PROPOSED UPGRADE OF THE HANS HOHEISEN WILDLIFE RESEARCH STATION, MPUMALANGA

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ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

APPENDIX B-8: HHWRS HAZARDOUS WASTE TREATMENT FACILITIES

Prepared for submission to:

The Department of Environmental Affairs

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On behalf of:

The University of Pretoria

Hans Hoheisen Wildlife Research Station (HHWRS)
Hazardous Waste Treatment Facilities

Additional research was done through a desktop study of the alternative hazardous waste treatment facilities which may be used to minimise the risk of disease and negative impacts on the environment. The research aims to provide additional information on the proposed treatment method and its suitability to the proposed additions to the Hans Hoheisen Wildlife Research Station (HHWRS).

The following alternative treatment systems are discussed:

- Incineration
- Alkaline hydrolysis
- Chemical stabilization
- Biological treatment
- Composting
- Bio-digestor.

1). Incineration

Medical waste incineration (MWI) involves the burning of wastes produced by hospitals, veterinary facilities, and medical research facilities. These wastes include both infectious medical wastes, as well as non-infectious, general housekeeping wastes. The primary purposes for MWIs are to activate the destruction of waste by converting the organic material to carbon dioxide and water vapour by fire. Ash is the incombustible inorganic residue.

The incinerator is suitable for the following:

- Medical waste containers, slides and sharps;
- Animal tissue, laboratory liquid waste and body fluids; and
- Animal bedding and carnivore faeces.

These objectives are accomplished by exposing the waste to high temperatures over a sufficiently long period of time to destroy threatening organisms and burn the combustible portion of the waste. There are many types of hazardous waste incinerators including:

- Rotary Kiln Incinerators;
- Fluidized Bed Incinerators;
- Liquid Injection Incinerators;
- Multiple Chamber Incinerators;
- Catalytic Combustion Incinerators;
- Waste-Gas Flare Incinerators; and
- Direct Flame Incinerators

Potential Issues and Impacts

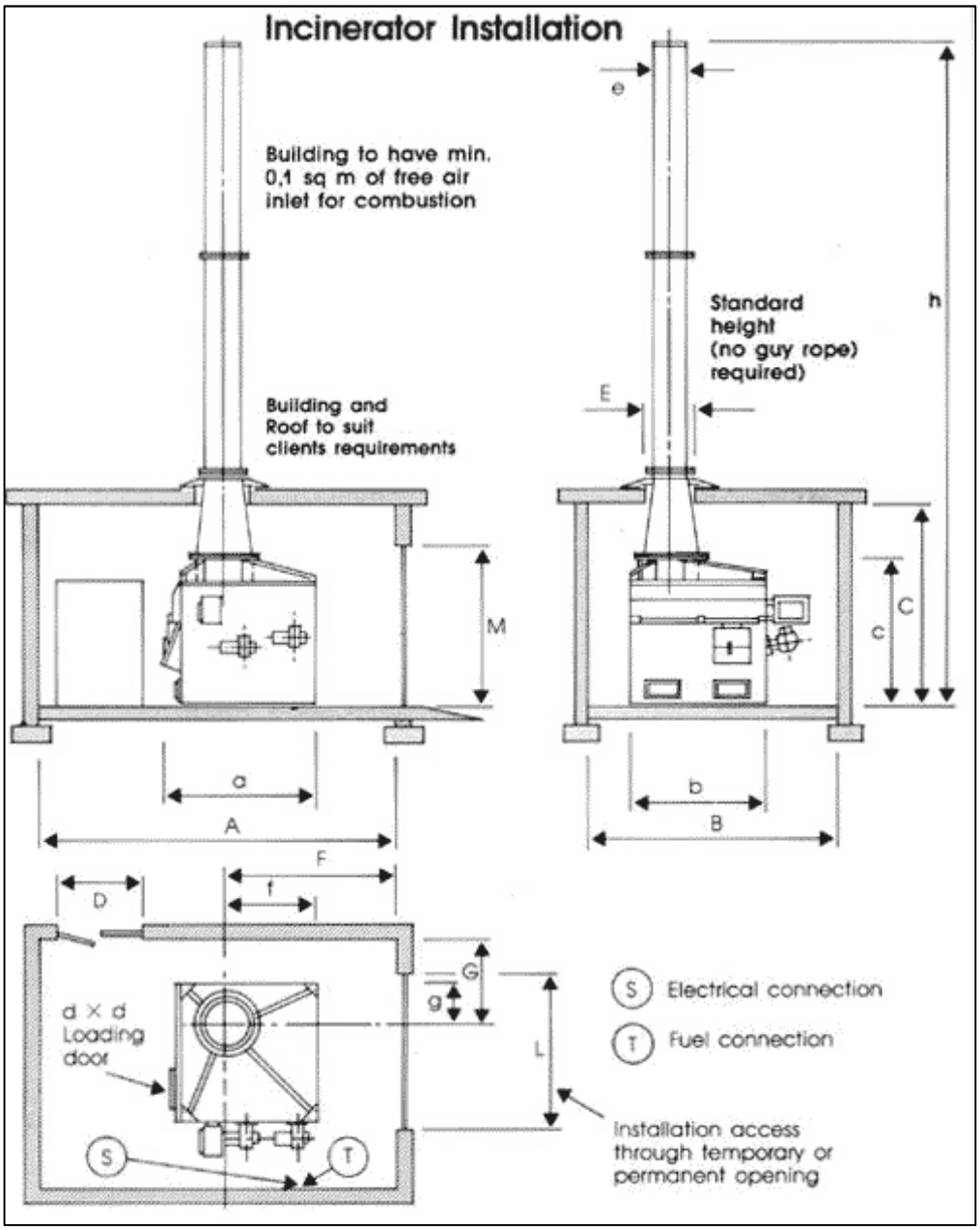
The disadvantages of incineration include the necessity of ash disposal and the potential for emissions of toxic and other pollutants. According to *Bassey et al (2006)*, the burning and incineration of medical and municipal waste have been linked to severe public health threat and pollution resulting in the release of toxic dioxin as well as mercury and other toxic substances. This pollutes the air significantly with noxious fumes and emissions. These substances also produce a remarkable variety of adverse effects in humans at extremely low doses.

