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Chapter 1: Literature Review

When we hear the word medical, we usually think of positive things such as doctors, or healthcare, or treatments that can save people's lives, but we rarely think of the ramifications which stem from this sector of the economy. Thousands to millions of tons of medical waste are produced each year, all with varying degrees of danger to the biota of natural ecosystems.[1] Most are considered general, non-hazardous waste, but around 10-15% can be considered hazardous and toxic to the biota and the natural environment.[2] We need to be able to answer questions such as: What is medical waste? Which substances are hazardous and toxic? How can we tell they are hazardous and toxic? What are the impacts of medical waste, really? What can we do to alleviate these ramifications?

Healthcare waste is the umbrella term for all wastes produced in the healthcare sector of the economy.[3] Medical waste is a category of healthcare wastes generated at health care facilities, such as hospitals, dental practices, and veterinary hospitals/clinics, as well as medical research facilities and laboratories.[4] In general, "medical waste is defined as any solid or liquid waste that is generated in the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals."[5] These wastes include infectious waste, pathological waste, sharps, chemicals, pharmaceuticals, genotoxic waste, radioactive waste, and nonhazardous or general waste.[6]

General waste, or nonhazardous waste, don't pose a hazard to the biota and the environment in the biological, chemical, radioactive or physical sense.[2] General waste usually comes from the administrative and housekeeping sections of healthcare establishments and may also include waste generated during maintenance of health-care premises. The municipal waste disposal services should take care of the general waste produced in the medical sector.[7]

Infectious waste is waste contaminated with blood and other bodily fluids, cultures and stocks of infectious agents from laboratory, or waste from patients with infections.[2] These wastes are suspected to contain pathogens such as bacteria, viruses, parasites, or fungi in sufficient concentration or quantity to cause disease in susceptible hosts.[7] These wastes can originate from discarded diagnostic samples, from autopsies and infected animals from laboratories, or from swabs, bandages and other disposable medical devices.[6]

Pathological waste are typically human tissues, organs or fluids, body parts and contaminated animal carcasses [2] but in this category, recognizable human or animal body parts are also called anatomical waste.[7] This categorical group is also considered as a sub-category of infectious waste, even though it could also include healthy body parts.[7]

Sharps waste are exactly what their name suggests – objects that are sharp and can cause cuts or puncture wounds.[7] Syringes, needles, disposable scalpels and blades are all items within this category of medical waste.[2,6]

Chemical waste is waste containing chemical substances. These chemical substances can be laboratory reagents, film developer fluids, disinfectants that are expired or no longer needed, solvents used in experiments and tests, and waste with high content of heavy metals (such batteries and broken thermometers).[6] Chemical waste can also be separated into hazardous or nonhazardous. If talking about protecting health, a chemical waste is considered to be hazardous if it has at least one of the following properties: toxic, corrosive (acids of pH < 2 and bases of pH >12), flammable, reactive (explosive, water-reactive, shock-sensitive), or genotoxic (cytostatic drugs).[7]

In general, pharmaceutical waste are expired, unused and contaminated drugs and vaccines that are disposed.[2] Some would also consider serum that are no longer required and needed to fall within this group of wastes. This waste category

also includes discarded items used in the handling of pharmaceuticals such as bottles or boxes with residues, gloves, masks, and drugs vials.[7]

Genotoxic wastes are highly hazardous and may have mutagenic, teratogenic, or carcinogenic properties. Genotoxic waste may include certain cytostatic drugs, vomit, urine or feces from patients treated with cytostatic drugs, chemicals, and radioactive material. Because of these reasons, these wastes raise serious safety problems and should be given special attention.[7]

Radioactive wastes are waste from radiology, such as iodine-125 or iodine-131.[8] They can also be products contaminated by radionuclides including radioactive diagnostic material or radiotherapeutic materials.[2] Ionizing radiation cannot be detected by any of our sense. This means that other than burns which can usually occur in exposed areas, radioactive wastes cause no immediate effects unless exposed to a very high dose. The ionizing radiation of interest in medicine include X-rays, α (alpha) and β (beta) particles, and γ (gamma) rays emitted by radioactive substances.[7]

As seen in the above paragraphs, there are quite a few medical waste categories. It is important to not only to know the types of wastes, but also to know how to properly dispose of each type of medical waste as to not cause more problems to the biota and environment. In general, most healthcare facilities have six different types of containers for proper disposal of medical waste materials that are considered hazardous: sharps (red sharps container), biohazard (dark red container or liner in container), trace chemo (yellow container), RCRA hazard (black container), pharmaceutical (blue container), and radioactive (shielded containers with radioactive symbol). General or nonhazardous medical wastes are commonly disposed of in trashcans for general use.[9] Different countries are also known to use different colored containers for their waste disposals.[3]

After the medical wastes are properly disposed in their correct containers, these wastes have to be transported to their next step of proper disposal. There are three main types of disposal treatments for medical waste: thermal processes, chemical processes, and irradiation processes.[10,13] The purpose of treating medical wastes is to reduce the potential hazard posed by these types of waste, while trying to protect the environment, therefore, it is important to select the most suitable disposal treatment for different types of medical waste.[11] There are many things to take into consideration when deciding on the type of disposal treatment, such as waste characteristics, quantity of wastes, types of waste for treatment and disposal, local availability of treatment options and technologies, capacity of the system, infrastructure requirements, operation and maintenance requirements, skills needed for operating the technology, environmental and safety factors, environmental releases, location and surroundings of the treatment site and disposal facility, occupational health and safety considerations, cost considerations, shipping fees and customs duties, annual operating costs, including preventive maintenance and testing, cost of transport and disposal of treated waste.[11] There is no one perfect solution to all the medical waste disposal problem, so each facility must make their own decisions based on their needs and capabilities, while hopefully, keeping in mind the affect their decisions may have on the surrounding biota and ecosystem.

The first main type of medical waste disposal treatment is thermal processes. These processes rely on heat (thermal energy) to destroy pathogens in the waste. They represent most treatment facilities in use across the world.[11] Under thermal processes are five methods that are commonly used: incineration, autoclaying, steam augur, gasification and pyrolysis, and plasma.[12]

Incineration "is a controlled combustion process where waste is completely oxidized and harmful microorganisms present in it are destroyed under high temperature."[10] It is one of the most commonly used disposal treatment methods

in the world.[14] The process of incineration will turn the medical waste into ash and gases. It is an effective method but it also produces potentially dangerous dioxin emissions, many that are carcinogens. Unfortunately, this method of medical waste disposal treatment is not managed the same way all over the world, especially in poorer developing countries where legislations and resources and equipment malfunctions have all played a part in the release of harmful dioxins and furans.[12]

"Autoclaving is a low-heat thermal process where steam is brought into direct contact with waste in a controlled manner and for sufficient duration to disinfect the wastes."[10] The autoclaving method has existed since the 1800s as a way to sterilize things. Autoclaving uses moisture, heat, and pressure to kill potential microorganisms on the items being autoclaved.[15] This type of disposal treatment method is very useful with a wide range of medical wastes including, but not limited to, sharps, laboratory wastes, gauze, bandages, gowns, and cultures.[11] Autoclaving has a higher cost compared to incineration, produces a bad odor, and it is not suitable for some other types of medical wastes such as chemotherapy treatment wastes, radioactive wastes, or hazardous chemical wastes. In addition, facilities will also need to invest in a drying mechanism and a shredder to partner with the autoclave to reduce the waste volume.[12]

Steam augur uses time and heat to kill microorganisms. The difference between this method and autoclaving is that steam augur performs at atmospheric pressure and requires the medical waste to be shredded before going through this process.[12]

Gasification uses high temperatures and a coreactor to convert solid medical wastes into a combustible gas, which then can be used in another form of energy technology.[16] Pyrolysis is similar, but its combustion happens in the absence of oxygen. Both of these waste disposal methods are useful for larger volume reduction in waste but uses high activation energy and specific necessary facilities and trained

operators to use them.[17,18] Even though this seems like a great choice for a disposal method, the requirements are too high for most facilities to consider.

