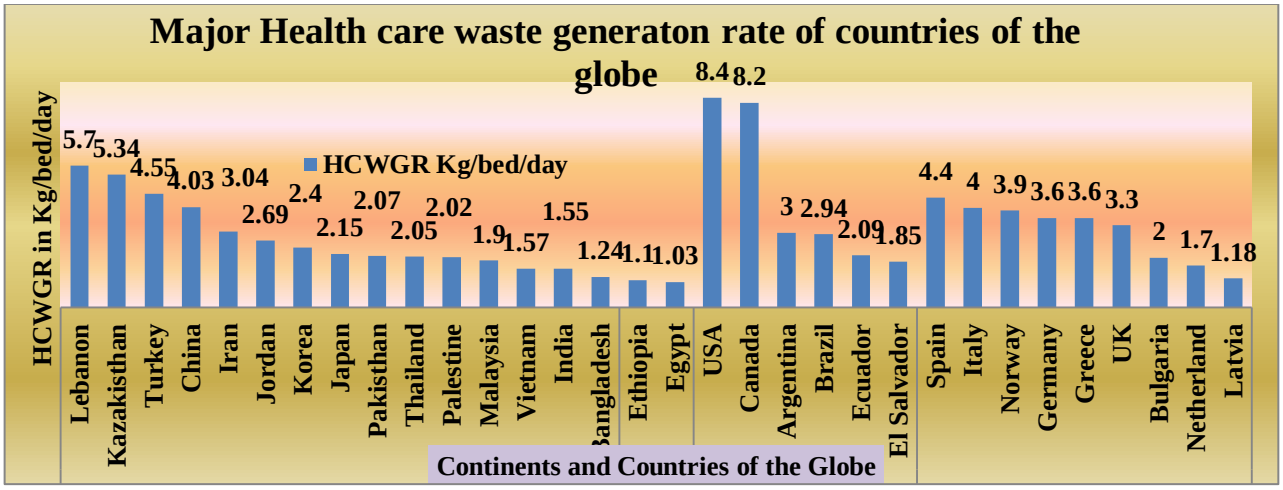

Fig 4 : Major HCW generation rate in different countries (Source Minoglou et al 2017[17]).

Sources of HCW in the globe/Asia:

The liquid wastes generated from HCU's are Hospitals, Clinics, Patho-Laboratories,, medical research activities, nursing homes, acupuncturist, ayush hospitals. The liquid wastes generated are sputum, vomit, urine, paramedic, ambulance services, mortuaries, autopsy centers, veterinary hospitals, animal research units and blood banks, BMW rule-1998[2], BMW Rules-2016[3], MOEF& CC, and the amended BMWM Rules-2016[4]. India generates HCWGR @ 1.55Kg/ bed/day(**Fig-4)** and highest being that of USA followed by Canada. In Asia generation rate is 14th whereas Lebanon stands the highest **Fig-5.**

The BMW Rule 2016 only reports that the liquid waste needs to be unglued at source by pretreatment and then it is to be mixed with other benign liquid waste discharged to drains. However considering the gravity of the nuiscence caused by BMLD, Govt. of India have introduced Karnatak model and Kalahandi model of treating BMLW with Bleaching powder and finally disposing to GW through soak pits or directly to local drains

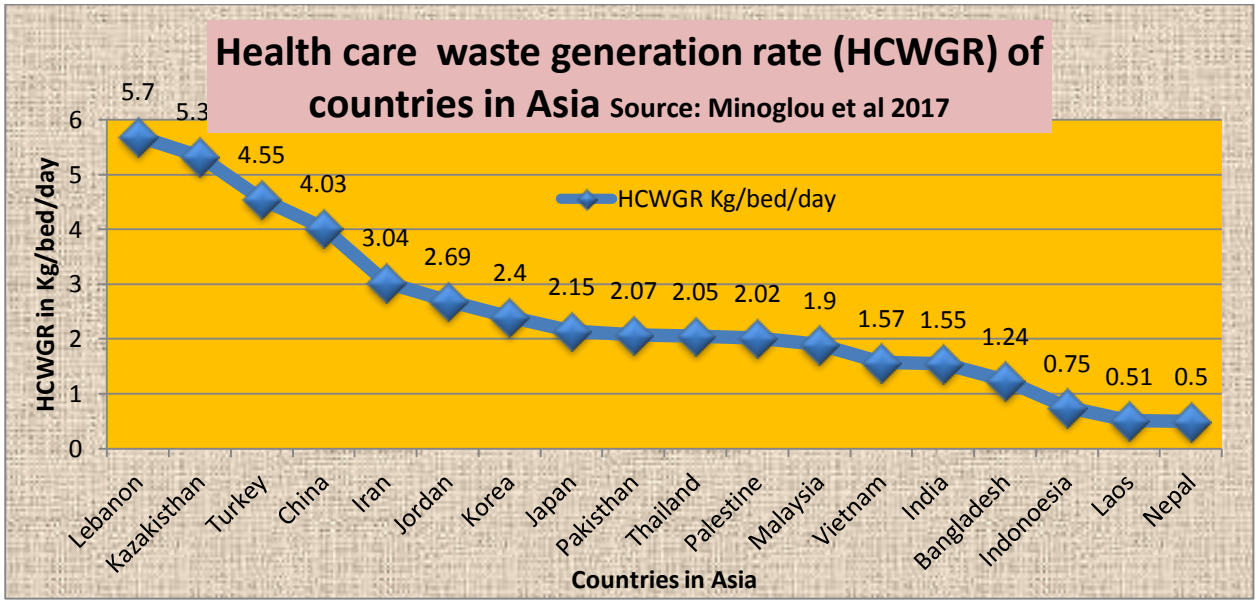

Fig 5 :The rate of HCW generation in countries Asia, data: Minoglou et al 2017[17].

The possible pathways are direct contact, vector propagative, air, water, ground water and environment polluting to causehepatitis-B and HIV infections. The most vulnerable persons are staffs from health care unit, Waste disposing personnel, waste pickers, Children, drug addicts, patients and their attendants.

The advanced countries (like USA, Canada,Lebanon, Spain, Italy, etc.) are generating HCW at a higher rate than the less adavnced countries HCWGR is @ > 4Kg/bed/day). The Asia countries like Lebanon, Kazakisthan, Turkey, China, Iran, Jordan, Korea, Japan, Pakisthan, Thailand, Palestine are generating HCW @ >2Kg/bed/day. India is producing 550.9MT (2018) and HCWGR is @ 1.55Kg.bed/day which is in an increasing trend @ 7%/year. ASSHOCAM has predicted that India shall produce ≈ 775.5 MT of BMW by 2022. According to Dr. Kriti Bhusan DG, Health serivces India. (https://timesofindia.indiatimes.com/ business /india-business/indias.