Recommendation

It is recommended that incineration should be limited to animal tissue and laboratory liquid waste and body fluids. For the purposes of this specific project, the local SA Incinerator Company (Pty) Ltd may be considered for the installation of a Multiple Chamber Incinerator. Manufactured in the Republic of South Africa, most parts are standard and can be obtained from the country. The commended natural draught, multiple chamber, retort type incinerator has been built to the design standards of the Los Angeles Air Pollution Control District, modified and improved. This particular incinerator may be changed and modified to suit the Consulting Engineers Specifications.

With respect to the potential impact of the air quality of the area as a result of possible air pollution emitted from the incinerator, some further insight into the suggested product must be stated. The multiple chamber of the recommended incinerator includes auto-mated combustion control, dry process neutralisation of acid gases, improved scrubbers, dry, high temperature ceramic filters and a host of other refinements that will burn without emitting dangerous levels of dioxins, furans, heavy metals, carbon monoxide, methane or any other harmful substances. With built-in emission control, air pollution is apparently minimized whilst greenhouse gases methane and carbon monoxide are eliminated and chloroform is destroyed.

The incinerator may be oil, gas or coal fired. After lengthy word-wide debates, according to the SA Incinerator Company (Pty) Ltd, it has been widely accepted that incinerators are beneficial in reducing global warming. As previously mentioned, in order to incinerate a maximum of 4 tons per day, and assuming an 8 hour per day operation, the incinerator would need to process 500 kg of waste per hour. Therefore, if the suggested incinerator from the SA Incinerator Company (Pty) Ltd is employed, the 1000 LA model would need to be installed.



(Image from: http://www.saincinerator.com/install_incinerator_table3.htm)

2). Alkaline Hydrolysis

Alkaline Hydrolysis is a water-based chemical resolving process using strong alkali in water at temperatures of up to 180 °C to rapidly reduce body tissue to ash. The body is loaded into a *Resomator* where hydrolysis takes place. Hydrolysis is the process of forcing water molecules between the chemical bonds holding large tissue molecules such as fats, DNA and proteins together.

This process breaks the tissue down, as well as infectious microorganisms and pathogens down to their original small molecular building blocks, as an aqueous solution. This mimics the natural process found in body decomposition after death (http://alkalinehydrolysis.com/). This process is also known as Resomation.

It must, however be noted that alkaline hydrolysis is not designed to digest any material derived from plants or other inorganic substances such as plastics, synthetic polymers and metals. Therefore, medical waste cannot be broken down through this method which is limited to the breaking down of animal tissue only.

