INSIGHTS INTO HEALTHCARE-BASED WASTE: GLOBAL CHALLENGES OF COVID ERA

SUKHVINDER PAL[1], MOHD YUSUF[1,*], VARUN KUMAR SHARMA[1], MUNESH SHARMA[2], NIZAMUL HAQ ANSARI[3], UMARFAROOQ A. HALYAL[1,4]

[1]Department of Natural and Applied Sciences, School of Science and Technology, The Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh 247121 India
[2]Department of Chemistry, Faculty of Science, J.V. College, CCS University, Baraut, Baghpat, U.P. 250 611, India
[3]Department of Physical Sciences, Sant Baba Bhag Singh University, Jalandhar, Punjab India
[4]M. G. V. C. Arts, Commerce and Science College, Muddebihal, Vijayapur, Karnataka- 586212 India

Correspondence: yusuf1020@gmail.com ; mohd.yusuf@theglocaluniversity.in

ABSTRACT

Globally, Covid-19 era, affects heavily to the whole world. In this timespan a huge increase in medical-usable products resulted into increase in healthcare-wastes which creates many types health related concerns worldwide. Medical-based wastes includes needles, scalpels, razors and broken glasses. Pathological Waste & Human or animal tissue, body parts, blood and fluids. Pharmaceutical Waste & Unused and expired drug or medicines, like creams, pills, antibiotics. Out of these, there are certain kind of particulars that may cause carcinogenicity, especially embedded-drugs, biochemical reagents and solvents etc. So, the treatment with scientific technologies and methodologies is essentially required. This paper overviews the environmental impact of healthcare-waste and related carcinogenic waste and their adverse consequences of handling and disposal methodologies.

KEYWORDS: Carcinogenic waste, Disposal methods, Environmental Sustainability, handling of waste, Medical-based waste, Risk assessment.

INTRODUCTION: HAZARDOUS WASTES, WHY INCREASES DAY-BY-DAY?

In December 2019, Covid-19 era refers to the dangerous virus SARS-CoV-2, known to cause acute and chronic respiratory, enteric, and central nervous system diseases in humans that belongs to the of *Coronaviridiae* Coronaviruses family, originated in Wuhan, Hubei Province of Republic of China. It was recognized as single-strand RNA viruses bearing crown-spikes and helical nucleocapsid-form (Khanal et al., 2021). Globally, Covid-19 era, affects heavily to the whole world. In this timespan a huge increase in medical-usable products resulted into increase in healthcare-wastes which creates many types health related concerns worldwide. Medical-based wastes includes needles, scalpels, razors and broken glasses. Pathological Waste & Human or animal tissue, body parts, blood and fluids. Pharmaceutical Waste & Unused and expired drug or medicines, like creams, pills, antibiotics. Out of these, there are certain kind of particulars that may cause carcinogenicity, especially embedded-drugs, biochemical reagents and solvents etc. So, the treatment with scientific technologies and methodologies is essentially needed. According to

the WHO, about 85% of the total is general type waste generated by health-care activities recognised as non-hazardous waste comparable to domestic waste, while, 15% residual type is known as hazardous materials that may be infectious, chemical or simply radioactive (Fig. 1) (National productivity Council, 2016; Yusuf, 2019; Fact-sheets detail health-care-waste 2022). In

Figure 1. Waste generated by health-care activities recognised as non-hazardous waste.

addition Fig. 2 depicts the hazardous waste comparable to domestic waste and causes severe as well as acute negative health issues. Hazardous wastes refer to the substances which are associated with potentially threatened to the environment by the action of serious impacts on human, animal & plant health as well as adverse responses. Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as saturated solution of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazine or of compounds containing isolated carbon-carbon double bonds (Rasul et al., 2021). No chemical

process should not be applied on carcinogen until it has been thoroughly tested for effectiveness & safety. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. Carcinogenic waste is a type of highly hazardous discarded waste, defined as the generative poisons or poisonous substances having acute toxicity level. Waste containing substances with genotoxic property, highly hazardous substances that are mutagenic, carcinogenic and cytotoxic used in cancer treatment. Items used in chemotherapy, could be contaminated with bulk amount of chemotherapeutic drugs which includes, disposable gloves, pipes, bags and tubes, bandage and dressing. According to HWP (Hazardous Waste Permitting) rules, more than 3% of the drugs remains carcinogenic properties are called bulk chemotherapeutic waste, if amount is less than a 3% then it is called trace amount.