The last method of thermal processing waste disposal is called plasma processing. This method uses an electrical current discharged through an inert gas in order to ionize and cause an electric arc to create extremely high temperatures. This is to decompose the compounds of the medical wastes.[19] Plasma processing can be used to convert organic and inorganic substances, as well as cytotoxic drugs and other waste materials into rock, inert gas, glass, and ferrous metal.[12,20] This method may seem like a promising way of dealing with medical waste, but unfortunately, it consumes extremely high energy, which means much higher costs, and the need for the right facility and equipment, plus the short-lived lifespan of the plasma torch with electrodes makes it impractical for most facilities.[21]

The second main type of medical waste disposal treatment is chemical processes. As the name suggests, this type of waste disposal uses chemicals to disinfect and treat medical wastes.[12] There is quite a big range of chemicals that can be used for chemical processes of medical waste disposal. Alcohols, detergents, alkalis, and phenols are all chemicals that are commonly used.[12] Unfortunately, many of these chemicals are known to produce disinfection by-products (DBP) which are health risks and have been known to be linked to cancer.[12, 22, 23] There are other hazardous medical wastes such as some pharmaceuticals that can cause chromosomal abnormalities in those that come in contact with the chemicals but were not the intended recipients of the treatments. These types of medical wastes require chemicals such as chlorine or ozone for more effective chemical disinfection.[24, 25] Disinfection by-products can also cause respiratory and allergic issues to those who come in contact.[26] *Maybe also add some info from WHO book? Number 11 on literature cited list*

The last main type of medical waste disposal treatment is irradiation processes. Irradiation processes include several different methods that are commonly used in practice: ultraviolet, Cobalt-60 electron beams, and microwaving treatments.[12] These types of disposal treatment methods require shielding for the personnel who work and take part in the processes because of the increased chance of exposure to radiation. The three common methods of irradiation treatment processes all differ in their effectiveness, with some methods strong enough to fully treat waste bags and containers, and others not able to do that but able to disinfect microorganisms that are airborne.[11] The methods will be discussed below.

The first method that falls under irradiation processes is the ultraviolet method. Ultraviolet (UV) is an electromagnetic wave with wavelengths between 200 to 400 nanometers (nm) long.[12] It goes without saying that precautions should be taken when using this method because of the possibility of developing various forms of cancers.[27] Unfortunately, because of the necessary precautions and equipment and the training for personnel, many medical facilities are not able to meet the requirements to use this method on their premises.[12,27]

The UV method lacks the ability to fully penetrate waste bags and containers, so it was not normally employed to treat medical wastes in the past.[11,12] It was more commonly used in hospitals and other medical facilities to treat healthcare wastewater.[28] However, in the recent years, there has been more development in using UV to increase the efficiency of shredder autoclave sterilization of medical wastes.[29] A lot of medical wastes are first shredded to decrease the size of wastes, then sterilized in autoclaves or other methods, but studies have shown that shredding and sterilizing does not completely finish the job as many types of bacteria were found growing on the wastes days after they were shredded and sterilized.[29] By using UV light at fifteen minute cycles with the shredder and the autoclave sterilization, bacterial growth was eliminated.[29] Utilizing UV light can break cell

bonds, which results in disrupted bacterial DNA, and create free radicals, which can cause toxicity in the cytoplasm of the cells.[30] This is how UV can destroy bacterial growth in shredded and sterilized medical wastes.

The second common method for irradiation processes is Cobalt-60 electron beams. When Cobalt-60 disintegrates it produces gamma rays, which are high energy electron rays that have a better and deeper capability to penetrate objects, such as waste bags and containers. These Cobalt-60 electron beams are known to be extremely effective at killing microorganisms.[31] This is mainly because the high energy of the gamma rays are able to break molecular bonds plus ionize the atoms, but they do not alter the atom's nucleus structures. This also means that whatever is being irradiated doesn't become radioactive itself.[32]

This method of using radioactive Cobalt-60 to irradiate waste has been popular since around the early 1960s. In the early days, it was mostly used to sterilize medical products and wastes, but as time went on, it was also developed into an effective method for treating sewage sludge, which of course also includes medical sewage. Countries such as Norway, Germany, Czech Republic, Austria, Canada, India, and Japan have all used Cobalt-60 irradiation technique to process drinking water, wastewater, sludge, well water, and landfill leachate, to disinfect these wastes in order to be able to use the treated substances for other necessary activities. Processing drinking water with Cobalt-60 can reduce the chemical contaminants with the disinfection. The phenols in wastewaters can also be reduced using this method. Disinfecting sludge can render the processed sludge into fertilizers to be used in agriculture. In Japan, it has also been used to destroy toxic materials in landfill leachates.[33] In the present age, Cobalt-60 is used as the main source for gamma radiation method of irradiation at all industrial irradiation facilities.[32]

Although this irradiation method of using Cobalt-60 as the source seems very promising, there are also drawbacks to the technique. The first issue is that this

technique requires the facilities using it to specially train workers to work in this field. This is because there are many different health problems that are linked to working long term with and being exposed to gamma irradiation, such as a myriad of cancers and developmental issues in cardiac function and structure.[12,34] Other than specialized training for the employees working in such facilities, the premises themselves have to be designed properly and have all the necessary safety technologies and precautions to shield the workers and the surrounding areas of radiation.[11,12] Major components of a gamma irradiation treatment facility include, but are not only limited to, the main irradiation room, shielded storage room, radiation shield around the irradiation room, control rooms, a transport system that can move objects through a shielding line, and room for loading and unloading. In order to have a complete and well-designed gamma irradiation facility takes a lot of time, finances, and training to accomplish.[32]

Another problem with this method of waste treatment is the limited amount of the source in nature. Ore that is rich in cobalt are very rare because it is actually only 0.001% of the earth's crust. The half-life of cobalt is around 5.27 years, which means that the radioactivity decreases to around 50% in the matter of 5.27 years. A Cobalt-60 pencil usually remains useful within the gamma irradiation chambers for up to around 20 years, after which they are removed and transported back to the original suppliers. The suppliers can choose to recycle, re-use, or completely dispose of the Cobalt-60 pencil. What is important to note is that by around the year 2060, over 99% of Cobalt-60 will have used and rendered into non-radioactive nickel, which cannot be used for further irradiation processes to treat waste.[32] This is a necessary point to consider because of how much the medical sector benefits from this method of waste disposal.

Another problem to consider with this medical waste technique is that because it is such a common and popular method, Cobalt-60 can be found unguarded in many

everyday civilian facilities. Cobalt-60 can be used to make "dirty bombs", which are basically just homemade bombs that can cause a myriad of problems if detonated.[35] This is a security concern that should not be ignored in case unsecured Cobalt-60 really fall into the wrong hands. No matter what kind of bomb is made with Cobalt-60, it will be dangerous. This is because an explosion of a dirty bomb can have a fly-out range of 100 meters in all directions. This includes the Cobalt-60 itself being dispersed into the air and the exploded shrapnel covered in Cobalt-60. The cobalt-60 that is dispersed into the air will cause short term problems such as radioactive ash fall, which would be very detrimental for the biota in the surrounding areas. It will also cause long term issues for the biota living in the area by polluting the soil and water supply and causing cancer and other health problems in humans and animals who were exposed to it for too long or accidently inhaled it while breathing or eating and drinking. If the cobalt-60 dirty bomb was more of a pellet type bomb, then people are at risk of being hit by these cobalt-60 covered pellets, which would be a big challenge to treat medically. If the cobalt-60 covered pellets are not cleaned up efficiently and effectively, there will be long term ramifications to the ecosystem.[36]

The medical sector heavily depends on cobalt-60 irradiation method of disinfection. If used responsibly with the necessary facilities and well-trained workers, cobalt-60 irradiation can continue to be very beneficial without causing too much damage to the surrounding biota and ecosystem. There would be a huge need for investment into making sure everyone and everything involved in using this method is up to standard, and kept up to standard. There is also a need for more research into the reuse and recycling of the spent cobalt-60 pencils. If there is no way to reuse or recycle these sources, we will run out of cobalt-60 in the near future. If cobalt-60 were to run out or be phased out from use, the medical sector would take a lot of damage in their medical waste treatment methods. Not using cobalt-60

irradiation would also require a lot of investment into finding a method that could do what this method can accomplish, butthat will most likely take a long time and a lot of money.[35]

Another irradiation method is microwaving. As the name suggests, this technique uses electromagnetic waves to disinfect medical waste. Microwaving works by heating the medical waste from the inside to the outside, with the medical waste having to be wet in order for this method to work properly. This is because the process uses the water to produce steam which is then used on the medical waste to disinfect them.[12] The only advantages that this microwaving method has are that it is more environmentally friendly and it tends to help reduce the waste volume as it processes the waste.[37]

There are quite a few disadvantages of using the microwave method for medical waste treatment. Microwaving actually can run into quite a lot of maintenance or operational problems because it involves not just the microwave processing in its whole disinfection process.[37] In order to use the microwave method, shredders are first used to crush all the medical waste. Shredders are known to be very loud and also tend to give off terribly smelling odors.[38] Another issue with this method is that it can only be a small scale operation. Because it cannot handle large scale medical wastes, in the long run it will become more costly to use this method.[39] With the above mentioned disadvantages of this microwaving method, even though this technique is still used in many different countries, it is not a widespread recommended way of treating medical waste. There are even some studies that show this method is not able to properly and completely disinfect medical waste because there have been microorganisms still found on the waste after going through the processing treatment.[40]