Nevertheless, Waste Resolution Technologies *(http://waste-resolution-technologies.co.za/)* state that indigestible materials still benefit from the thermo-chemical treatment in terms of providing pathogen control. There is no need to separate these materials if they are present in the animal tissue that is being treated. All indigestible materials may be safely removed and hygienically disposed of, once the tissue processing cycle has been completed.

Alkaline Hydrolysis is suitable for the following:

- Medical waste such as containers, slides and sharps; and
- Animal tissue.

Environmental Benefits

Alkaline hydrolysis has numerous benefits towards the environment. According to *Waste Resolution Technologies (2013),* alkaline hydrolysis allows the nutrients to be recycled back to the environment safely.

Through the thermochemical process, any pathogens that may be present in the tissues are sterilized. Returning the nutrients and amino acids to the environment has potential ecological as well as commercial value and may be done in the following manners:

- Land application as a rich natural fertilizer;
- Compost additive;
- Enrichment of manure slurry;
- Disposal in a methane-generating landfill;
- Nutrient feedstock for anaerobic digesters;
- Biofuel production through a biomass converter;
- Sewer disposal; and
- Landfill disposal.

Potential Issues and Impacts

With respect to the potential impact of the air quality of the area, *Waste Resolution Technologies (2013)* proclaim that alkaline hydrolysis systems have a very low odour process. Furthermore, alkaline hydrolysis digesters release no materials to the atmosphere. *Biosafe Life Sciences (2013)* add where concerning ground water, the sterile liquid exiting

the system may be safely returned to the water cycle free from any traces of pathogens and DNA.

Recommendation

Unfortunately, after extensive research considering the specific context of the Hans Hoheisen Wildlife Research Station (HHWRS), it was deduced that an Alkaline Hydrolysis Plant cannot be recommended. It is not a suitable application where the possibility for hydrolysing large animals such as elephants exists. According to Piet Kruger of *Waste Resolution Technologies (Pty) Ltd*, an extensively large unit would need to be erected for the process to effectively take place which could cost millions.

Furthermore, one of the biggest issues would be dealing with the fats residue of a large animal such as an elephant. If the specimen has been suffering from a disease such as anthrax, lipids are contaminated and cannot be used as biofuel. It would therefore be exceedingly difficult to eradicate the hefty fats residue of this process within a larger animal context and therefore it is not viable in this case for the Hans Hoheisen Wildlife Research Station (HHWRS).

3). Chemical Sterilization

Chemical Sterilization is also known as Cold Sterilization, and generally used for objects that cannot withstand high temperatures (ie. plastics), Chemical Sterilization is a method in which the specimen or object is immersed in liquid containing high concentrations of sanitizing chemicals. Glutaraldehyde is one such sterilizer, which must be in contact with the instrument for at least 10 hours for proper sterilization.

Other chemical sterilizers and oxidizing agents may require up to 24 hours of instrument contact and consist of ethylene oxide, ozone, bleach, glutaraldehyde, formaldehyde, phthalaldehyde, hydrogen peroxide, peracetic acid and silver for high-level disinfection. Once disinfected, the liquid may be poured into the sanitary sewer system followed by a water rinse. It is important to note that the liquid cannot have been mixed with other hazardous material that is not suitable for drain disposal.

Chemical Sterilization is most suitable for:

- Laboratory liquid waste and body fluids.

Potential Issues and Impacts

This method's popularity has declined in clinics and hospitals over recent years for a number of reasons. The turnaround time for sterilized loads is relatively long because of exposure time as well as the time required for sufficient aeration of loads to reduce toxic residuals. Until recently, ethylene oxide gas (ETO) was combined with a chlorofluorocarbon-stabilizing agent.

This method thus has inherent environmental issues over CFC's (chlorofluorocarbons) associated with the chemical sterilizers used which contribute towards ozone depletion. ETO exposure also represents an occupational hazard. Due to the potential scale of specimens needing to be sterilized, such as giraffes, rhinos or elephants, a particularly large Chemiclav would need to be custom-sized and made. Furthermore, a huge amount of water would have to be used in order for this process to be successful. Disposing the residue liquid into the on-site sewer system also poses risk of contaminating surface water with the

chemicals which have been used in the process. These may also leach into and intoxicate ground water.

In addition, the use of chemical sterilants poses numerous challenges for workplace safety. Although the chemicals used as sterilants are designed to destroy a wide range of pathogens, it is the same properties which make them extremely harmful to humans.