Figure 2. Waste generated by health-care activities recognised as hazardous waste.

With respect to handling, generation and, processing, the consequences of improper handling or discarding of dangerous waste products (Yusuf, 2019), particularly azo dyes and other industrial effluents that are highly recognised as unsafe to the water ecosystem associated with environmental hazards as well as adverse health concerns. Rapid industrialization in last few recent decades have led to the duple on of natural resources and increase in pollution in the country. As part of economic development, this industrialization has also led to genera on of huge

quakes of hazardous waste which causes severe environmental problems. In the scenario of Covid-19 there are certain types healthcare-wastes (Rubad et al., 2022) have been approached to a massive hike. With respect to sudden healthcare-based medical wastes have reached to an uncontrollable limits in developing countries, rather than developed ones, became an even larger concern after the COVID-19 outbreak that make the entire world in a huge doom-fire with high possibly infected wastes.

These industrializing has also led, apart from economic development to the genera on of huge quakes of hazardous waste which causes sewer environmental problems (National productivity Council, 2016). Medical-based wastes includes needles, scalpels, razors and broken glasses; pharmaceutical waste and expired drug or medicines, like creams, pills, antibiotics, and pathological-blood-fluids and living tissues and also plastic-based wastes (Rasul et al., 2021; Rubad et al., 2022). Out of these, there are certain kind of particulars that may cause carcinogenicity, especially embedded-drugs, biochemical reagents and solvents etc. So, the treatment with scientific technologies and methodologies is essentially required, overviewed in this work.

CARCINOGENIC WASTE: SOURCES AND TYPES

Cytotoxic wastes that can primary target to cause carcinogenic imbalance are created by several industrial units such as pharmaceutical/ drug companies, hospital wastes like discarded drugs (expired) and living tissues, syringes, needles, gauzes, vials and domestic-care wastes like left-over drugs, living tissues etc. based on Hazards Waste Permitting by Resource Conservation and Recovery Act (RCRA), the carcinogenic wastes are categorized into two types, (a) More than 3% of the residual drug remains called bulk chemotherapeutic waste, which can be disposed only in black RCRA container and (b) Less than 3% then it is called trace chemotherapeutic waste (El-Ramady et al., 2021; Soffian et al., 2022).

Code of Federal Regulations proposed the wastes in three classes

- The F-list (40 CFR section 261.31) refers to wastes from collective industrial and manufacturing methods as harmful.
- The K-list (40 CFR section 261.32) including the hazardous wastes from definite segments of industry and manufacturing units.
- The P and U lists are labeled as dangerous wastes by the action of pure and commercial grade formulations of certain disposed chemicals.

STORAGE OF CARCINOGENS AND TREATABILITY OF MEDICAL-BASED CARCINOGENIC WASTE

The proper storage of carcinogens can be achieved *via* three methods, records, location and containers (Fig. 3) (Agamuthu & Barasarathi, 2021; Fact-sheets detail health-care-waste, 2022; Jebaranjitham et al 2022). The schematic from chart for medical-based Carcinogenic Waste cyclization is presented in Scheme Fig. 4. Various Treatment Processes are currently available for proper waste minimization. There are different methods used for the treatment of carcinogenic waste, which is illustrated in Fig. 5 described below (El-Ramady et al., 2021; Rubab et al., 2022).