Categories of health care waste water:

According to module 23 of WHO's BMLW (2008) management protocol the HCU's liquid wastes were highly polluted ***Black Water*** (Sewage of hospitals containing highly contaminated faecal and urine and toxic liquids and chemicals). The 2nd type is the ***grey water*** which is less polluted comprising of wash out and fluxed liquids from wash rooms, research laboratories, technical processes like ringing of X-ray films, hospital washouts, Veterinary hospitals, laundries *etc.* and the storm water which comprises of run off from health care premises which infiltrate to ground water or discharged to drains directly. The chemical anesthetics, disinfectants are like formaldehyde, Mercury, photochemical solutions (hydroquinone), bacterial, parasitic and virus infective agents, and Absorbable OrganoHalogen compounds (AOX), antibiotics, and radioactive are in the list of liquid wastes.

In 2009, the International Clinical Epidemiology Network observed that around 82% of primary, 60% of secondary, and 54% of tertiary, health care facility(HCF's) are not having HCLWM system in India. In2009, safe disposal of HCLW was introduced to save our water bodies and rivers from medical waste pollution. CPCB urges insitu separation of HCLW before running to drains and the common biomedical waste treatment and disposal facility (CBMWTF)must be adhered stringently.The HCW category, type, colour code for segregation, disposal & preservation**Table 2.**

Table 2: The HCW category, type, colour code for segregation,disposal & preservation

HCUW class	Name of waste	Type (Solid/ liquid)	Waste category	Disposal procedure	Segregation Colourdrums
I	Human anatomical waste	Solid/liquid	Body parts, blood, organs, Tissues, saliva, sputum, bodily fluids.	Incineration or deep burial,	Yellow
II	Animal/anatomical	Solid/liquid	animal carcasses, blood,tissues,saliva, sputum	Incineration or deep burial,.	Yellow
III	Microbiological/biotechnical	more liquid	Toxin, vaccine, cells, lab-culture microorganisms, specimens,	Microwaving, autoclaving, incineration,	Red or yellow
IV	Sharps,gadgetsinstruments,	Solids tainted	Needles, ample, syringes, scalpels, Razors, blades, glass, staples	autoclaving, shredding, mutilation, deep burial	Blue/white or vesselsleak proof
V	Cytotoxic/expirydrugs	Mainly liquid	Expired /discarded drugs, injections, Lab/ pathological chemicals	Incineration, landfill, destruction	Black
VI	Solid but contaminated	solids	Chemicals, soiled bed sheets, lab. waste, cottons tainted with blood, body fluids soiled plasters, linen	autoclaving, micro waving /shredding incineration landfill/ burning.	Yellow or red
VII	Solids disposable	Solids	tubes, Empty IV's attachments, catheters, IV sets	Microwaving, disinfection, autoclaving, mutilation,shredding	Red
VIII	Health care liquid wastes	Liquid	Liquids of lab,OT, washing gowns, cleaning, disinfection	Disinfection/chemical mngt. &release into the drains	Blue/white containerslea k proof
IX	Incineration residues	Solids	Ashes after incineration	deep burrial/landfill	Black
X	Safe chemical waste	Liquid	Liquids from cooking, drink, washing	Treatedchemically/efflux todrains.	Black
XI	General wastes	Mixed	Food, office/garden wastes,	Recycling or land fill	Green

Permissible Physico-chemical parameters HCLW:

The liquid waste generated or treated from the HCU's or from waste treatment plants before disposal into the drains/sewer should conform to permissible limits such as pH:6.5-9.0 TSS: 100mg/l, Oil and grease: 10mg/l, BOD 30mg/l, COD 250mg/l and Bio-assay test to satisfy 90% survival of fish after 96 hours in 100% effluent. In addition, Sludge from ETP's should be given to CBWT facilities for incineration/ hazardous waste treatment/ storage and disposal facility for clearance.

Health care liquid waste (HCULW) contains pathogens and particularly the multi-drug resilient bacteria's. HCULW generated from HCU's laundries, housework and disinfecting accomplishments must be disinfected by chemical treatment and then discharged to local drains/ water bodies but more attention is to be given to mutilated or contaminated BMLW, http://creativecommons.org/licenses/by/2.0. The BMLW and its chemical-related diseases can be cancer, asthma, natal defects, disabilities, endometriosis, and infertility. Adding to the level of environmental toxicants,sharp wastes and body fluids are significant source of disease transmission. The liquid pathogens and the allied toxin are the potential hosts after exposure for diseases. The blood (plasma, RBC, WBC), blood yields (soaked in blood like gloves, gauze, gowns etc.,) and other excretory fluids like semen, fluid secretion from vagina, mouth, synovial, pleural, cerebrospinal, peritoneum, pericardium,

amniotic fluids, and other body fluids are major sources which cannot be separated from the liquid waste of a HCU. The possible causes of different infections, diseases and their carriers are given in **Table 3.**

Table 3: The possible infections, causes, carriers and contamination by different HCLW

Dysfunction types	**Type of diseases**	**Causes**	**Carrier**	**Source**
Stomach flu	Diarrhea/ abdominal pain/ vomiting /	Viruses/bacteria /parasite/fungus	Faeces/ liquid waste/ vomit	https://apps.who.int/iris/\bitstream /handle/10665
Respiratory infections	Common cold,epiglottitis /Sinusitis/URI(respiratory infection)/ Asthma/pertusis	Bacteria/virus	Inhaled secretions/slobber	https://epi.publichealth.nc.gov/cd/diseases/respiratory.html
Eye infection	keratitis/vitritis /Conjunctivitis	Bacteria/virus/fungus	Eye secretions	https://www.webmd.com/eye-health/eye-infection-symptoms-types#2
Genital rash	Genital warts / blister-liksores /STDs gorrheaon	Bacteria/yeast/virus	Genital secretions	https://www.healthline.com/health/herpes-implex#symptom
Skin problems	Cellulitis/Erysipelas/chicken pox/ringworms	Bacteria/virus/parasitic/fungus	pus	https://www.healthline.com/health/skin-infection
AIDS	Damage immune system	Virus(Human immunodeficiency virus)	Blood/Sexual secretions/body fluids	https://www.webmd.com/hiv-aids
Hide porter's disease	Cutaneous anthrax/Pulmonary antrax/Gastrointestinal antrax	Bacillus anthracis	Skin secretions	https://www.who.int/csr/resources/publications/anthrax_
Viral hepatitis A	Acute liver failure	Hepatitis A virus	Faeces	https://www.vaccines.gov/diseases/hepatitis_a/index.html
Viral hepatitis B and C	Liver cancer	Hepatitis B and C virus	Infected blood and body fluids	https://www.vaccines.gov/diseases/hepatitis_a/index.html
Candidaemia	Septicshock/low blood pressure	Candida albicans	Blood	http://www.candidaovergrowth.co/candidemia-treatment

The National Institute for Occupational Safety and Health (NIOSH) has classified hazardous drugs as under heads such as carcinogenic, tera-togenicity (developing toxicity), reproductive toxicity in human. NIOSH maintains a list of antineoplastic and other hazardous drugs used in healthcare settings. The infectious and hazardous liquid wastes are contaminated through syringes are Hepatitis B, Hepatitis C, HIV, radiation burn injuries. Liquid wastes also contain infectious, geno-toxic or cytotoxic, biologically aggressive, radioactive, and drugs using nanotechnology.