Recommendation

Due to the reasoning above, this method is out of date and cannot be recommended.

4). Biological Treatment

The Biological Treatment of waste involves the use of microorganisms and bacteria to remove contaminants by assimilating them through a natural process. Because they are effective and widely used, many biological-treatment options are available today. They are, however, not all created equal, and the decision to install a biological-treatment system requires ample thought.

Biological Treatment is suitable for:

- Laboratory liquid waste and body fluids; and
- Boma wash water.

Environmental Benefits

A Biological Treatment Process will aid in the natural degradation of organic waste resulting in the following:

- Bioassay/toxicity control - The ability to control and minimize the impact of toxic constituents in wastewater on indicating organisms when the treated water is released.
- BOD removal efficiency - The ability to remove biodegradable, organic compounds.
- COD removal efficiency - The ability to remove chemically oxidizable substances that may or may not be biodegradable
- Operating and Maintenance Costs - The low cost to operate and maintain the treatment method.
- Nitrification Efficiency - The relative ease of converting ammonia contained in wastewater to nitrates.
- Energy efficiency - The amount of energy used by a treatment method.

Potential Issues and Impacts

Although the biological treatment of waste is always of benefit to the environment, its holds certain disadvantages such as sludge disposal, low performance during winter months, performance quality with cold and warm water and its expandability.

Recommendation

The Biological Treatment Process maybe a viable option considering the positive benefits to the environment. It should be noted that this treatment option is not suitable for the disposal of waste that has a high risk for the spreading of disease.

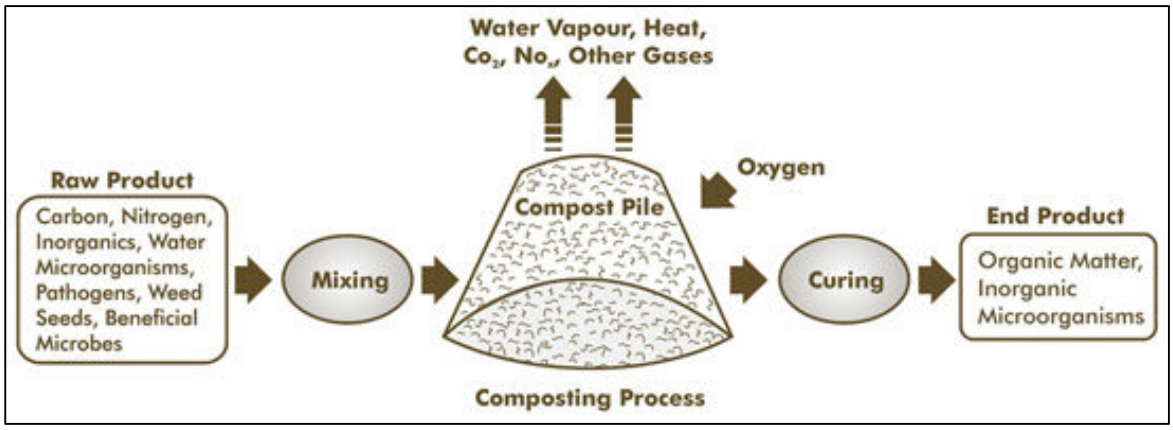
5). Composting

Composting is the decomposition of herbivorous animal waste along with plant remains and organic kitchen waste to make an earthy, dark, crumbly substance that is excellent for enriching soil. It is a critical step in reducing the volume of waste needlessly sent to landfills for disposal. Composting takes place through an aerobic process, which involves biological breakdown of materials through microbes in presence of oxygen.

The bacteria involved with the composting process destroy disease pathogens as the material waste is broken down, providing the temperature remains above 40°C for a minimum of two weeks (Alberta Agriculture and Rural Development, 2006). The main by-products of this biological breakdown are carbon dioxide and heat.

Composting is suitable for:

- Manure processing.



(Image from: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex8875)

Environmental Benefits

The quantity of manure applied is reduced by up to half through the composting process, as odours are decreased in spreading operations. The by-product of composted manure produces a quality soil conditioner with stabilized organic matter which is highly beneficial to crops, gardens and soil microbes alike. Other environmental benefits of composting are listed below:

- Pathogens are destroyed;
- Improves soil constitution;
- Reduces soil compaction;
- Provides nutrients both of micro and macro kind;
- Diminishes soil erosion and leaching of nutrients;
- To some extent, composting may suppress soil borne diseases;
- It improves the presence of good bacteria in the soil;
- It decrease pollutants;
- Stabilizes the volatile nitrogen into large protein particles; and
- Water retention of soil is improved by increasing aeration.