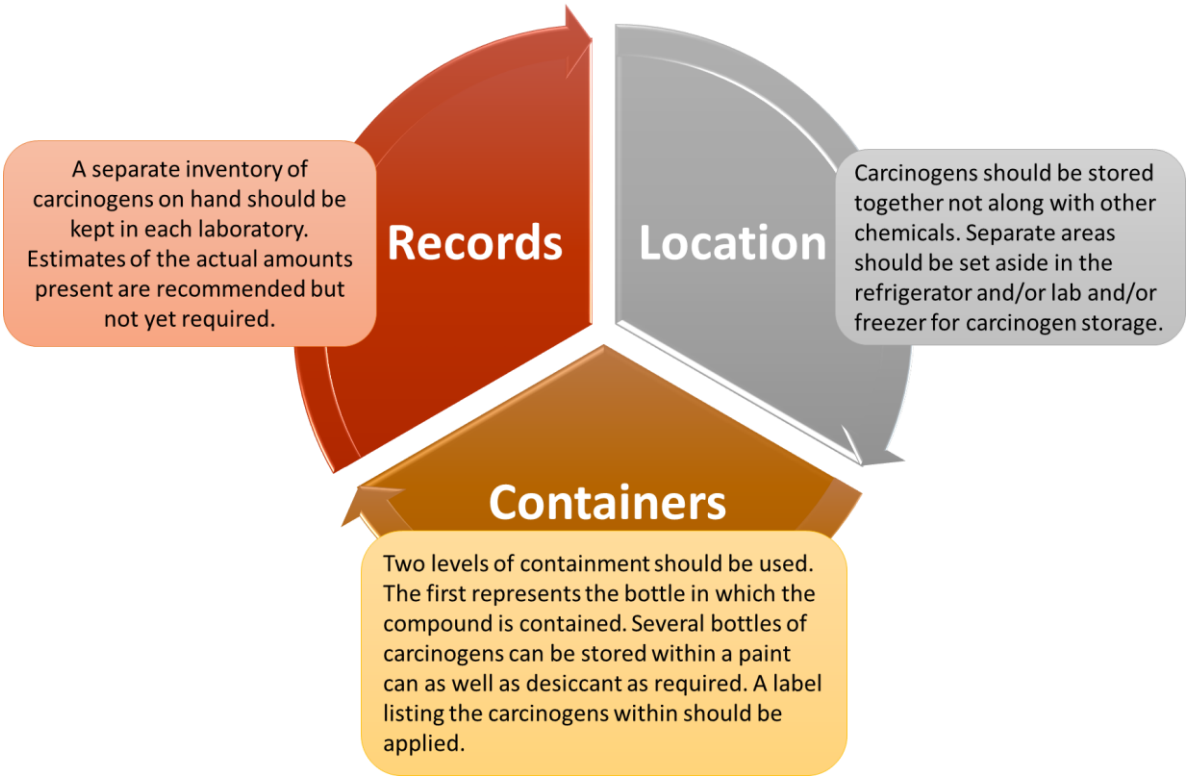

Figure 3. Schematic representation of proper storage of carcinogens.

Chemical process

Suitable chemical substances are utilized under this category which proceeds *via* ion exchange, precipitation, redox (reduction-oxidation), neutralization etc. Some commonest examples are including; hydrogen peroxide, ozone, Sodium hypochlorite, per-acids, nitrous acid etc.

Physical Process

Physical processes include sedimentation, evaporation, flotation, filtration and solidification procedures depending on the operation selection. In case of thermal process following steps have been given in Fig. 6.

Mechanical process

To transform in physical appearance or characteristics of the hazardous waste have been considered through mechanical methods. It can be employed to change the physical form *via* two kinds; (i) Compaction applicable for reducing in the volume of the waste, and (ii) Shredding applicable for destroying plastic-related as well as paper wastes to avoid their reuse and to make disinfect.

Irradiation process

Higher energy radiations than ordinary sunlight, such as ultraviolet or ionizing radiations in an enclosed chamber refers to irradiation processes. Basic types of irradiation systems which are currently being used in waste treatment operations, including X-rays or gamma-rays (Agamuthu et al., 2021).