Liquid wastes from HCU's are reservoir of detrimental organisms producing transmission of pathogens and cause serious public health consequences. The impacts of BMLW can cause itching, radiation burns, and poisoning through toxic elements, wastewater and pharmaceutical products. Data from WHO reports contaminated syringes caused 21 million Hepatitis B virus infections. HCW's are susceptible to health hazards in medical settings if not using personal protective equipment's PPE,s like gloves, Masks and N95 Respirators

and gowns, prevention of extent of infection. Expired medicines are recycledcause public health nuiscence. Prolonged low-level exposure to dioxins and furans may affect immune system, the endocrine system and the reproductive functions. Temporary, elevated exposure to hazardous liquid wastes may result in itching, skin lesions and weaken liver function.

HCU medical waste Odisha

The waste management procedures and facilities are available in Odisha are AIMS (GOI), six medical colleges and hospitals, ShishuBhavan, Capital Hospital, Rourkela Government Hospital (RGH) and all district headquarters hospitals (DHHs), now it is provided to all 27 sub-divisional hospitals, 79 area hospitals and 377 CHCs besides 1,226 PHCs managed by Govt of Odisha and the numbers are increasing.

The Odisha state Pollution control board, (OSPCB) is the ombudsman of the health care Waste and regulates as per the BMW Management Rules -2016[3]of GOI and subsequent amendments.

Mercury in Hospitals:

Hg in healthindustry are used inEsophageal dilatorsThermometers,Electron Microscopes, Thermostat probes, Sphygmic-manometers, gastrointestinalmedicines,esophageal dilator, Cantor tubes, batteries, sewage traps anddentalamalgams can contain mercury. Fixatives, preservatives, medicines for syphilis, Parasites and typhoid, as lab chemicals, cleaners and other products may also contain HgSingh et al, 2014[25].It is a neurotoxin which may attack the nervous system and memory problems due to brain damage.Mercury can affect digestive, nervous, respiratory, immune systems, kidneys and lungs causing tremors, paralysis,impaired vision/hearing, emotional instability, insomnia, fetal disorder, affect child growth.Mercury as a liquid is bio-accumulated in nature by spilling and evaporated to gas which is toxic need a special disposal. Mercury is commonly found being accumulated in sewage, pipe lines or corners of HCU's which must be treated hazardous. WHO's attempt for mercury free environment in HCU's have been introduced on short term, medium term and long term basis RustagiNeetiet. al.,2010[26].According to Minamata convention, 2014, HCU's having Hg as waste, must be kept away from incineration units.

Dioxins, Furans and Co-Planar PCBs

The incineration procedure of BMLW generates dioxins (Polychlorinated dibenzo-para-dioxin) (PCDDs) and Polychlorinated di-benzo-furan (PCDFs), and co-planar poly-chloro-biphenyls (PCBs). It is an air quality parameter yet it is intake through foods and drinks Gibbs et al, 2003[27]. Theseman mediated hazardous products are of varying toxic levels. 2, 3, 7, 8-tetrachloro-p-dibenzo-dioxin and (2, 3, 7, 8 TCDD) is measured to be most toxic which are incinerated product from BMWLober M et al 1997[28]. They are proved to be carcinogenic, changes hormone levels and disrupting endocrine systems and affect liver, thymus, spleen, endocrine and skin. They are non-biodegradable and bio-accrued in the food chain whose rate of morbidity and mortality is not established yet.Adhering to maintenance of strict emission norms for dioxins and furans in many countries have reduced the release of these substances into the environment Turyk M, 2005[29]

As per BMW rule 2016[3], In addition, the HCF has to do pretreatment of various laboratory waste and blood bags according to guidelines of WHO and NACO, to decrease chances of infections being transmitted to HCWs handling waste at treatment stage. Within 2 years, plastic bags, gloves, and blood bags have to be phased out to eliminate emissions of dioxins and furans during their burning into the environment. The new rule also calls for a bar code system for all bags/containers used for BMW treatment and disposal. This step will help in tracking and identifying bags during inspection for quality control and also quality assuranceYves et al 2001[30]

Cytostatic drugs

Cytostatic drugs are medicines that inhibit cell growth and used to destroy cells of carcinoma being transported by blood circulation. Examples are Cytoxan (cyclophosphamide), Imuran (azathioprine), and methotrexate.Chemotherapy uses these cytostatic drugs during treatment of cancer, unidentified tumors, skin diseases and treatment of infections. Besides curing effect they kill healthy cells, cause nausea, hair loss and damage to bone marrow, mouth and pharynx mucosa with long term effects as heart and lungs damage and may lead to kidney failure. So Basel convention, *Stockholm*, these hazardous liquid drugs should not be included in general liquid waste HCU's and should be treated separatelyYeves C et al., 2001[30].

Corrosive/toxic liquid chemicals:

The toxic and corrosive chemicals that impinge to HCU's are cleaning, disinfecting, sterilizing, pathological testing, fumigating, gasses, anesthetic agents, and pharmaceutical substances. These potential health hazardous liquids can cause health hazards affecting respiration, skin sensitization, can be exploding or flammable and cause fire hazards and may affect the surrounding if not used/ disposed erroneously. HCU workers may suffer from breathing problems, inhalation, and absorption due to skin contact, ingestion (via food or water or inoculation by unnoticed contaminated pricks.