Potential Issues and Impacts

Excessive moisture within the composting facility may cause potential issues and impacts. Odour problems associated with composting may occur if the process is not properly

managed and covered from rain, as stockpiled organics are forced to become anaerobic, leading to offensive smells. Considering the impacts of surface and ground water, there is a possibility that composting may generate leachates that need careful management *(Haug, 1993)*.

Leachates from composting and related organics-processing facilities have the potential to pollute groundwater and surface water bodies. What is more, surface water run-off from composting and related organics-processing facilities may cause unacceptable loads of sediment and suspended solids in receiving waters *(Department of Housing, 1998).*

Additionally, the decomposition process of composting releases greenhouse gases into the atmosphere, such as nitrogen, methane and carbon dioxide. It is also important to note that carnivore faeces cannot be used for the composting process and must be dealt with in a separate method. Composting requires a time and labour commitment to properly manage the windows to produce quality compost. Furthermore, the composting site and storage for the finished product may use a considerable area of land.

Recommendation

Besides for the cost of initial equipment, this process is low cost and highly effective. It contains numerous holistic benefits for the maintenance of the grounds of the Hans Hoheisen Wildlife Research Station (HHWRS).

6). Bio-Digestor (Biogas)

A Bio-digester is an anaerobic fermentation tank. Organic waste such as manure, carnivore faeces, animal bedding, grey water and food scraps may be mixed with water and ingested into the tank. As the fermentation process takes place, anaerobic bacteria destroy pathogens and malignant bacteria, thereby producing biogas, which is a combustible mix of methane and carbon dioxide. This greenhouse gas is captured by the bio-digester, ensuring it is not released into the atmosphere as it is utilized instead as renewable energy source for cooking fuel, lighting and heating. What is more, the safe and nutrient rich effluent may be used as an organic fertilizer.

The Bio-Digestor is most suitable for:

- Manure; and
- Animal bedding and carnivore faeces.

Environmental Benefits

According to the 1997 report, anaerobic digestion facilities have been recognized by the *United Nations Development Program* as one of the most useful decentralized sources of energy supply, as they are less capital-intensive than large power plants. The benefits of employing a Biogas System are listed below:

- Animal manure can be disposed of safely, reducing smells, flies, and the spread of disease;
- It is odorless, as opposed to composting toilets and septic tanks;
- Bio-Digester effluent is a powerful organic fertilizer reducing the need to purchase and apply chemical fertilizers to the grounds of the Hans Hoheisen Wildlife Research Station, saving money and decreasing chemical runoff;
- It prevents animal and human waste, including untreated water from contaminating groundwater, and

- As part of an integrated waste management system, anaerobic digestion reduces the emission of landfill gas into the atmosphere.

Potential Issues and Impacts

With respect to the potential impact of the air quality of the area, it is already mentioned that this system reduces the emission of landfill gas into the atmosphere, while the process is odourless. Therefore, no negative impacts to the air quality of the area are created by the Bio-Digestor System.

Furthermore, with respect to the potential impact of the ground water of the area, no negative impacts are made by the system. It has been cited that the Bio-Digestor System prevents animal and human waste, including untreated water from contaminating groundwater. The biggest potential issue of the Bio-Digestor System would be the training, technical assistance and follow-up that would need to be undertaken in order for this system to work efficiently.

Recommendation

According to Robin Thomson of *AGAMA Bio-Gas Pro of South Africa*, *AGAMA Bio-Gas Pro 6* is the recommended model for the Hans Hoheisen Wildlife Research Station. There would need to be several in series and possibly situated in parallel in order to cater for the load. It is said that each digester can take about 30-35 kg per day, and an equivalent water loading would generate the best gas.

7). Evaporation Dams

Evaporation dams are essentially artificial dams with very large surface areas that are designed to efficiently evaporate water by exposure to sunlight. An evaporation dam placed at the Hans Hoheisen Wildlife Research Station would remove the sterilized liquid effluent from any solid residue hazardous waste. This allows the waste to be more easily transported, treated and stored.

Evaporation dams are suitable for:

- Sterilized liquid effluent.