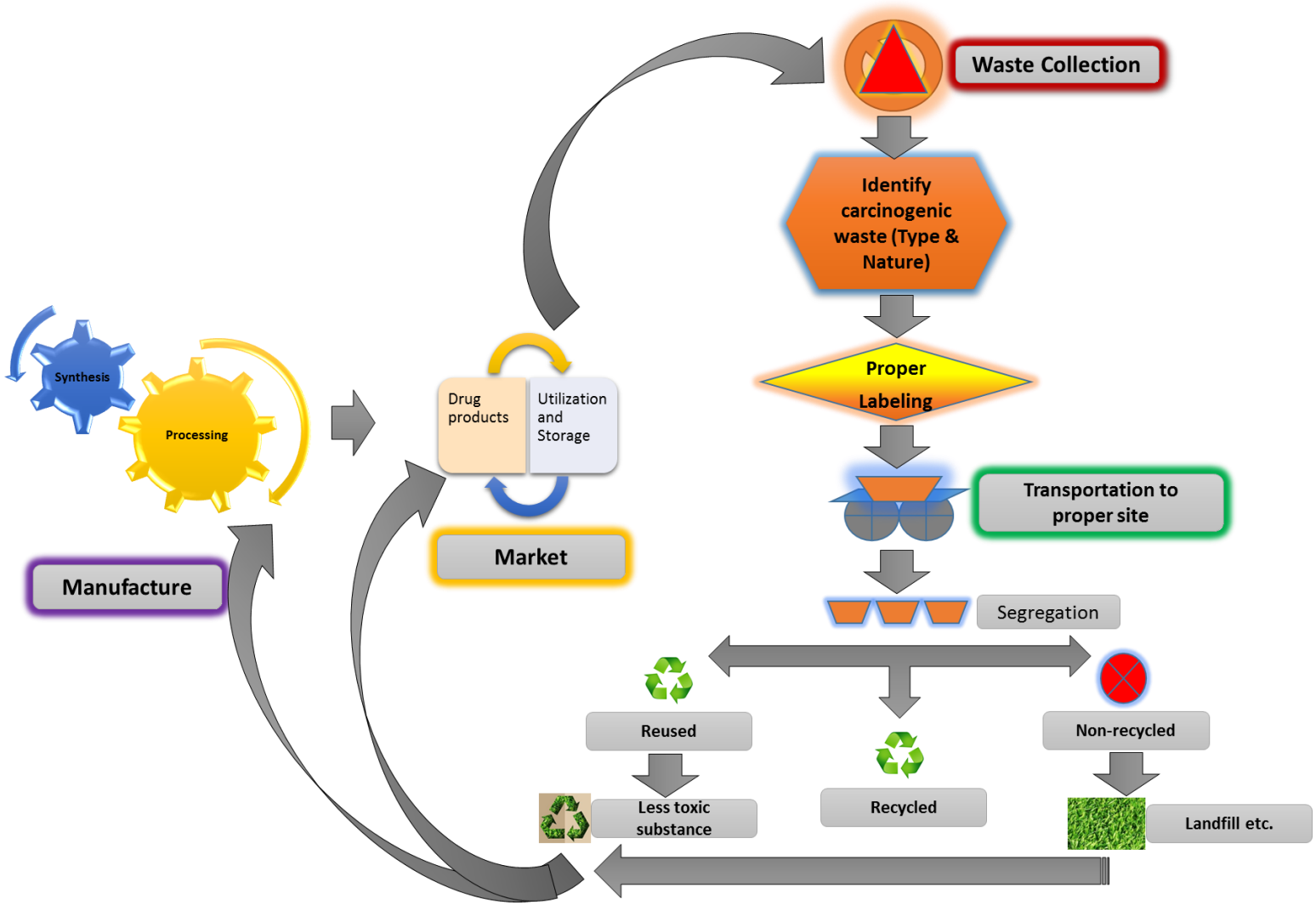

Figure 4. Schematic from chart for medical-based Carcinogenic Waste cyclization.

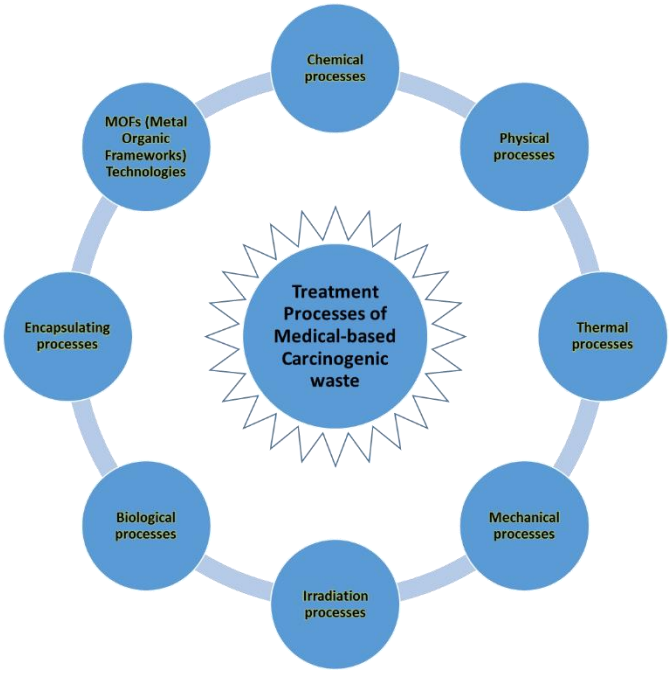

Figure 5. Various Treatment Processes of Medical-based Carcinogenic waste.