Methodology:

Location and Sampling :

It is required that the samples to be collected is small in quantity but well protected representing the whole water body and it should retain its original characters with least significant changes: http://wgbis.ces.iisc.ernet.in/energy/monograph1/Casepage1.html

- Water quality parametric valuation shall be flawless
- Should maintain the status and the trends in effluent quality of the given sample.
- Sampling points were well representative.
- Sampling locations were away from disturbances and interventions
- Out of three types of sampling methods (grab, composite and integrated), the present study has adopted Integrated (discharge-weighted) samples. The grab samples mixtures were collected at various points at a time at equal width increment (EWI) or equal discharge-increment (EDI) procedures and equipment, when the hospitals were in full swing of activities, cpcb.nic.in/openpdffile.php?id
- The nonreactive sampling glass bottles were used to collect samples without bed materials and floating materials.
- The inert sampling container used is of adequate capacity and do not react with the sample and sterilized before use to make it free of contamination.
- Preservation of the collected sample in the laboratory and stored as per CPCB norms so that the intrinsic property of the sample is retained.
- Highly unsteady parameters such as temperature, pH, transparency, DO, etc. are observed either in situ or immediately after receipt at the laboratory.

Sampling procedure:

Samples was collected from Hospital main drain not from any auxiliary drain and at the peak hour of hospital at 10AM to 12AM using a weighted well cleaned bottle or DO sampler. DO is determined only in sample collected DO bottle. The DO of the sample was measured instantly aftercollection, using DO fixing reagents. Labeling of the sample bottle was done just after collection by a water proof marker indicating i. Sample code number (location), Date/ time of sampling, Source/ type of sample, field observation about colour/odour, Pre-treatment/ preservation carried, any special notes, Sampler's signature. Precaution observed for infection of samples it was plastic (PE) gloves were used, minimum contact time was allowed before sealing the sample, the observer and the analyst took care not to be in contact with the inside of bottle and cap and all recording to be done in field or lab log book.For different physical/ chemical (Nonmetal, metals, metalloids and REE's) the different gadgets/ instruments used are in **Table 4.**

Table 4: Sample collection, preservation and apparatus and formula used (CPCB norms) CPCB, MINARS/27/2007-08 .http://cpcb.nic.in/openpdffile.php?id[31] **and** WHO (2nd), 2014[32]

#	Parameter	Limits permissible/unit	Volume collected	preservation	Instrument used	Formulae
1	In situ (field) Colour(Hazen) /Odour	Hazen	200 ± 20ml	Not needed	Eye estimation	Light brown, Brown, Dark brown, Light green, Green, Dark green and clear
	InsituOdour	nil	100ml	Not needed	inhaling	Odour free, Rotten eggs, Burnt sugar, Soapy, Septic,

						Aromatic, Fishy,Alcoholic, Chlorinous, Unpleasant
2	Temp (^{0}C)	25^{0}C	>500ml	In situ	Thermometer	Min- max. Temp^{re}(09 to 45^{0}C)
3	pH	6.3-9.0	>500ml	Immidiatelyat Lab	pH meter digital	=7 (Neutral) >7 (basic) <7 (acidic)
4	Turbidity	0-5 NTU	>1000ml	Imm.receipt at Lab	Turbidity (digital)	Must be less turbid and the SPM to be allowed to settle
5	Total Hardness	$CaCO_3$, in mg/L	Medium 60-120 mg/l	Imm.receipt at Lab	EDTA titration method	Soft 0-60 mg/L, Medium 60-120mg/L, Hard 120-180mg/L, Very hard >180mg/
6	Dissolved Oxygen	As measured	<30mg/l	Not needed	Titrimetric	Dissolved oxygen must be 5mg/l to 11mg/l before disposal to drain
7	COD/NH_3/ oxides of N_2	250mg/l	>500ml	H2SO4, pH	Closed reflux (titrimetric & colorimetric), COD apparatus	COD as mg O2/L = (A – B) x M x 8000 / ml sample,A = mL FAS used for blank,B = mL FAS used for sample,M = molarity of FAS, 8000 = meqwt.of O_2 x 1000 ml/L
8	BOD (5days)	30mg/l	>1000ml	4^{o}C, Dark	BOD incubator, (Titrimetric)	When dilution is not seeded (D1 –D2) x 100, BOD as O2 mg/L =% dil.
9	Metals/metaloids	Mg/l or ppm	<100ml		XRF spectrometer	The safe metal gradient Fe> Zn>Cu >As must be seen

Fig 6: The XRF Photospectrometer for evaluating the nonmetals/ions/metals and REE's

XRF Photometers:

XRF (X-ray fluorescence) is the emission of characteristic fluorescent X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays**(Fig -6).** It is a non-destructive technique to find quantity of element present in a sample (Liquid, solid) of any element from Mg to U of the periodic table. It is used to analyze Foods, Agriculture products, heavy metals/metalloids, Material certification, Mining & Exploration and many more Li C. S. et al., 1993[33].

Physico-Chemical tests conducted:

All the sample collection, preservation and laboratory tests have been done as per CPCB norms and guide lines. The CUTM Universitylab is used to find the physic-chemical parameters, Alkali/alkaline earth

metals/ions , Metals/metalloids and Bio-chemical parameters of the effluent samples received from seven major hospitals of Bhubaneswar [**Fig 5(a), Fig 5(b), Fig 5 (c), Fig 5 (d) and Fig 5 (e)].** The major hospitals from where the samples are collected were Notation: **H-1**: Capital Hospital, **H-2**:GovtAurvedic Hospital **H-3**: Kids Hospital,**H-4**: Sum Hospital (Hanspal), **H-5**:Municipal Hospital, **H-6**:Govt. Homeopathic Hospital, **H-7:**Hi-Tech Hospital, Hanspal, Bhubaneswar. The time is chosen 1130AM as it is the peak hour for hospital activities.

Table 5 (a) : Physicochemical Character of effluent from seven Hospitals of BBSR,Odisha

#	**Physical**	**Unit**	**instrument**	**H-1**	**H-2**	**H-3**	**H-4**	**H-5**	**H-6**	**H-7**
1	Temp.	^{0}c	Thermometer	31	30	34	31	32	31	35
2	Colour	Hazen	Visual	clear	yellow	yellow	brown	yellow	Nocolour	black
3	Odor	nil	by smell	septic	No odour	Septic	Septic	septic	No odour	Septic
4	Taste	nill	tasting	Not done	Not done	Not done	Not done	Not done	Not done	Not done
5	H-ion conc.	*pH*	pH meter (digital)	7.89	6.14	7.22	7.55	7.94	7.45	8.09
6	Turbidity	NTU	Turbidity meterdig	5.2	4.6	3.9	4.7	5.3	4.1	3.6
7	Hardness	mg/l	Tritation method	1400	900	1301	1390	1527	894	1067
8	SPM	Mg/l	heating	0.04	0.06	0.003	0.12	0.31	0.03	0.09

From the physicochemical results obtained from 7 hospitals from Bhubaneswar municipality it can be inferred that the pH value of one unit is acidic, rest are relatively alkaline but within permissible unit. The quantity of SPM is also within the acceptable limits (**Table 5**).