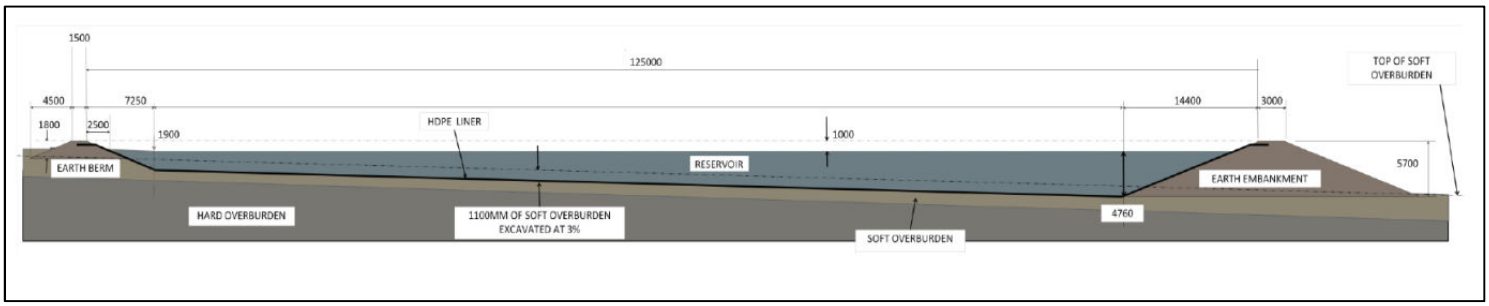
Potential Issues and Impacts:

According to the *Geophysics Study Committee of the National Research Council (1984)*, the most common problem with evaporation dams is that they often leak and contaminate the underlying groundwater. If an evaporation dam was to leak and seepage was to escape from the facility, the toxic solutions would contaminate the underlying soil, potentially reaching the water table which would detrimentally impact groundwater resources.

Furthermore, evaporation dams have been known to cause problems for wildlife. As evaporation takes place, waste waters become more concentrated with salts, hazardous waste and heavy metals. It is these wastewaters of hazardous substances that attract and kill migratory birds and other wildlife. It is imperative that evaporation dams are properly sealed and regularly checked in order to prevent leakage into ground water reserves. In order to prevent wildlife mortality, dams should be covered with appropriate netting to prevent access into the contaminated water reserves

Recommendation

Recommended for secondary treatment and disposal of liquid effluent.



(Image from: http://www.damsforafrica.com/uploads/1/6/0/0/16002766/dams_-_preliminary_design_of_evaporation_dam.pdf)

8). Release to Environment

Waste water, run-off and wash water from bomas, pens and holding areas are discharged into an existing drainage line on campus. 'Release into the environment' may also describe the utilization of the liquid waste for irrigation purposes.

This option is suitable for:

- Boma wash water and sterilized liquid effluent.

Potential Issues and Impacts

Releasing possibly highly contaminated liquid effluent into the environment will have numerous detrimental impacts. Discharge could still, and with high possibility potentially contain residue contaminants. Releasing this liquid contaminant into the environment would most certainly infect surface water, thereby posing the risk of poisoning wildlife. Additionally, release into the environment would irreversibly intoxicate ground water reserves. Soils may be poisoned with residue toxins. This would kill vegetation, eventually leading to soil erosion and soil compaction due to their absence. What is more, infected vegetation may disturb and possibly kill any wildlife feeding from it.

Recommendation

There are many effective and environmentally-friendly solutions for the expulsion of liquid waste, as has been suggested. It would be ignorant and irresponsible to release liquid effluent which is highly likely to be contaminated into the environment. Therefore this process cannot be recommended.

9). Removal off site to registered Facility

Waste is physically separated into specialized medical bags or bins and couriered to applicable registered facilities. It is the facilities themselves that manage the applicable waste treatment and sterilization. This is done mainly through incineration and autoclave disposal technology.

This viable option is suitable for:

- Medical waste, containers and sharps;
- Animal tissue, laboratory liquid waste and body fluids;
- Animal bedding and carnivore faeces.

Potential Issues and Impacts

Air emissions from courier trucks transporting waste contribute towards the pollution of the atmosphere. There is a possibility that hazardous waste may leak or spill out of the vehicles and be released into the environment. Furthermore, if a truck happens to turn over, spilled over hazardous waste may contaminate the surrounding environment, spill into surface water, leach into groundwater and poison wildlife and humans alike.