Other than all the methods mentioned above, there are also a few other methods of medical waste treatment and disposal that are not as technically complicated as

the already mentioned methods. These next methods are also not as useful in the sense that they only work for certain types of medical waste and does not cover the entire spectrum of medical wastes. These other methods are landfilling, reuse and reprocessing, and recycling.[12]

Landfilling is a very common method of medical waste disposal treatment all over the world, mostly meant for waste that are nonhazardous. It is a simple concept, quite low cost, and does not require the workers to have as much technical training as compared to the previously mentioned methods that are more specialized.[12,41] Although these are great advantages, landfilling still needs a lot of work to become a method that does not cause problems to the biota and surrounding ecosystem. Landfills are known to be the underlying cause of a lot of soil and water pollution through contamination from the waste dumped onsite. Soil and water contamination will then become health hazards for those living around the area.[38] Landfills usually also emit dangerous gases that build up over time due to the various types of waste bundled together at the site. These gases include, but are not limited to, volatile organic compounds, ethylbenzene, and benzene.[42] Another danger to using landfills and not having proper management and treatment is landfill leachate which is a type of highly toxic liquid that is produced through the decomposition of waste materials.[43] Many landfills are not managed properly and will end up having both nonhazardous and hazardous medical wastes piled onsite.[41] Unfortunately, when this happens, it defeats the purpose of having this type of medical waste disposal because it ends up causing even more problems to the environment, biota, and ecosystem.

The reuse and reprocessing method is another method that is not meant to be used for all medical wastes. There are certain items used in the medical sector that can be reused after being sterilized, such as scalpels, different types of trays used in hospitals and clinics, patient gowns, and different solid waste containers. It is more

financially and environmentally practical to take these reusable items and reprocess them for reuse.[44] Although this method reduces the amount of certain medical waste needing to be disposed, there are still risks involved. Studies have shown that even by putting these reusable items through a sterilization process, some harmful microorganisms still are able to survive and can be detected.[45]

The last method to be discussed is recycling, another method that is only meant for certain types of nonhazardous medical waste. These wastes are normally waste that are considered not contaminated or are not produced from clinical processes. Paper, plastic, and certain recyclable packaging can be disposed of using this method. There are actually a lot more items that can be recycled in the medical facilities, but unfortunately, many different legal and logistical requirements keep the medical facilities from doing so and therefore resulting in needing other types of disposal methods to deal with the medical waste.[46]

There are various types of medical waste treatment and disposal methods as discussed above and they all have their advantages and disadvantages, requirements, limitations, and effects on the environment, ecosystem, and biota. There is no one method that reigns supreme over all other methods because of the different needs and abilities of whichever medical facility is in question. Many different aspects and viewpoints need to be taken into consideration when a facility is trying to decide on the best suitable method that will also hopefully have the least amount of detrimental effect on the environment, ecosystem, and biota.[47,48] At the end of the day, a facility will have to make their own decisions on which method best meets their needs and how they can minimize the harmful effects to the environment.

Table 1. Comparison of the various types of medical waste treatment and disposal methods.

Type of medical waste treatment and disposal method	Advantages	Disadvantages/Challenges
Thermal Processes		
Incineration	• Effective way of disposal since everything is burned to ashes • Can be large scale	• Produces potentially dangerous dioxin and furan emissions, many that are carcinogens • Ineffective management and no set universal standard results in many malfunctions, pollution, and contamination through by-products of this method
Autoclave	• Long history, well established protocols • Well suited for a wide range of wastes that are considered nonhazardous	• Higher cost compared to incineration • produces bad odors • Not suitable for other types of medical wastes such as chemotherapy treatment wastes, radioactive wastes, or hazardous chemical wastes. • Need to invest in a drying mechanism and a shredder to partner with the

		autoclave to reduce the waste volume
Steam augur	• Economically practical • Relatively quick treatment time • Compared to other methods, considered safe to use for the environment	• Cannot treat objects that are sensitive to heat • Requires medical waste to be shredded before treatment • Lots of different variables to consider (such as temperature, moisture content, pressure)
Gasification and pyrolysis	• Can convert solid medical wastes into a combustible gas, which then can be used in another form of energy technology. • Useful for larger volume reduction in waste	• Needs high activation energy and specific necessary facilities and trained operators. • Requirements too high for most facilities to consider (expensive to build the proper facility, train personnel, and keep the treatment facility functioning)
Plasma	• Can convert organic and inorganic substances, as well as cytotoxic drugs and other waste materials into rock, inert gas,	• Uses extremely high energy • High costs • Need to invest a lot in building the right facility with the right equipment

	glass, and ferrous metal.	• Plasma torches have short lifespans
Chemical Process (such as alcohol, detergents, alkalis, phenols, chlorine, or ozone)	• Wide range of chemicals that are available to use for disinfection and sterilization	• Many chemicals are known to produce disinfection by-products (DBP) which are health risks and have been known to be linked to cancer and other health problems. • DBP also detrimental to the environment
Irradiation Processes		
Ultraviolet	• Can treat for a wide range of medical wastes as it uses electromagnetic waves • Suitable to treat medical wastewaters • Can break cell bonds and disrupt bacterial DNA to eliminate microorganisms	• Can cause a myriad of cancers • Need the proper facility with high safety standards • Workers must be trained to a high standard • Lacks ability to penetrate waste bags and containers • Needs to be accompanied by shredders in order to give the best sterilization results
Cobalt-60 electron beams	• Uses gamma rays that have a better and deeper capability to penetrate objects, such	• Workers need to be trained • Facility and workers need the proper safety protocols and equipment

	as waste bags and containers. • Extremely effective at killing microorganisms • Can treat large scale medical wastes • Reliable treatment method	• Long term or unprotected exposure to gamma radiation is known to cause health problems • Cobalt source is limited • Easily accessible by civilians because of its widespread use in medical facilities, which is dangerous because it can be used to make "dirty bombs" • Needs more investment into research for the reuse or recycling of the cobalt-60 pencils after it reaches the end of its lifespan
Microwaving	• More environmentally friendly • Can help reduce the waste volume as it processes the waste	• Small scale operation only • Higher cost in the long run since it can only treat small batches of waste at a time • Needs shredders to make waste smaller before treatment • Needs waste to be wet • Cannot completely and properly sterilize waste
Other		

Landfill	• Common method • Simple and straightforward concept • Workers do not need highly specialized training • Low cost • Can be effective if well managed with proper protocol and legislation	• Most are not properly managed and many countries do not have effective protocols and legislation to keep landfills in check • Soil and water contamination • Landfill leachate • Foul smelling gases from the decomposition of medical wastes • High possibility of having nonhazardous and hazardous medical wastes all mixed together
Reuse and reprocess	• Economically and environmentally practical • Effective in treating certain types of medical wastes that are reusable, such as trays, gowns, some catheters, scalpels.	• Needs another medical waste treatment method to help in disinfecting and sterilizing the reusable materials. • Can only be used for a small niche of items • Depending on the effectiveness of the disinfection and sterilization method, risks of microorganisms surviving are present

Recycle	• Economically and environmentally practical • Helps reduce waste that will otherwise be thrown in a landfill or treated with another method that will cause problems to the ecosystem and biota	• Only works for certain types of wastes • Lots of legal and logistical requirements in medical or treatment facilities that render this method ineffective in the big picture

Why is medical waste such an important topic in today's world? This is because as the world progresses, the medical sector also has to keep up with the progression. With progression usually comes more waste because of the amount of new people coming to terms with using the new developments and new problems arise with how to handle the by-products of production and the post-treatment of the used items.[12] The consequences of medical waste disposal are many and can cause global health and environmental problems if not properly managed. People will often argue that only 15% of medical wastes are considered hazardous, therefore disposal treatments of medical wastes should not be such a big problem. This is far from the truth because the other 85% of medical waste that is considered nonhazardous can cause as much problems in their disposal treatments as the 15% of hazardous wastes.[49]

Many of the previously discussed methods of medical waste treatment produce a lot of by-products during their processing that are harmful to the environment and biota. In fact, these by-products are some of the greatest pollutants to the environment. Pollution causes many global issues, such as acid rain, smog, contributes to the greenhouse effect, and can be the underlying cause to diseases, cancer included.[50] Landfills and incineration are known to produce furans and

dioxins which can cause different types of respiratory problems and cancer.[38] Other gases that are produced from medical waste disposal and treatment include sulfur dioxide, carbon dioxide, carbon monoxide, and nitrogen oxides. These gases are related to global warming which has become a pressing matter in the recent years.[51,52] Some studies have shown that with average temperatures rising overall, more people are suffering from heat related hospitalizations or deaths, especially the older generation.[53] Other studies have also shown that global warming has caused more parasitic diseases to appear in regions where they have never been detected before.[54] This may not seem like a big issue since many can argue that travel has become very convenient which can cause the transport of different diseases and parasites to different areas of the world. However, the parasites arrived at the regions where they were never seen before, it can be agreed that the fact they can survive in new ecosystems means that global warming really does make a difference. It also means that the balance of the biota and ecosystems in different areas of the world can and will be disrupted.[54]

The consequences that follow the treatment and disposal of the 15% of medical waste that are considered hazardous are also very important to discuss, as they are very detrimental to the health of the general public, the environment, and the biota.[12] The consequences have some similarities when comparing medical waste treatment and disposal in developed and developing countries, but there are also differences in the way that these consequences occur or effect the people and the environment.