Alkali and alkaline earth metals

Table 5 (b) : Physicochemical Character of effluent from seven Hospitals of BBSR,Odisha

#	**Metals(ppm)**	**Unit**	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
1	Silicon(Si)	ppm	982.9	694.4	813.2	594.5	661.7	438.1	526.3
2	Phosphorous P	ppm	703.8	556.8	610.5	565	560.4	526.3	600.8
3	Chlorine Cl	ppm	556.8	352.7	289.6	251.7	307.6	211.7	246.8
4	PotassiumK	ppm	NA	NA	NA	NA	0.133%		0.158%
5	CalciumCa	ppm	353.6	159.8	192.5	347.1	192.9	139.9	239.8
6	MercuryHg	ppm	0.69	NA	NA	NA	0.35	NA	NA

Table 5(c) : Character of effluent from seven Hospitals of BBSR,Odisha (Metals and Metaloids)

#	**Metal /Metaloid**	**Symbol**	**Unit**	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
1	Manganese	Mn		0.269%	Nil	Nil	Nil	Nil	Nil	Nil
2	Ferric	Fe		21	15.2	19.5	29.3	50.41	Nil	24.19
3	Stannic	Sn		56.7	Nil	Nil	Nil	56.7	Nil	Nil

Table5(d): Character of effluent from 7 Hospitals of BBSR,OdishaRare earth elements(REE)

#	**REE**	Unit	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
1	EuropiumEu		19.9	Nil	Nil	Nil	13.3	Nil	8.63
2	PraseodymiumPr		31.3	Nil	Nil	Nil	22	Nil	21.6
3	SamariumSm		20.34	Nil	19.1	Nil	16	Nil	Nil
4	ErbiumEr		69.5	Nil	11.5	Nil	60.93	Nil	Nil
5	GadolinumGd		18.3	Nil	Nil	Nil	Nil	Nil	10.63

Table 5(e): Character of effluent from 7 Hospitals of BBSR,Odisha. (Biochemical parameters):

Hospital	**Methods/Unit**	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
#		**1**	**2**	**3**	**4**	**5**	**6**	**7**
DO mg/ltr	Titrimetric	2.7	1.9	2.1	2.39	3.43	1.75	2.1
(PL)	mg/l	0-30	0-30	0-30	0-30	0-30	0-30	0-30
BOD(mg/lt)	Titrimetric	431	219	560	661	709	220	311
PL	mg/lt	30-250	30-250	30-250	30-250	30-250	30-250	30-250
COD (mg/lt)	Titrimetric/Colourimetric	1106	356	925	937	750	296	915
PL	mg/lt	250t	250	250	250	250	250	250
DO: Dissolved Oxygen, BOD: Biochemical oxygen demand, COD: Chemical Oxygen demand, PL: Permissible limits								

Legal and institutional framework In India:

India, the first in South Asian countries,launched legal framework and rights for Health care waste management (HCWM)in 1995. The Central PollutionControl Board (CPCB) under MOEF, GOI is the authority to look after the BMWM later called HCWM. They have estimated ≈ 150MT/day is HCWM is generated from health care units (HCU's) in India and are directlydisposed to municipality/ NAC drains without any treatment procedures (CPCB 2000). The BMLWcreated from HCU'senhances the threatas per sub-sections (2, & 3) and sub rules (4 &5) of the EP act 1986, and the Bio-Medical Waste Management Rules, 2016, later amended in 2018 as the Bio-Medical Waste Management (Amendment) Rules, 2018. Categorization of BMW has been done in Schedule I (Rule-5) of BMW (management and handling) rules, 1998 where BMLW was less accounted for.

The BMWM rule-2016 and its amendments 2018 covers management of all wastes generated, collected, received, stored, transported, treated, and disposed in liquid form in organizations like hospitals, nursing homes, clinical establishments, dispensing units, veterinary institutions, animal houses, pathological laboratories, blood banks, ayush hospitals, research or educational institutions, health camps, medical or surgical camps, vaccination camps, blood donation camps, first aid rooms of schools, forensic laboratories and research labs etc. But the rule does not include the radioactive wastes as per provisions of the Atomic Energy Act, 1962(33 of 1962), the Manufacture, Storage and Import of Hazardous Chemicals Act/Rules, 1989, MSW, e-wastes etc.