Recommendation

It is recommended that medical waste limited to containers, slides and sharps are removed off site and couriered to a registered facility. Registered facilities should be situated as close by as possible in order to reduce unnecessary fuel emissions. If not possible, the current status quo of the waste disposal system may be kept as *Oricol Environmental Services* continues to transport the waste to the *Onderstepoort Facility* in Pretoria where it is eventually incinerated.

Tabulated treatment methods and evaluation criteria					
TREATMENT METHOD	**EVALUATION CRITERIA**				
	Application	**Potential Environmental Impacts**	**Potential Environmental Benefits**	**By-product Management & Disposal**	**Recommendation**
Incineration	• Medical waste containers, slides & sharps; • Animal tissue, laboratory liquid waste and body fluids; and • Animal bedding & carnivore faeces	• Emits toxic and other pollutants into the atmosphere. Noxious fumes and emissions • 15m tall chimney required will have a visual impact.	No dangerous chemical used and no dangerous by-products	Ash disposal needs to be separately managed	Suitable for organic matter (animal carcasses and bedding). Not recommended for inorganic material (drug & chemical containers and sharps) due to emissions and odours.
Alkaline Hydrolysis	Animal tissue	No significant impact	Pathogen-free nutrients may be returned to the environment as fertilizer. By-products may also be used for bio-fuel production.	By-products are easily managed and used as fertilizer and/or biogas production.	Not recommended due to capacity and volume limitations.
Chemical Sterilization	Laboratory liquid waste and body fluids	• CFC emissions • Disposing residue liquid into the on-site sewer system poses risk of contaminating surface water with the chemicals which have been used in the process. • Disposed residue liquid may also leach into and intoxicate ground water.	None.	Liquid residue (sterilized) is flushed down the sanitary sewer system as grey water waste	Although suitable for wash water from laboratories, clinic, pens and boma's, this system is outdated and costly and is therefore not recommended.

Biological Treatment	• Laboratory liquid waste and body fluids; and • Boma wash water.	• Greenhouse gases methane, nitrogen and carbon dioxide are released into the atmosphere. Poor management may lead to odour.	No dangerous chemical used and no dangerous by-products.	Sludge by-product needs to be separately managed.	Suitable for wash water from laboratories, clinic, pens and boma's.
Composting	• Herbivorous animal waste; • plant remains and • organic kitchen waste.	• Greenhouse gases methane, nitrogen and carbon dioxide are released into the atmosphere. • Poor management may lead to odour. • Leachates have the potential to pollute surface water bodies. Run-off from composting facilities may cause unacceptable loads of sediment and suspended solids in receiving waters. • Leachates from composting facilities may pollute groundwater	Destroys pathogens, improves soil constitution, reduces soil compaction, increases the water retention of the soil.	Compost may be used as fertiliser and methane may be captured and used as bio-fuel.	Suitable for small volumes of inert organic matter (kitchen waste). Not recommended for animal bedding due to limited capacity.
Bio-Digestor (biogas)	• Manure; and • Animal bedding and carnivore faeces.	• Visual impact varies according to the design chosen which may be above or below ground	Reduces the emission of landfill gas into the atmosphere.	Bio-digestor effluent may be used as fertiliser and methane may be captured and used as bio-fuel.	Suitable for small volumes of inert organic matter (kitchen waste) and grey water. Not recommended for animal bedding due to limited capacity.

Evaporation (dams)	Sterilized liquid effluent / waste water.	• Limited visual impact • Potential to leak and contaminate soil and groundwater • Potential to leak and contaminate surface water • Potential to leak and contaminate soil and groundwater			Suitable as secondary treatment and disposal of waste water
Release to Environment	Waste water, run-off and wash water from bomas, pens and holding areas	• Discharge could potentially contain residue contaminants and contaminate surface water. • Release into the environment would irreversibly intoxicate soil and ground water reserves.			It would be irresponsible to release liquid effluent which is highly likely to be contaminated into the environment. Therefore this process cannot be recommended.
Removal off-site (to registered facility)	• Medical waste, containers and sharps; • Animal tissue, laboratory liquid waste and body fluids; • Animal bedding and carnivore faeces.	Impacts are related to the road transport of the materials to an off-site disposal facility. i.e. fuel emissions, risk of accidental release into the environment due to motor transport accidents etc.	None	None	It is recommended that medical waste limited to containers, slides and sharps are removed off site and couriered to a registered facility

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