In developed countries, treatment and disposal of hazardous waste also produce a lot of pollutants into the environment. One problem with the developed countries is that there are less limitations to access medication that are prescribed by medical personnel. This means that there are more medications that are in circulation in society.[55] Unfortunately, most civilians are not well educated on how to properly

dispose of expired or unnecessary medications in the homes. Many throw them out in the trash with all the other wastes produced in the homes. These will go through the disposal process of choice of the city or county in which the civilians live. Depending on what the disposal method is, these disposed medication could end up in landfills or be part of the pollutants being emitted by incinerators. If the household medications find their way to the landfills, there is a risk of them dissolving in liquids and seeping into the soil and the water sources around the landfill. This will be a tricky pollutant to the biota in the ecosystems nearby and could cause medical and growth problems down the line.[56]

There are also those who dispose of their unwanted medication by flushing them down the toilets. These medications will end up in the city's water ways of the water supplies and can potentially cause whatever microorganisms are in the water or whoever drinks the water to develop unwanted antibiotic resistance. Down the road, this will cause more problems because other ways of dealing with microorganisms will have to be developed, or patients will not be able to take certain medication because of their decreased ability to work in the bodies.[57,58] So, even though developed countries may have less issues with the more common treatment and disposal methods due to more advanced technology, their openness and lack of barriers can cause medical items meant to help the population become another hazard to the ecosystem and biota.[12]

In developing countries, disposed hazardous wastes also pose big threats to the population, ecosystems, and biota, but in different ways. Many developing countries do not have proper legislation and execution of protocols that are meant to help protect the people and environment from medical wastes.[61] Much of the population do not have the knowledge or lifestyle means of properly disposing of any types of wastes. Medical facilities do not have the right training or enough funding to be able to treat their medical wastes and dispose of them correctly and

safely. Even if there were medical waste treatment and disposal facilities, workers are not well-trained, the funding is too low to upkeep the facilities, and there is not enough investment in trying to minimize the pollutants and by-products that these treatment and disposal facilities produce.[12,62] A lot of hazardous medical wastes find themselves dumped in municipal landfills along with all the other types of waste produced from all sectors of society. This means that used needles, blood samples, anatomical waste, and infectious samples could all be in the landfills mixing with other wastes.[59] Many civilians in developing countries frequent the municipal landfills to scavenge for things they can potentially take and sell for a little bit of extra income to help with the family, so having these hazardous medical wastes laying in landfills with all the other wastes poses a threat to these people.[63] The used needles could potentially hold infectious diseases such as HIV, and if the civilians scavenging are pricked with the infected needles, they would have a high risk of contracting the diseases.[60] At the end of the day, all of these issues point to problems at the national level with unclear and improper policies and legislations from the government, and no one to execute them when necessary.[64,65]

The past few years have been trying years in all aspects of life for all the nations of the world, no matter if the countries are considered developed or developing. The challenges can be attributed to the outbreak of COVID-19 all over the world, quickly turning into a pandemic. While many focus on the extreme lifestyle changes and the economic challenges both locally and globally, much of how COVID-19 has influenced the environment, ecosystems, and biota have gone under the radar for most people. It should not be a surprise to anyone that because of the pandemic, there has been an extreme increase in the use of many medical equipment and also personal everyday protection products.[12] Medical facilities use more protection equipment such as face masks, gloves, single-use protection gowns, COVID-19 antigen tests, and swabs. Civilians also produce a lot more medical waste mostly in

the forms of face masks and gloves.[66] This has put a lot of pressure in most countries on the medical waste treatment and disposal facilities, many of which have had to run at maximum capacity for the last few years and still have not been able to fully mitigate the problem of medical waste increase. It goes without say that by running the disposal facilities at full capacities, the harmful by-products increase and pollute the ecosystems and effect the biota.[67] This will continue to be a global problem and leadership needs to invest in the best ways to take care of all the extra medical waste but also minimizing the detrimental effects of the processes on the environment, ecosystem, and biota.

Every country will have its own specific challenges in how they execute the processes of treating and disposing medical wastes. Developed countries have their types of challenges and developing countries have theirs, but the common goal should be to find the most efficient and effective method of disposal of medical wastes that also minimizes the harmful effects it has on the people, ecosystems, and biota of the area. The future of our planet depends on developing innovative solutions to this problem of medical waste disposal. Too many harmful effects are connected to this global problem: global warming, greenhouse effect, contaminated soil, contaminated waters, polluted atmosphere, destruction of the ozone layer, destruction of natural habitats, biota endangerment, and increased human health crises. There needs to more investment into innovative methods of medical waste disposal so that medical waste of all kinds can be disposed of properly and the ecosystem, biota, and population would not be harmed by the extreme amount of detrimental by-products produced throughout the processes.[12]

Chapter 2: Theoretical methodology

In order to see firsthand how certain medical wastes could affect our environment, the ecosystem, and the biota with which we share the habitat, there are certain principles and methods that are foundational and important to learn and understand. A few of these will be discussed in brief and then an overview will be done with a couple examples to illustrate the process and importance of these types of indicator values and experiments.

Dose-effect: "The dose-effect relationship is the relationship between the dose of harm-producing substances or factors and the severity of their effect on exposed organisms or matter."[104] What this means is the fact that with an increase in the dose, the level of damage to the organism, or other parts of the ecosystem increases. This dose-effect relationship is observed at all levels of the organization of living matter: from molecular to population.[105]

EC50: EC50 is the median effective concentration. What this means is that this is the concentration of the substance that we are testing which will kill 50% of the test population organisms, such as algae or Daphnia.[106]

IC50: IC50 is the concentration of a substance that will cause 50% inhibition of the test subject. It is essentially a measurement of how effective a drug is in inhibiting certain biological or biochemical functions or processes in an organism.[108]

NOEC: NOEC is the "No observed effect concentration" where this is the concentration of the substance that will not induce an effect in the test subjects.[106]

Pharmaceutical wastes are a type of medical waste. Pharmaceuticals are meant for human consumption and sometimes, animal consumption as well.[107] There are thousands of different kinds of pharmaceutical substances being used worldwide everyday.[109] Even though these drugs are meant for human and some animal

consumption, there are a lot of other organisms that can accidently become the target of these pharmaceuticals if they are released into the environment.[110,111] Traces of pharmaceuticals are also often found in sewage treatment facilities, and though the concentrations are not high and probably will not be any harm to humans, they can be detrimental to the non-target organisms who come in contact with the substance or live in an ecosystem that will come into contact with the substance.[107] Another point as to why it is important to minimize the amount of pharmaceuticals in the environment is because rarely do these drug exist as single compounds, but most are found as complex mixtures. Due to the fact that no one can predict how each of these complex mixtures will affect the soil organisms and aquatic organisms, it is important to try and understand.[112]

Most pharmaceutical drugs are soluble in water. Once the drugs are in the environment, as long as there is some moisture around, it can dissolves and be absorbed by the soil or become part of the aquatic system. Of course, every drug is different and how it reacts in the environment will differ based off of its polarity, solubility, pH, and the soil type or water type will also play a role in the variety of ways drugs can react and be dispersed in the environment.[113] As the pharmaceuticals travel in the wastewaters, they will come across sewage treatment facilities. If the sewage treatment facilities are not able to eradicate the drugs, then they will continue to travel down into the natural aquatic environments such as rivers and lakes. Eventually, they could end up back in the drinking water.[114] In many studies and experiments, only the acute toxicity of the drugs are tested on the organisms, but what is also important to study are the long term effects these drug could have on different organisms. Detectable traces in the environment does not always show the true concentrations, therefore, it would be wise to study the long term effects so that there can be an understanding of how pharmaceuticals can effect the organisms and what steps need to be taken to prevent the release of these

detrimental drugs into the environment.[111] Below will be some discussion on how different types of pharmaceutical drugs can affect organisms in the environment.