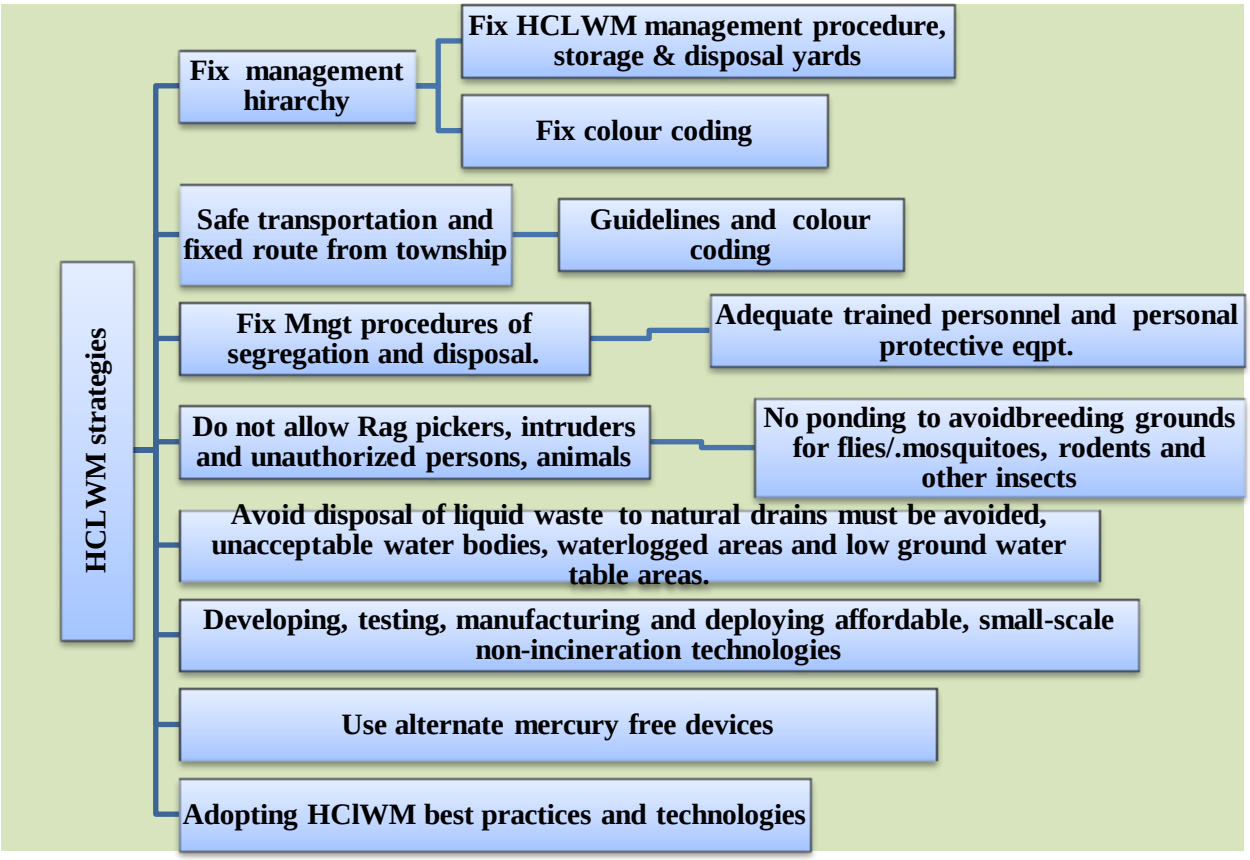

Fig 7: Strategies planned for management of health care unit liquid waste in Indian scenario

Strategies for BMLD management:

HCLWM Strategies:

However the BMW management rules-2016 stresses upon preventive measures such ss vaccination, blood donation, surgical camps and many health care activities along with ban of chlorinated plastic bags/containers.

The rule accentuated upon pretreatment of solid wastes and liquid effluents before disposal to landfills or open drains. Further it pressures to bar code system to containers, standards for incinerator (minimum,retention of Dioxin and Furans in secondary chamber for two years), EPA and proper gadget/ PPE to all health workers. Training should be compulsory to all health workers and record of all accidents.

India formulated its first BMW management policies in 2016 only and BMLW management is a part to the main procedure. So the absence of policy, guidelines and standard operating procedures formulation is highly necessary to clearly make protocols.Apart from the above maintaining liquid waste daily records, methods of disposal, periodical inspection, midterm federal checks, reviews and updating project results and finally recording day today statistics for future analysis.

Awareness policies

that can be adopted are aware the HCU's stakeholders about BMLWManagement Legislation, BMLW management must be a part of medical rule for health managers, strict adherence to any specific waste management procedure, Aware about BMLWAuthorization, Recording and periodical review of BMLW management of the health unit. Similarly the disposal procedures are cost-prohibitive onsite segregation, labeling according to colour code, Training and appointment of trained health workers or a third party authorized vender with a thorough knowledge about offsite waste management. Transport/hauling of BMLW must be done by licensed disposal agencies or mail or sealed package servicesIsmail et al 2013[34].

Proposed Colour coding In India:

The BMW Rule, India 2016 has not specified separately for the segregation of liquid waste but considering the type of source of liquid waste generated from total BMW, fluids from hazardous health care units (HCU's)can be discriminated in the biomedical units and the colour assigned can be done as follows:

Chemical Liquid Waste:

Health care Liquid waste created during use of chemicals, (expired or residue), pathological laboratories, Biological research units, used or discarded disinfectants, liquids from X - ray film developing, discarded Formalin, infected secretions, body fluids received on aspiration, or received from washings, cleaning, house - keeping and disinfecting activities etc. are to be separately collected in a chamber and treated as effluent. As a batch or lot after source recovery the effluent need to be addressed as effluent and treated separately either by incineration, or chemically and finally drained to sewage water system conforming to BMW Rules, Schedule – III and Zhao et al., 2009[35]

PPE's forHCU's waste disposal workers:

Mandatory Personal protective equipment's for HCU's waste handling workers must have heavy duty rubber gloves (bright yellow in colour), which should be washed with carbolic soap after each use. They must be cladded with long boots, face covering masks, goggles, fire protective aprons or gowns/apparels to protect them from infections and fire during incineration processesFEPA-2004[36] and CDC 2018[37].

Cleaning gadgets:

The health workers must use soft brooms (minimu size 1.2m long), plastic or enameled metal dust pans of soft contours and ribs. They should use long handle mechanical screw type mops to swab the floor with disinfecting liquids. With proper PPE they can use vacuum cleaners.

Storage and handling devices:

According to BMLW rule 2016, the health care units should keep leakage proof containers inner walls of impervious disposable plastic of the prescribed colour. The medicals and all health care units should install and operate an in-house effluent treatment plant (ETP) for management of liquid waste in the ownership of the HCU. The categorization of BMLW disposal arein **Fig 8.**

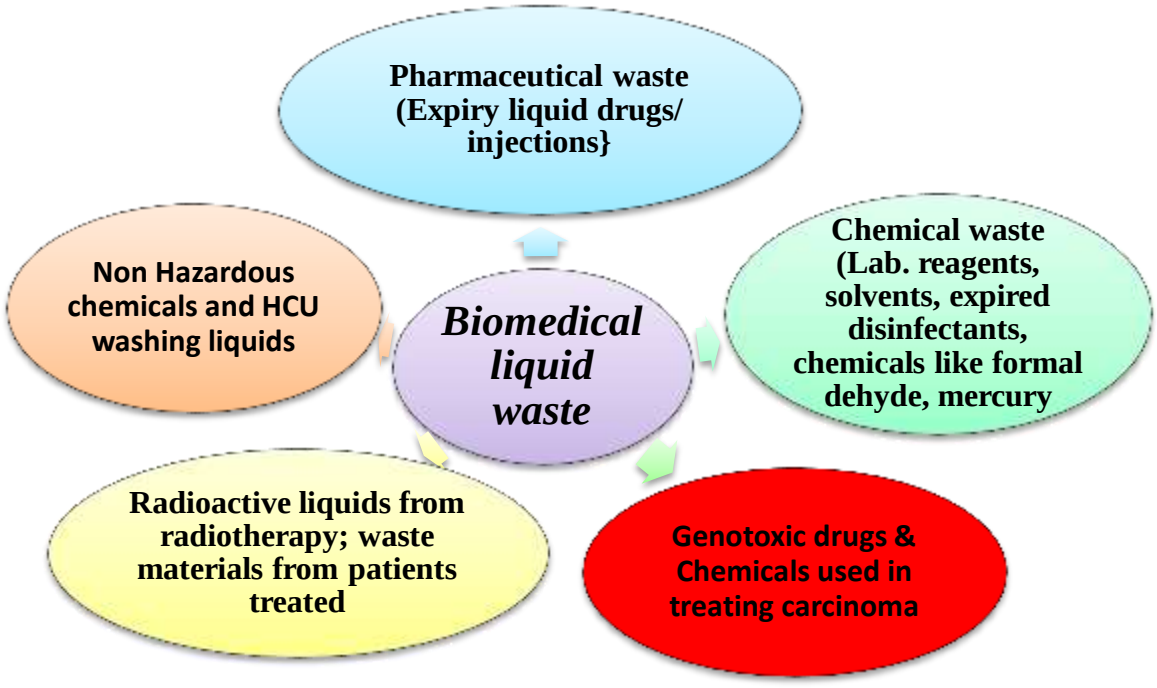

Fig 8: A proposed classification of health care liquid wastes and the different ingredients