Biological processes

It is noticed that biological reactions will not only minimize the contamination, but also helpful to break through the organic molecule chains. Biological enzymes, particularly those which solubilize the organic contamination and impurities have been successfully found to be suitable to treat medical wastes.

Encapsulation

Encapsulation process is applicable for those wastes which can easily mixable with cement like product, fly ash, lime and water to form mixed solid. The other important process is solidification, which is achieved by encapsulating the waste in concrete, asphalt, or plastic produces a solid mass of complex material that is resistant to leaching.

MOFs (Metal Organic Frameworks)

Metal-organic frameworks (MOFs) have been receiving high attention in recent era due to their excellent properties such as relatively high surface area, pore size, tailor-made structure with diverse applications in waste treatment in many types media *via* adsorption (Jebaranjitham et al., 2022). There are significant research works published for efficient removal of different kinds of waste categories including, organic dyes, heavy metals, healthcare-wastes and others (Kumar et al 2016; Fei et al., 2022).

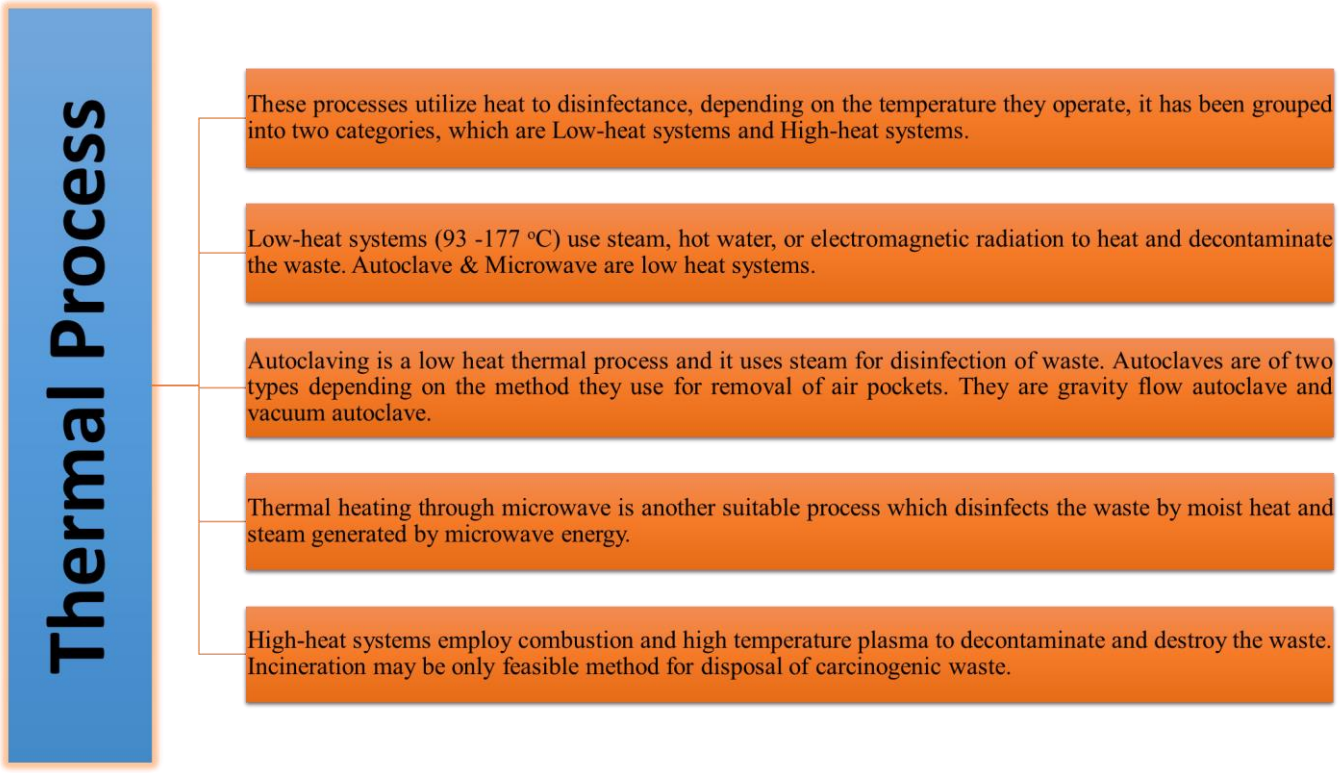

Fig. 6: Several steps of a typical thermal process.

ENVIRONMENTAL RISK ASSESSMENT AND CONTROL

All types of carcinogenic waste should be kept to a minimum and less experiments conducted so that the amount of solid and/or liquid waste generated is as small as possible. All carcinogenic waste containers should be labeled with the name of carcinogen following all safety guidelines. There is no specific method which can 100% nullify the effect of carcinogenic waste and also not specific disposal method applicable for all types of carcinogenic waste. Some methods are very needful to treat some carcinogenic waste, some methods expose potential hazards to the environment, for example incineration method releases some toxic fumes, in chemical method extraction of chemical is problematic, leachate and land fill method produce soil as well as water pollution. Land fill method also increases the issue to destroy plastics. Therefore the essential concern is that to prevent the exposure of toxic and hazardous vapours from different processes. Polychlorinated dibenzo-p-dioxins, polycyclic aromatic hydrocarbons (PAHs), benzene, 1-butadiene, arsenic, cadmium, chromium, and nickel were found as the most significant possibly carcinogenic compounds coming from a state-of-the-art clinical waste incinerator (CWI) and vehicle emissions. The notional maximum exposed individual's (MEI) long-term exposures in the local