Non-steroidal anti-inflammatory drugs (NSAIDs) take effect through the cyclooxygenase enzymes (COX-1 and COX-2) inhibitions which are part of the process of making different prostaglandins from arachidonic acid. Some fish have been found to also have this cyclooxygenase enzyme, which means that if the fish is living in an environment with NSAIDs, the fish would not be able to make and release prostaglandins. Another organism that could be effected are birds, because prostaglandins also are involved in the making of the eggshells of birds.[107] Anti-inflammatory drug such as ibuprofen also show some detrimental effects to non-target organisms. They can accumulate in different organs, causing lesions in different types of fish such as trout and zebrafish.[112,115] Ibuprofen is also known to change the spawning process in some Japanese fish.[115] For bacteria, algae and mollusks, ibuprofen is considered toxic. This is not always a bad thing, since sometimes it is necessary to kill infectious agents such as bacteria. Ibuprofen causes cyanobacteria to grow though, and inhibits duckweed and algae.[107] The drug, paracetamol has been found to be not toxic to the bacteria V. fisheri that had an IC50 (inhibition concentration) of high than 550 $mg\ l^{-1}$.[115]

Antibiotics are an enormous type of pharmaceuticals that are very common in use in the human and animal world. These drugs are mostly all soluble in water. The biggest concern with these types of pharmaceuticals is the bacterial resistance that could occur, or the cross resistance between different types of antibiotics. If found long term in the environment, it is a risk that certain microorganisms will develop resistance to the drugs. If a person or an animal developed a sickness that needed a certain type of antibiotics, but the cause of the sickness was resistant to the drug, then that would be a big problem. In normal situations, antibiotics are known to be able to do organic damage on microbes.[115,116] Antibiotics can be excreted

through urine and feces, so in certain cases where agricultural animals have to take these types of drugs, they are known to be excreted and accumulate in the soil. Antibiotics are very mobile in soil and in water, so once on the ground, they can travel into groundwater, or be flushed away with surface water.[107] Since antibiotics can kill some microorganisms, it is risky for there to be concentrations of antibiotics in the aquatic ecosystem. Its toxicity could eliminate primary producers, which could potentially result in an elimination of a whole section of a food chain.[117] A group of antibiotics that are commonly taken by humans are called sulphonamides. These types of drugs will stop the growth of chrlorophyll in algae and duckweed. This is important to understand and prevent this from happening because these organisms are the foundation, the beginning of the food chain. Any sort of decrease in their population would throw the rest of their ecosystem into disarray.[107]

Steroids are pharmaceuticals that can disrupt endocrine compounds and mess with the hormones in the body. The processes they can interfere are homeostasis, reproduction, behavior, and development. Quite a few of the drugs that make its way into the environment have these types of endocrine disruption properties. In aquatic and land ecosystems, they can accumulate in fish, different reptiles and amphibians, and mollusks. These organisms are sensitive to these steroidal compounds and they can have long term effects on the organisms.[111,115] Another problem with this accumulation in organisms is that if humans are to eat them, the steroids will enter into the human's body and effect the human in that way.[107] Below is a table with that summarizes some of the potential effects low concentrations of steroidal drugs can have on organisms in the ecosystem.

Table 2.2. Effects of steroidal drugs at low concentration on organisms in the ecosystem.[107,111,112,115]

Pharmaceutical drug	Effect on organism	Organism (non-target)
17-α-ethynil-estradiol (EE2; estrogen) Levonorgestrel (gestagen, progestin) Equilenin (estrogen) 17-β-dihydroequilenin (estrogen) Trembolone acetate (androgen)	Decrease: fertilization success, expression of secondary male sex characteristics Abnormal testes and malformation of the sperm duct, Reduction of spermatozoa number Altered oogenesis in females Increase egg production and mortality rate.	Fathead minnows (Pimephales prometlas), zebrafish (Danio rerio), Japanese medaka (Oryzias latipes)
Flutamine (antiandrogen)	Adult male spermatogenesis is effected Courting and nest building behavior altered	Guppy fish (Poecilia reticulata)

17-α-ethynil-estradiol (EE2)	Alteration of tadpole metamorphosis, sex ratios, and sexual development in the males Abnormal gonads Also large numbers of intersex	Northern leopard frog (Rana pipiens) Amphipods (Hyalella azteca)

Anti-epileptics, beta-blockers, and antidepressants are all types of pharmaceuticals that are involved in the functions of the central nervous system (CNS). They are known to be persistent drugs and help to regulate behaviors and moods. Although used to help humans in a good way, it was shown to affect some organisms in the aquatic ecosystem in a bad way, altering their reproduction patterns.[114]

Carbamazepine will cause acute toxicity in aquatic organisms such as duckweed, green algae, and marine bacteria. In crustaceans, it will affect their reproduction and mortality. In the rainbow trout, carbamazepine will change liver, kidney, and other tissue structures which could potentially alter the way the fish lives or lower its quality of life. In the zebrafish, this drug could be fatal.[111,115,118] Carbamazepine usually have relatively low mobility in soil that are organically rich, but studies have found that its mobility increases in soil that is not organically rich.[113] With its low degradation properties, this drug can be found everywhere in the environment for a long time.[107]

Beta-blockers act pretty much according to their name, they block and inhibit beta-adrenergic receptors in the central nervous system. Fish also have beta-

receptors in their hearts and reproductive system. Long term effect of this type of drug in these aquatic organisms could range from structural changes to altered egg production.[107] Propranolol is the drug in this category that has the highest and biggest effect on organisms – it causes both acute and chronic toxicity in Japanese medaka fish and different types of crustaceans.[107,119]

Antidepressants are some of the most widely used drugs in this day and age, with the selective serotonin reuptake inhibitors (SSRIs) to be the most common antidepressants. As their name suggests, they inhibit the reuptake of serotonin in the brain. This allows for serotonin to stay longer in the brain, thus allowing for the uplifting of the person's mood. A lot of SSRIs are biodegradation resistant so they tend to stay in the environment for a long time.[107] Below is a table summarizing the effects that antidepressants can have on various organisms.

Table 2.3. Effects of low concentration antidepressants on non-target organisms.[111,112,114,115,120,121]

Organisms	Effect
Crustacean: Dapnhia magna, Cerodaphnia dubia	Increase mortality Stimulates reproduction Decrease ability to move and broods per female
Mussels: Dreissena polymorfa (zebra mussels) and dark false mussels	Spawning and oocyte maturation are influenced.

Freshwater mudsnail: Potamopyrgus antipodarum	Decrease in reproduction
Fingernail clam: Sphaerium striatinum	Parturition and metamorphosis are stimulated
Algae: Chlorella vulgaris, Pseudokirchneriella subcapitata, Scenedesmus acutus	Inhibits growth Cells get deformed
Nematoceran flies: Chironomus tetans, C. riparius	Growth is inhibited Increase in clutch size and egg cell proliferation rate Emergence decrease
Blackworm: Lumbriculus variegatus	Asexual reproduction Increased reproduction rate
Fish: Gambusia affinis (western mosquitofish)	Development of mature sexual form is delayed Lethargic
Fish: Oryzias latipes (Japanese medaka)	Accumulation of drug in tissues Abnormal developments Estradiol level increased in females Increased half life

Another type of pharmaceuticals are lipid regulators. These are used to decrease the cholesterol and triglycerides in the blood. The two main types of lipid regulators are statins and fibrates. Statins work by enzyme inhibition that is part of cholesterol synthesis feedback process. Fibrates work in catabolism, differentiation, and metabolism of fat.[107]

Statins alter the development of grass shrimps and marine phytoplankton. They are also able to decrease the juvenile hormone creation in insects.[115] Fibrates can have a lot of detrimental effects on many different organisms. In rodents, fish, and amphibians, they can block the development of embryos. In daphnids, bacteria, and algae, they can decrease proliferation. They can change the body shape of certain fish species. They can accumulate in the organs of certain fish and cause crustaceans to become immobile. Fibrates can definitely cause a lot of problems to the biota in the ecosystem.[109,111,112,115]

There are still many other types of pharmaceuticals in circulation that can cause great harm to the ecosystems and the biota within them. It is important to continue to learn and understand the effect medical wastes can have on the environment. Since most people do not know the harmful effects of this type of medical waste, many dispose of them in the garbage or down the toilet without a second thought. Increased education and awareness on this matter would be beneficial for everyone, but there should also be stricter legislation concerning these wastes.[107]

In another study by Damasceno de Oliveira et al, acetaminophen, chlorpromazine, diclofenac sodium and propranolol were tested on Daphnia magna so see what the acute toxicity and the chronic toxicity would be in this organism when in contact with these four drugs.