BMLW Management hierarchy:

The waste management hierarchy is a organizational framework for BMLW management /waste management options on their potential consideration to reduce their disastrous effects on the environment Sasikumar& Krishna, 2009[38]. Its main beliefs are to divert these BMLW from HCU's and by modern technique to deactivate it and subsequently the options of reduce, recycle and reuse these them if possible if not to be land filled or left to drainsWhite, Franke &Hindle, 1994[39]**.** The related conditions for the correct use of the receptacles must be covered and are of continuous availability of black, yellow, red, blue, white bags with same coloured linen/ polythene (non-porous) linings at indoors, outdoors and hospital with biohazard symbols in the premises which is specific for liquid waste and the wash basins have two taps one with tolerable warm water for instant washing and the second one for cleaning of handsMishra et al., 2o16[40].

1. **Insitu segregation of liquid wastes**:

   During segregation at source the black bag should contain only general waste, yellow bag soiled infected biomedical and biochemical liquid waste, red bag contain (liquid wastes from plastic attachments) and blue bag should contain only liquids from sharps waste?
2. The hypodermic needles, are made bent nozzles destroyed and should not be directly disposed to drains.
3. The plastic bottles/ tubing's are to be mutilated before recycle. The bottles and the remaining chemicals to be emptied for further treatment and the plastics should be disinfected before recycled.

Medical Waste Treatment Methods

The common Bio-medical Waste Treatment and Disposal Facility (CBWTF) used in India are the following treatment procedures Aurora 2013:

Incineration:

BMLW can be processed, and treated by incineration, autoclaving, microwave, biological, or chemical treatment. Incineration, once by far the most popular method, has decreased in usage since the 1990's, as regulation has forced other methods to come online. Before 1997, over 90% of all infectious BMW was disposed of by incineration. Changes to EPA regulations have led providers to seek other disposal means. This is still the only method used on pathological waste, for example body parts and recognizable tissues. The incinerators are designed as per CPCB norms.

Plasma Pyrolysis:

It is an alternative substitute to incinerator where the HCW thee waste is dried at high temperature under measured state to evolve CH4, H2 and CO and CO2 and then oxidised (oxidation) in a 2ndary chamber. The residue of the process is converted into small clinker which can be ready for safe landfills.

Auto-claving:

Autoclaving is a low heat thermal process at high pressure. Steam sterilization can treat bio hazardous waste non-infectious. After it's been sterilized, the liquid waste can be disposed of normally in solid waste landfills, or it can be incinerated under less-stringent regulation.

Hydro-claving:

It is similar to autoclaving where the BMW is subjected under indirect heating by application of steam in the outer jacket. The waste is continuously stumbled in the chamber during the hydro-waving process.

Micro-waving:

The alternative to treat and dispose hazardous HCW's to convert it to non-hazardous by microwave is done and the general wastes are finally disposed to landfill after incineration or dry heat sterilization as per asper BMWM-2016 Rules. This method should be applied to tainted waste sharps are treated at a temperature $<1850^0$ C using hot air for a period minimum 150mnts/cycle or sterilization @ 90mnts.

Shredder:

It is the process of reducing size of contagious and infectious waste like cultures, tissues, dressings, swabs, and other blood-soaked when reuse is banned and disposed according to BMWM. The shredding is also done for HCU items like waste sharps, syringes, blades, scalpels, plastics, catheters, intravenous, blood bags, gloves, bandages etc after microwaving, or autoclaving or hydro-claving.

Deep burial::

SPCB/PCC should not allow 'deep burial' of bio-medical waste as peras per CBWTF norms without proper recommended treatment.. CBWTF guidelines are disposal of solid bio-medical waste as deep burial or burning or leaving liquid wastes to drains must go through the requisite treatment as specified under theBMWM Rules,

Non-burn technology:

TheNon-incineration technologies involve shredding and disinfection by autoclaving/microwaving/ chemicaltreatment for liquid wastes. The hot treated liquid waste to be cooled and can be disposed along with municipal drains.

Vehicle/Containers washing facility:

The regular washing of HCU carriages are to be in an open unused area on an impermeable surface and the liquid effluent generated must be disinfected and shall be conveyed for treatment at the ETP. Theimpermeable area shall be of appropriate size so as to avoid spillage of liquid duringwashing.

Chemical disinfection:

Some chemical wastes may be neutralized by applying reactive chemicals that render it inert. This is generally reserved for waste that's chemical in nature.Many chemicals(liquid/solids)used for digestion of BMLW and disposal. Effluent treatment plants (ETP's) are currently under development and wide use in Hospitals. The advantages of chemical-based technology include fully automated technique, easy to use, ease of discharge of liquid effluent into the sewage, and no by-products of combustion formed. The disadvantages include toxic by-products due to large-scale chlorine and hypochlorite use, chemical hazards, and often production of offensive odor. The chemical-based technology can be divided into chlorine- and nonchlorine-based systems.

Biological Treatment:

This experimental method of treating biomedical waste uses enzymes to neutralize hazardous and infectious organisms. It's still under development and rarely used in practice of. Biological methods employsBio-converter are nowadays used for HCLW. It uses a solution of enzyme to decontaminate medical waste, and the resulting sludge is put through an extruder used to remove water for sewage disposal and the solid waste is sent to landfill.

Causes of failure of HCLWM in India:

Indian condition of HCLW management is inadequate and poor due to increased demographic rate, inadequate planning, lack of govt restrictions, Lack of knowledge, public awareness, adequate training to HCU workers, lack of infrastructure, costly HCLW management systems, and acuteepidemicform of diseases. In such a scenario proper HCLWM can be implemented by adopting low cost management procedures and kits, incineration procedures and chemical treatment of the medical run off to be enforced legally for each HCU. Implementation of norms of HCLWM must be periodically inspected, reviewed and legal penalties to be imposed on the defaulters.