environment, as well as aggregate emissions from clinical waste transit, were calculated. The CWI's PAH mass emission rates to air were compared to previously reported estimates of CWI bottom ash mass emissions to land. Aggregate emissions from road transport of clinical waste were of a similar order to stack emissions from incineration. Mass emissions of PAHs to landfill generally greatly exceeded those from stack emissions. Emissions linked with the CWI's operation contribute very little to the overall cancer risk posed by PAHs and other carcinogens.

The incinerated ash contains toxic pollutants such as chlorinated plastics, mercury, and other solvents. This increases the risk of acid rain, groundwater contamination, and health hazards affecting the eyes, the respiratory tract and causes cancer in human beings (Gao et al., 2019; Yusuf, 2019; El-Ramady et al., 2021; Rubab et al 2022). The incineration process converts the toxic medical wastes in a solid or liquid state into a gaseous form such as nitrogen oxide, sulfur dioxide and other particulate matter. The furans, dioxins, and other air-borne toxic pollutants found in the residues or fly ash of incineration are harmful to the public's health. However, other forms of solid healthcare wastes were mixed with communal waste without any form of pre-treatment (Abanyie et al., 2021). The incineration of biomedical wastes is also an alarming issue since, it emits harmful chemicals like dioxins, furans and the ash produced contains toxic metals like mercury and lead (National productivity council, 2016; Yusuf, 2019; Rasul et al., 2021; El-Ramady et al., 2021; Fact-sheets detail health-care-waste, 2022) which has an intense adverse impact on the environment (Yusuf et al., 2019; Rubab et al., 2022). Incineration of plastic materials containing an element of chlorine produces dioxin, a powerful cancer causing agent that destroys the immune system and results in congenital disabilities, endometriosis, etc (WHO, 2020).

Despite having a successful recycling program recovery of chemicals from the waste, and conversion of hazardous waste into less toxic waste is the best way environmental sustainability. The job creation that comes with reusing, composting, and recycling our trash can be substantial and lead to new businesses centered on turning trash into treasure. Many countries can support and encourage recycling businesses by clustering them in eco-industrial parks and etc. WHO recommended the suitable exclusion and minimization methodology for both normal and Covid-19 wastes treated as other healthcare wastes; the following specific instructions were offered for the disposal of COVID-19 wastes (Fig. 7) (Wei et al., 2020).