For the acute toxicity, there were two types of glass tubes, one type that had 10mL of test solution and the other type have 10mL of a negative control which was clean ASTM medium. Daphnia were separated into four groups of five for each

treatment. The study used six to seven different test concentrations. The researchers had to run bioassays in order to find the right EC50 values from the fit dilutions. The concentrations that the study used were 1.2–9.0 mg L^{-1} for acetaminophen; 0.50–3.14 mg L^{-1} for chlorpromazine; 52.0–155.3 mg L^{-1} for diclofenac sodium and 4.0–11.9 mg L^{-1} for propranolol. They allowed the test to run for a total of 48 hours, then they counted the dead organisms and recorded the data.[122]

The results of the acute test showed a very visible and consistent dose-effect response where when the concentrations of the drugs increased, the percentage of immobilized organisms also increased. The EC50 are as follows: chlorpromazine (EC50=1.81 mg L^{-1}) > acetaminophen (EC50=2.83 mg L^{-1}) > propranolol (EC50=5.53 mg L^{-1}) > diclofenac (EC50=123.3 mg L^{-1}). With this result, it can be seen that the Daphnia reacted more drastically to the chlorpromazine, only needing 1.81 mg L^{-1} to immobilize half the population of the organisms in the glass tubes. The Daphnia were least sensitive to the diclofenac, which needed 123.3 mg L^{-1} in order for half the organisms to become immotile.[122]

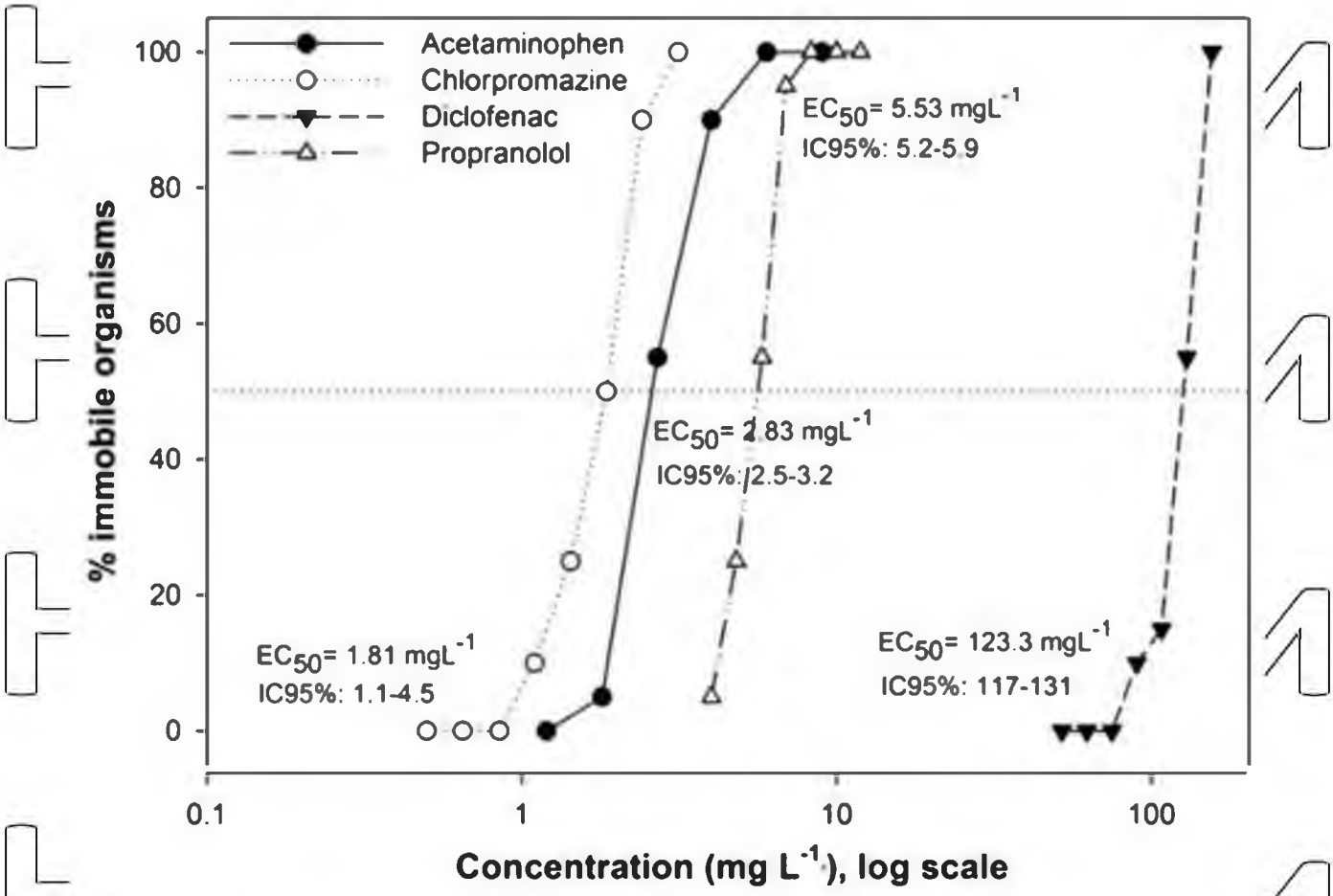

Figure . Acute effect of the four pharmaceuticals on Daphnia after 48 hours.[122]

The chronic toxicity test took 21 days, using randomly chosen Daphnia organism in two different types of solutions (control and different concentrations of test solution). For the duration of the 21 days, the Daphnia had daily transfers to fresh drug dilution beakers, they were fed their normal feeds, and the researchers checked on them daily to record deaths and reproduction. The results showed that there was significant loss in reproduction in the beakers that had chlorpromazine and propranolol. For the other two drugs, acetaminophen and diclofenac sodium, not a lot of changes were observed like for the previous two drugs.[122]

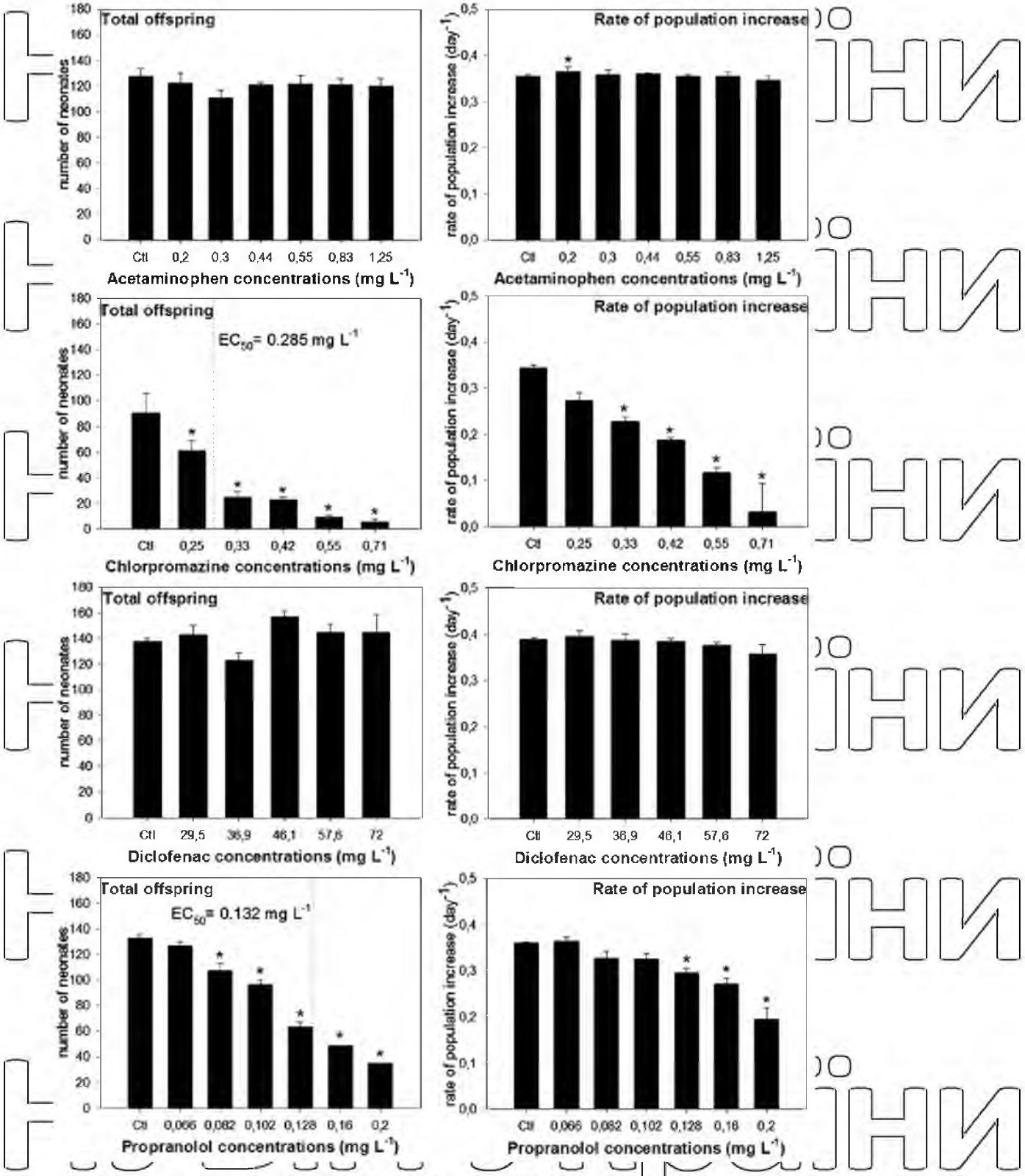

Figure . Responses of Daphnia to the four pharmaceutical drugs over a 21 day period (chronic test)

