

Benefits of switching from incineration to sterilisation of health-care waste in Beira, Mozambique: sustainability, reuse of treated material, safety at work.

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Introduction

Incineration of health-care waste (HCW) has been widely practised in low-income countries, especially by small-scale incinerator and open burning. The advantages over other methods are significantly lower volumes of waste generated and the potential recovery of heat/electricity (its viability depends also on the treatment capacity of the plant). On the other hand, inadequate incineration, or the incineration of unsuitable materials, results in the release of pollutants into the air and in the generation of hazardous ash.

Sterilisation of HCW results in the reduction of microbial load by 6 logs, which represents a percentage reduction of 99.9999%. The NW15™ electric steriliser is a machine that can treat approximately 30/40 kg of HCW per hour. The treatment is carried out in a closed sterilization vessel, under negative pressure and in absence of chemicals. During the cycle, the temperature inside the chamber rises up to 150°C. The main difference with an autoclave is that water is never in direct contact with the waste. The heating, combined with simultaneous shredding of the waste by rotating blades, ensure an output material, at the end of the cycle, that is dry, sterile, and finely ground.

Mozambique ranks low on the human development index (HDI) at 0.446, or 185 out of 191 countries. Beira is the capital and largest city of Sofala Province in central Mozambique. In an area of 633 km² there are 16 Health Units of the National Health Service, including a Central Hospital, a Provincial Hospital, 12 Health Centres and 2 Health Posts, plus several private clinics. The Central Hospital is the only place where the HCW of most of the hospitals of the city is treated by an old incinerator and, since September 2022, by an electric steriliser.

Material and methods

Funded mainly by the Autonomous Province of Trento, the European Union Delegation in Maputo, the Italian Agency for Development Cooperation, and the Italian private company Newster Group, the LimpamOS MOÇambique and SIRSU projects aim to improve the waste management in Beira. Both projects are still ongoing. LimpamOS project worked mainly on the internal management and segregation of HCW in Health Centres, that is fundamental to treat and dispose it in an optimal way (i.e., separating common waste from biomedical waste to reduce the hazardous quantities to be treated). SIRSU project aims to improve especially the treatment system, by donating an electric sterilizer to a new local start-up that will use the machine in Beira Central Hospital, also offering a collection and transport service for the other hospitals.

During three periods of three months each spent in Beira, the main operations conducting during field work have been:

- Weighting operations to discover the quantities and kind of HCW burning every day in the incinerator, to state the future correct loads of the sterilizer.
- Interviews in most of the hospitals to understand the internal HCW management and the eventual final disposal. 7 Health Centres are practising open burning of all their waste; the others have a bad collection and transport municipal service.
- Personnel training on waste management (particularly on segregation) and on the use of the steriliser.
- Work office together with the new start-up to study the sustainability of their activities.

Results

The present incineration system is a threat for the environment and for people's health. This study aims to show the main benefits of shifting from incineration to sterilization of HCW.

1) *Sustainability*. The incinerator is not environmentally, economically, nor socially sustainable.

Incinerated materials containing or treated with chlorine can generate dioxins and furans. Incineration of heavy metals or materials with high metal content (lead, mercury, and cadmium) can lead to the spread of toxic metals in the environment. Temperatures above 850-900°C for the abatement of furans

and dioxins, and the presence of filters and gas treatment systems are not present in Beira's incinerator; the emissions, therefore, are uncontrolled and very dangerous, also considering the residential area immediately next to the hospital. It is possible to estimate the production of CO₂, H₂O, SO₂ and the flowrate of N₂, the main components of the off-gas, and then calculate the specific volumetric flowrate (per kg) of stoichiometric off-gas, moving on to that of actual off-gas under real conditions. Knowing the quantities and kinds of HCW burnt every day and the liters of fuel used every day, it is possible to estimate the total volume of off-gas.

The steriliser is an environmentally friendly machine with a low environmental impact, listed among Best Available Technologies in the Stockholm Convention

In addition, the economic and social sustainability of the project was analysed, thanks to the foundation of the start-up, establishing the minimum number of kilograms to be transported and treated and the unit cost to be paid by private clinics to cover all costs (mainly water, electricity, work hours, taxes).

Analyses of benefits for all the stakeholders were finally assessed.

- 2) *Reuse of output material.* HCW incineration is known to not completely destroy the metallic components of the waste stream but rather concentrate heavy metals into the bottom ash. Their unsafe disposal in uncontrolled dumpsite, therefore, is extremely dangerous. On the contrary, the output of the sterilizer is dry and safe material that can be dumped without risks. Moreover, it is possible to reuse this material: the construction of blocks by mixing it with cement has already started in Beira and in another project in Zimbabwe. In Zimbabwe, the bricks have already been used to pave a new hospital section; in Mozambique, the first samples have been made, but mechanical tests of the material are still to be done. The output material can also be used in cement kilns due to its high calorific value.
- 3) *Safety at work.* Currently, the incinerator operators are working in very unsafe conditions. They don't have sufficient DPI, and the loading door of the incinerator is broken so that it's always open, with risk of sparks escaping. The 6 hours exposition to off-gas is also very dangerous, especially because of the lack of good masks and off-gas treatment. The operations to load, start, unclean, and unload the steriliser, on the contrary, are very easy and safe, due to the very low emissions. Operators will stop working in a dangerous and very hot environment, also considering the already high temperature of the area. The new structure that hosts the steriliser has been built considering resilience requirements against cyclones, typical of that area. The building of the incinerator every year suffers due to strong wind, losing part of the roof and the top part of the stack of the incinerator itself.

Discussion and conclusions

The previous 3 points are only the main groups of benefits. The willingness expressed by the Mozambique's Ministry of Health, during a meeting on the project, is to close the incinerators and encourage new technologies. The change will obviously have to be gradual, and a period of coexistence between the two plants is therefore necessary.

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