CONCLUSION

Covid-19 timespan, affects heavily to the whole world and a huge increase in medical-usable products was noticed which resulted into increase in healthcare-wastes which creates many types health concerns. The universal truth is that, till date reusing, recycling, and composting disposes of large amounts of waste are more efficiently conducted through incineration compared to land filling method. Hazardous wastes that are not destroyed by incineration or other chemical processes need to be disposed-off properly. The most widely applicable procedure is oxidation with potassium permanganate and sodium hypochlorite solution. The management of healthcare-based wastes should be conducted with priority owing to associated health protocols and general guidelines of internationally-recognised healthiness interventions. Though there are several successful recycling programs for recovery of healthcare-hazardous wastes and carcinogenic wastes, the transformation of hazardous waste into less toxic waste is considered and globally required as one of the best way for environmental sustainability to minimize the overall pollution.

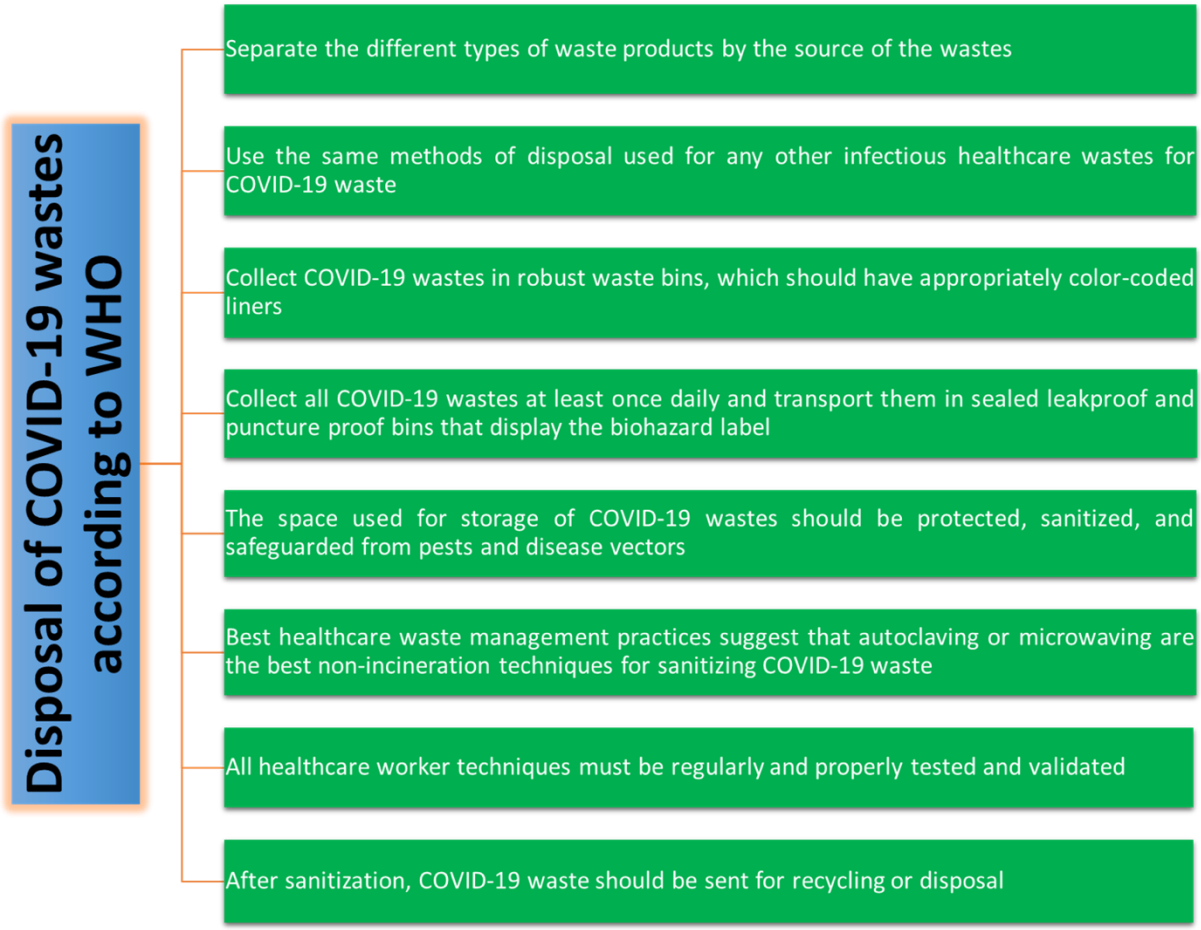

Figure 7. Specific instructions suggested by WHO to treat COVID-19 wastes.