There are a few things to be learned from this study. First, even though there were some significant results obtained from this study, it must be reminded that the concentrations used in these experiments are much higher than those found in the natural ecosystems. So, while in this study, the Daphnia reacted very sensitively to chlorpromazine and propranolol, the concentrations were in mg L^{-1}, while in the natural ecosystem, the concentrations would most likely be in the ng L^{-1}, which is much less than in the experiments. Second, although the concentrations for propranolol were high in this study, other works have shown that different organisms that are not Daphnia can react quite significantly to these beta-blockers, even in small concentrations. Third, diclofenac was the drug of least worries for the Daphnia in this study. The concentrations used was much higher than that found in the natural environments.[122] And lastly, even though this study used significantly higher concentrations of drugs in order to show results, it cannot be downplayed. These studies are models for the real world, they answer the what-ifs and can educate the population on the adverse effects medical drugs can have on the environment if we are not careful. This study can show that if the general population and even the medical facilities do not learn to properly treat and dispose of waste such as pharmaceutical drugs, then slowly but sure, the improperly disposed drugs will start to harm the biota in the ecosystem.

Chapter 3: Analysis of the production of medical waste in the conditions of martial law

Armed conflicts are known to cause a myriad of problems. It has the ability to dramatically change the world in which we live, in all aspects of our lives. Militaries use weapons that are a great hazard to not only infrastructure and the innocent citizens but also to the ecosystem and the environment. Many weapons leave holes of various sizes all over the battle fields, shrapnel and other contaminants cover the environment, and the loud explosive sounds cause extreme noise pollution to the surrounding ecosystem. Habitats are destroyed or altered, the environment becomes more polluted, landscapes are destroyed, biota and humans are displaced, and poaching also becomes a concern. All of the points mentioned above are what we usually automatically think about when we hear about the reality of wars, but we seldom consider the medical waste aspect of armed conflicts. With war comes a greater demand of medical services and resources, but this also means an increase in the medical wastes that are produced. Medical wastes are also big sources of pollution and contamination to the environment and, therefore, should be more closely monitored and have proper disposals, even during conditions of martial law.[68] Below are examples of war-torn countries and regions and how medical care and wastes in these areas are handled.

The first war-torn country to be discussed is Syria. Syria's civil war began in 2011 and continues on in the present. This war has caused a multitude of issues, but we will focus on the medical care and waste aspect. Since the start of the war, more than thirteen million people have lost their homes whether due to destruction or having to evacuate to safer areas. Many of the Syrian refugees have gone to the coast or entered into bordering countries in search of safety. This means that wherever the refugees have gone, demand for all kinds of services have increased, which can lead

to many problems such as overcrowding, invasion of biota habitat, or overuse of resources.[69,72]

Some of the biggest problems the civil war has caused is the lack of access to quality health care and the absence of proper medical waste treatments. With war ravaging the country and even sometimes spilling into neighboring countries, safe and stable locations for hospitals are hard to find. Even when a hospital is set up, there is not enough equipment and space to provide all the necessary services (such as x-rays and surgical procedures) and proper disposal of the different types of medical wastes produced. Many hospitals are movable, either borrowing farms or schools to set up a temporary medical facility, or using collapsible tents to set up in caves found in the mountains. The type of location and how often the hospital has to move play a big role in how the medical wastes are managed. In locations where there is enough space, medical wastes can have the proper containers or spaces to be separated, then later taken to be properly disposed at disposal facilities. But in locations that do not have enough space (such as mountain caves), the medical wastes are all thrown into the same container to minimize the need for extra equipment and containers in the small spaces. This can cause many issues further down the waste disposal cycle, such as cross-contamination, unnecessary injuries to workers carrying or disposing of the wastes, loss of recyclable material and equipment, and improper disposal and treatment techniques. Although the problems are identified, the solutions to these problems are hard to execute due to the volatile environment in which the hospitals are found.[69]

Before the civil war began in Syria, the country's healthcare system was actually relatively stable, comparable to other middle-income countries in the world. But less than 5 years into the war, Syria's healthcare system has fallen apart in all aspects because of many reasons, including hospitals and clinics being destroyed, medical care providers being forced to close down or leave the country, and supply shortages.

In just less than 5 short years, the life expectancy of the country was reduced by twenty percent.[73] The war is now the leading cause of death in Syria.[74] Unfortunately, war doesn't discriminate and since the beginning of the war, medical facilities and medical personnel have all been attacked, with many being destroyed and many healthcare workers dying. This further worsens the medical care availability in the country.[75]

One of the most important aspects of medical care during wartimes is surgery, which is also one of the ways much of medical waste is produced. This also happens to be a part of the medical care realm that becomes very limited in developing countries or countries in the middle of a war.[76] Because of attacks on medical care facilities and medical care personnel, this creates an even bigger limitation of access to necessary surgical care.[77] Studies have shown that more and more civilians are dying in Syrian due to the inaccessibility of medical care because of the war.[78] Local healthcare facilities and international nonprofit health organizations continue to work tirelessly in an effort to keep the availability of surgical care opened to those who need it, but it is a difficult task since no one can promise safe environments to set up medical facilities.[69]

Ever since the war began 2011, the state of the country's waste management has deteriorated, which means that medical waste treatment has also worsened.[79] Due to the war, infrastructure have been destroyed, civilians are forced from their homes, displaced to try and find a safe place to stay while the war rages on, people have resorted to looting, and people are literally fighting for their lives.[80] Because of all these problems resulting from the realities of war, waste treatment and management suffers, and in some areas even become almost nonexistent.[81] Even with the war, the country continues to develop in urbanization and the population growth continues to increase. This has exacerbated the waste management problem in the country because more and more waste of all types are being produced, while

the waste management facilities have not been able to keep up.[82] Landfill dumpsites are not properly managed and controlled so most of the waste produced are simply thrown into the sites and left there with no further treatments. Both hazardous and nonhazardous waste are thrown in the landfills together with no regard to the ramifications of these actions. The result of disposing of hazardous and nonhazardous waste all together in the same dumpsite is pollution and contamination of the water, soil, and air in the region.[83] This is not only because of the war, but also because of the lack of knowledge and resources to properly train personnel, educate the public, and not enough financial investment is made in this sector to provide the correct and necessary equipment for the proper handling and processing of the wastes.[84] Now, with the addition of a full fledged war ravaging the country, the waste treatment and disposal services have fallen apart to the point where huge amounts of waste are simply thrown into the streets with no one to properly dispose of. Because of the sheer amount of waste lying around the streets all over the war-torn country, many cities have started to openly burning the waste just on the streets or continuing to dump all the waste in the landfills with no concrete plans on how to further treat and dispose of them safely.[85]

Before the war began, the Syrian government had a relatively solid system operating for their waste management in the country. They had environmental laws that included instructions and protocols that had to do with waste management, and also had the penalties and sanctions for anyone who violated the laws. They also had laws that touched upon cleanliness to support the environmental laws. These detailed the different waste types that the country can produce, how to categorize and separate them, treatment and disposal methods for the different waste types, and also included penalties for those who did not follow these laws.[86] A few years before the war, the Syrian leadership decided to set up directorates in various cities across the country that would oversee the waste management of each city. The directorates

had many responsibilities, but some of the main ones included supervision the transportation of waste to their designated treatment and disposal facilities, finding sources of financial support in the forms of loans or grants, observing the whole process of waste management in order to be able to draw conclusions to what is working well and what needs to be fixed and be able to articulate and update that to the higher ups in order for new or updated legislation to come into place, and supervision of the councils in the cities that were in charge of working the waste treatment and disposal management processes.[87]

There was actually a good system and hierarchy implemented before the war which will be detailed below (and in Figure 1). The prime minister oversees the entire country and therefore, needs to delegate the work down to other specific councils or administrations. There are three main ministries and councils that work together to oversee waste management and environmental safety, which are the Ministry of Environment, the Ministry of Local Administration, and the Higher Council for Environmental Safety. The Ministry of Local Administration oversees the governates, who are responsible for supervising the councils and offices of the cities, or town, or villages that are under the administration of the governate. The governate councils also need to make sure that the regional waste management strategies are working smoothly. The councils of the cities, towns, villages, and rural units are then responsible for the local waste management implementation. They are also in charge of the finances of waste management in their area.[87]