Best Practices for liquid Medical Waste Handling

The health-care waste management in emergencies, emerging pandemics, drug-resistant bacteria, and climate changes were covered, Arora M., 2013[41],Dutta et al 2018[8].Healthcare workers can avoid most

medical waste problems by adhering to a few key best practices. Employees should know the laws, then classify and separate all waste by type into the correct, color-coded waste containers. Waste should be labeled depending on its category, and the right documentation should accompany all containers during transit. A dependable medical waste disposal company can help a facility put these best practices to work. The BMLW disposal process involves Sensitization and public awareness, Knowledge of health care statutory by-laws by health workers and waste managers, Sorting/classification at source using to colour code and in situ, collection of HCLWin lined containers, collection from unit wise and containerwise of HCLW, Interim storage according to same colour code, disinfection of HCLW if needed, processing of liquid medical waste, final disposal of HCLW to drains or soak pits.

HCLW management culture and improved practices:

Knowing HCLWM laws and regulations:

Healthcare waste is regulated by the DOT, EPA, NIOSH, OSHA, and the DEA. It's vital to be aware of all guidelines from each agency when preparing, transferring, and disposing of hazardous waste.

Shorting/Classify medical liquid waste at source:

Identifying the kind of waste you're dealing with is the first step in properly disposing of it. Avoid putting non-hazardous waste in with the rest to prevent overspending.

Separate the liquid waste by category:

Waste should be separated out into the different categories, including sharps, pharmaceutical, chemical, pathological, and non-hazardous. Regulated medical waste goes in red bags. Sharps that go into these bags must be put into puncture-proof containers..

Right medical liquid waste containers:

Put all waste in approved containers depending on how it's classified. Some waste can go in certified cardboard boxes, while other waste gets put in special tubs or even locked up for transit.

Bar coded leak proof containers:

Healthcare waste containers and bags must be taped for shipment, then packaged according to DOT weight restrictions. Containers should be stored in a secure, dry area before pickup or shipping. It's essential to properly label all waste before transport as well.

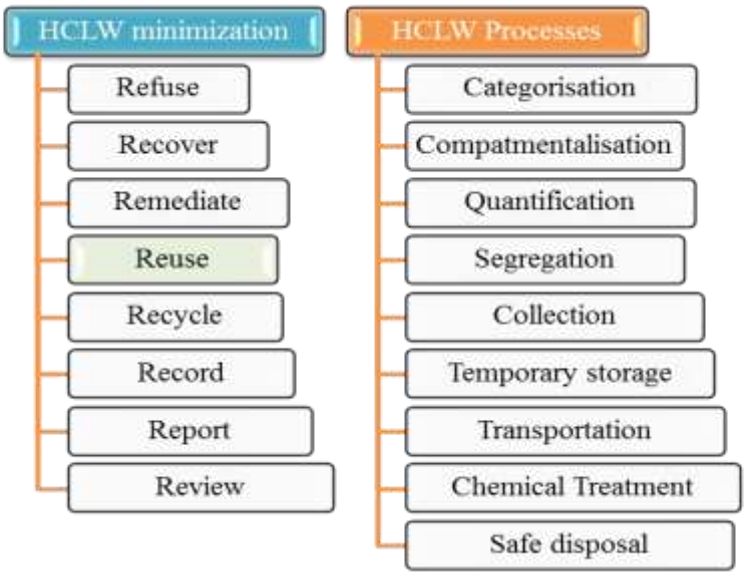

Fig 9: The minimization and processes used for HCLW wastes

Implement the HCLW color code:

The color coding system for waste segregation calls for all sharps to go in puncture resistant red biohazard containers. Biohazard waste goes in red bags and containers. Yellow containers are for trace chemo waste, while pharmaceutical waste goes into black containers for hazardous materials and blue for all others. Radioactive wastes like Fluorine-18 or Iodine-131 get put in shielded containers marked with the radioactive symbol.

Include the right documentation:

Proper documentation of generation, collection, storage, transported, treated and disposed quanity of liquid waste of healthcare waste is crucial to protect both the provider and the waste disposal company. The right paperwork should accompany each container and bag throughout the process. Report all minor/ major accidents and document waste workers health card as per Common Bio-Medical Waste Treatment and Disposal Facility (CBMWTDF)

Hire the right liquid waste disposal company.

Multiple regulating bodies, various hazards, and several different kinds of waste present a daunting challenge for healthcare employees. Partnering with a reliable vendor is often vital.

Management of toxic/ corrosive BMLW: HCLW may contain pathogens and multi-drug resistant bacterias. So the liquid waste created from activities like Hospital/laboratory washing, cleaning and disinfecting should be made hygienic by treating chemically before quitting in drain

Some common management of toxic/ corrosive BMLW in HCU's are :

1. Conc H_2SO_4, HCL and NaOH are corrosive. Any activity with these chemicals to be done in a well-ventilated/wide open fume cupboard.
2. Avoid direct adding solid $KMnO_4$ in conc. H_2SO_4 soln. for preparation of solutions of $KMnO_4$.
3. Convert unsafe CHCLW from liquid to solid by treatment and prevent propagation of potential infectious pathogensKelli et al.,2001[11]
4. Do not add direct water to conc. H_2SO_4
5. Dry $NaNO_3$ is highly combustible keep it away from fire
6. Affected Skin should be washed under running water if it is in contact with toxic/ eroding liquids.
7. HCLW shall be collected separately must pass through effluent treatment system. After recovery of resources, the liquid chemicals shall be pretreated by using 1 to 2 % Sodium Hypochlorite having residual Cl_2 30% for 20mnts or any other equivalent chemical reagent which reduces log 10^4 efficiency for microorganisms BMLWM rule amended in 2018Published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (i) published in 16.3.2018 MOEF&CC, GOI.

Conclusions:

The hazards posed by HCLW are depicted considering collection, segregation, storage, transport, and disposal of wastes. There is increase in population, anthropogenic pressure and advancement in health consciousness. New urban and rural settlements have established in large numbers and proportionately HCU's have developed to supply health care facilities. Bhubaneswar city in India is one among them which has started its population of 16512 in 1951 and reached ≈ 917766 in 2017 Mishra et al, 2017 whereas HCU's only one small Medical at old town, to 15 major hospitals at Bhuabneswar. It is highly essential for careful planning which is essential for liquid waste management, appropriateways to minimize liquid waste production. Details of coloured containers for individual category of waste, labeling, storing and mutilation and treatment are to be provided with modern technologies for insitu/inhouse treatment of liquid waste and proper disposal.

To ensure harmless, effective, costoptimized disposal of HCLW in developing township. Adequate training to users, health workers and doctors and particularly to nursing staffs is essential for liquid waste management. Long-term strategies to be developed to refuse, reduce, reuse, and recycle is to be introduced along with community awareness for a healthy HCU environment.

Healthcare liquid waste management practice was not found to be satisfactory. Installation of effluent treatment plants and the development of standards for environmental indicators with effective monitoring, evaluation and strict control via relevant legal frameworks were not yet standardized though realized.

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