ACKNOWLEDGEMENTS - Prof. (Dr.) S. A. Ahmed, Vice Chancellor, Glocal University is acknowledged for his moral support and critical suggestions.

REFERENCES

Abanyie S.K., Amuah E.E.Y., Douti N.B., Amadu C.C. & Bayorbor M., 2021. Healthcare waste management in the Tamale Central Hospital, northern Ghana. An assessment before the emergence of the COVID-19 pandemic in Ghana. Environ. Challenges, 5: 100320.

Agamuthu P. & Barasarathi J., 2021. Clinical waste management under COVID-19 scenario in Malaysia. Waste Management & Research 39: 18-26.

El-Ramady H., Brevik E.C., Elbasiouny H., Elbehiry F., Amer M., Elsakhawy T., Omara A.E.D., Mosa A.A., El-Ghamry A.M., Abdalla N. & Rezes S., 2021. Planning for disposal of COVID-19 pandemic wastes in developing countries: a review of current challenges. Environmental Monitoring & Assessment 193(9): 1-15.

Fact-sheets detail health-care-waste, 2022 https://www.who.int/news-room/fact-sheets/detail/health-care-waste, Accessed 19 October, 2022.

Fei X., Jia W., Chen T. & Ling Y., 2022. Life cycle assessment of food waste anaerobic digestion with hydrothermal and ionizing radiation pretreatment. Journal of Cleaner Production 338: 130611.

Gao Q., Xu J. & Bu X.H., 2019. Recent advances about metal–organic frameworks in the removal of pollutants from wastewater. Coordination Chemistry Reviews 378: 17-31.
https://doi.org/10.1016/j.jclepro.2020.125246.

Jebaranjitham J.N., Christyraj J.D.S., Prasannan A., Rajagopalan K., Chelladurai K.S. & Gnanaraja J.K.J.S., 2022. Current scenario of solid waste management techniques and challenges in Covid-19-A review. Heliyon, e09855.

Khanal P., Chawla U., Praveen S., Malik Z., Malik S., Yusuf M., Khan S.A. & Sharma M., 2021. Study of Naturally-derived Biomolecules as Therapeutics against SARS-CoV-2 Viral Spike Protein. Journal of Pharmaceutical Research International 33(28A): 211-220.

Kumar S., Verma G., Gao W.Y., Niu Z., Wojtas L. & Ma S., 2016. Anionic metal–organic framework for selective dye removal and CO2 fixation. European Journal of Inorganic Chemistry 2016(27): 4373-4377.

National productivity Council, 2016. Guide book- Hazardous waste management rules.

Rasul S.B., Som U., Hossain M. & Rahman M., 2021. Liquid fuel oil produced from plastic based medical wastes by thermal cracking. Scientific Report 11(1): 1-11.

Rubab S., Khan M.M., Uddin F., Abbas Bangash Y. & Taqvi, S.A.A., 2022. A Study on AI-based Waste Management Strategies for the COVID-19 Pandemic. ChemBioEng Reviews 9(2): 212-226.

Soffian M.S., Halim F.Z.A., Aziz F., Rahman M.A., Amin M.A.M. & Chee D.N.A., 2022. Carbon-based material derived from biomass waste for wastewater treatment. Environmental Advances 100259.

Wei Y., Cui M., Ye Z., & Guo Q., 2020. Environmental challenges from the increasing medical waste since SARS outbreak. Journal of Cleaner Production 291: 125246.

WHO, 2020. Rational use of personal protective equipment (PPE) for coronavirus disease (COVID-19): interim guidance, 19 March 2020.

Yusuf M., 2019. Synthetic dyes: a threat to the environment and water ecosystem. In: Shabbir, M. (ed.), Textiles and clothing: Environmental Concerns and Solutions, Scrivener Publishing, Beverly, p.11-26.

DOI: 10.15167/2612-2960/BELS2023.5.1.2097