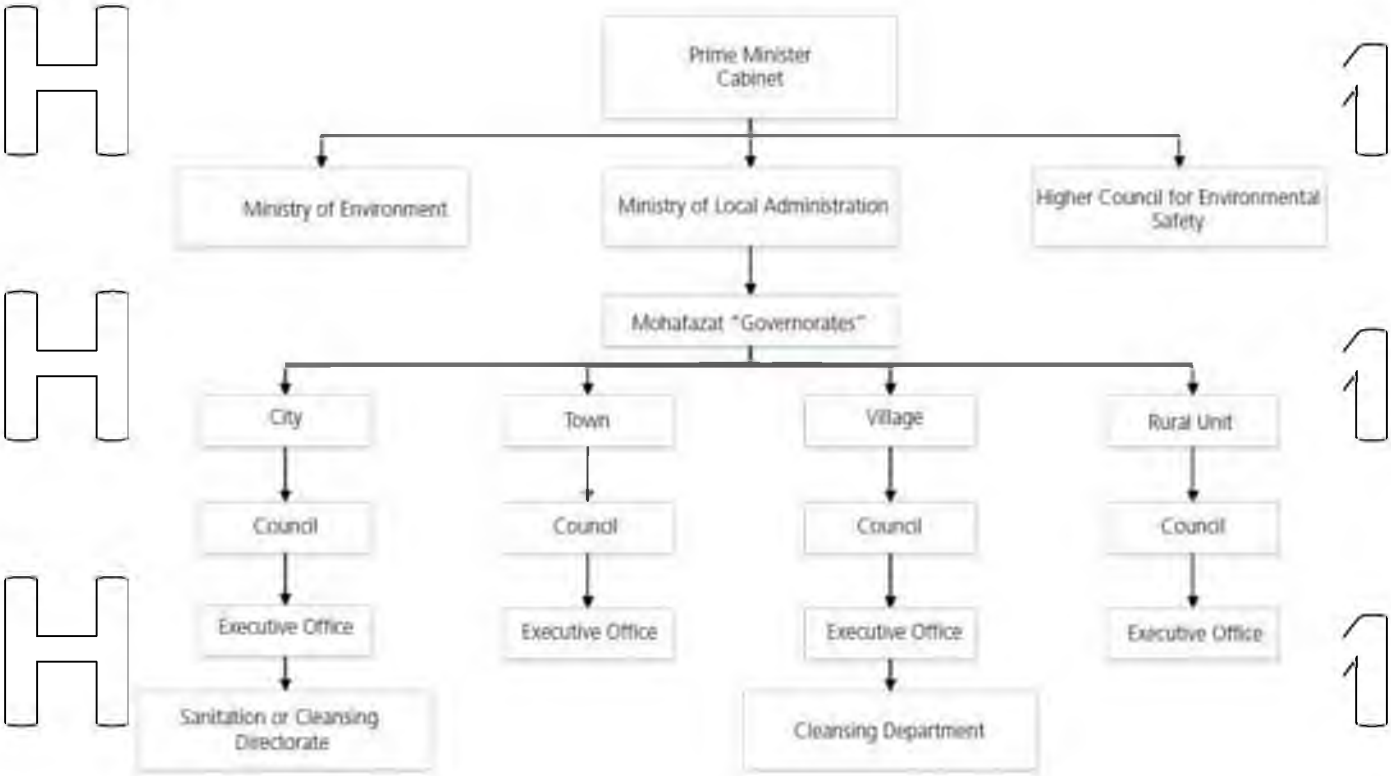

Figure 1. Breakdown of the hierarchy of organizations and administration in charge of waste management in Syria.[88]

Unfortunately, this whole organized system fell apart due to the war that began in 2011. Many of the organizations listed above had to shut down or relocate depending on the specific situations in each city. There were even reports that some of the officials and workers in these organizations and administrations were kidnapped or killed. Since the war is still technically ongoing, Syria needs time to adjust, recover, and pick things back up again to implement the necessary steps to return back to normal.[79]

Noufal MJ and team conducted some waste management research in Homs, Syria, one of the country's largest cities, and was a rapidly developing industrial center in Syria before the war broke out. They found out how the waste treatment and disposal system really works from the ground, and not just according to the laws, regulations, and the higher up officials.[79]

In the city of Homs, containers are put in set locations across the city for people to throw their waste in. There are two main problems with this method: there are not enough of these containers in the city for everyone to throw their waste in and for those who live in more rural areas of the city these containers do not exist unless they travel long distances to get to one. For the people that do not have proper access to these collection containers, an alternative practice came into being and has become what is considered common practice of waste disposal in the city. The people simply use plastic bags, collect all their waste in these bags, and when the bags were full, they took them out to the streets and placed them on the roadsides. For some people who live in apartments, there could be designated areas for waste collection, but unfortunately, the common practice in the city is simply to collect waste in plastic bags and leave them out on the roadsides.[79]

There are public and private organizations who are in the business of collecting waste. There are few that provide house collections, but this is not common. The most common form of waste collection is what they call "communal collection system".[79] Similar to many cities around the world, the types of collection services and frequency of their services are all dependent on the area in which the people live. Services varied depending on the demographic of your neighborhood and the geographical location of your neighborhood. Most of the service companies, whether public or private, use different types of trucks for their waste collection: compactor trucks, open trucks, and pick-up trucks. The compactor trucks are more popular to use as they have the function of compacting waste as they go about their collection. This allows the truck to carry more waste compared to other trucks. What type of truck is used in what area or neighborhood also has to do with truck availability, the street conditions of the area, and the financial means for both those living in the neighborhood and the company or organization in charge of the waste collection.[79]

In the current situation, waste collection services are not frequent due to many issues caused by the civil war. This means that most people have no other choice but to leave their plastic bags full of waste out on the sides of the roads. The waste bags could sit out in the open for days at a time before a collection service finally comes around to pick up all the bags. The long interval between waste collection causes other problems. Decomposition of the waste in the bags give off foul odors that make everyday life uncomfortable. Waste bags also attract stray animals to come and scavenge for sustenance, ripping the bags apart and scattering waste everywhere on the streets as they eat. Collection workers do not pick up the scattered trash, only the bags, or what is left of the bags. The result is waste scattered all throughout the streets with no one to clean up.[79]

According to Noufal MJ and team's study, recycling is not an established system in Homs, Syria. As a matter of fact, there is no set system for the separation of the different types of wastes at all. This means that all types of wastes are thrown and mixed together, including medical wastes which could potentially have hazardous materials present. Even though there is no official system for separating the wastes into their waste categories, there is the unofficial system of the civilians. Usually, the poor and needy can be seen rummaging through the waste containers or the plastic bags on the streets looking for anything that is plastic, cardboard, or tin cans. Many even go to municipal waste landfills to carry out their searches for anything that can be recycled. These scavengers then take their collection of recyclable items to some industrial facilities to sell for some money. The fact that this type of recycling is an everyday occurrence means there is a market for recycling, but in reality, this is not something that can be set up overnight.[79]

The final disposal site of the waste collected in Homs is a landfill dumpsite called "Dir Baalba". All wastes are transported and dumped at this place. Even through the municipality had started efforts in rehabilitating this site, there are still terrible odors

coming from the tons of mixed waste dumped there. To manage the increasing amount of waste dumped in the site, open fires are still set which produces harmful by-products that pollute and contaminate the atmosphere, soil, and waters. Since it is such a big site, there is still a lot of soil and water pollution as the waste decomposition leaches into the ground.[79]

Moving forward and looking to a brighter future, there are definitely recommended steps and systems that Syria can implement to achieve a more environmentally friendly and sustainable waste management work. There is a waste management system called the integrated solid waste management, which is known to be quite an effective approach to waste management across the world.[89,90,91] What this system essentially is that it develops a hierarchy to oversee the process, which aims to reduce waste production, invest more in reusing and recycling of items that can be reused and recycled, and using better treatment and disposal methods to neutralize the waste produced and collected.[92] In this type of waste management, the leadership are no longer forced to take on all the responsibilities of waste management, but should look for more coordination and collaboration with other organizations and administrations in the government. They should also be opened to new types of waste management systems that can help solve their waste treatment and disposal problems.[79] More time, money, and effort need to go into the entire management of waste treatment and disposal to have better planning for the operations that need to be carried out and for more workers to be properly trained so they can do their jobs right and teach others to do their jobs right. This makes the job easier for the managers and overseers, which means they can spend more time planning and searching for more financial support. They should also have systems in place for data collection that can help with analyzing the whole waste situation in the city, analyzing the waste composition, predicting how much waste will be generated based on trends and patterns in the data, and always looking for ways to

improve equipment and execution plans for efficient and sustainable waste management.[79] Through their research, Noufal MJ and team have constructed a system that could be integrated into Syria's waste management system to improve their current state (Figure 2).

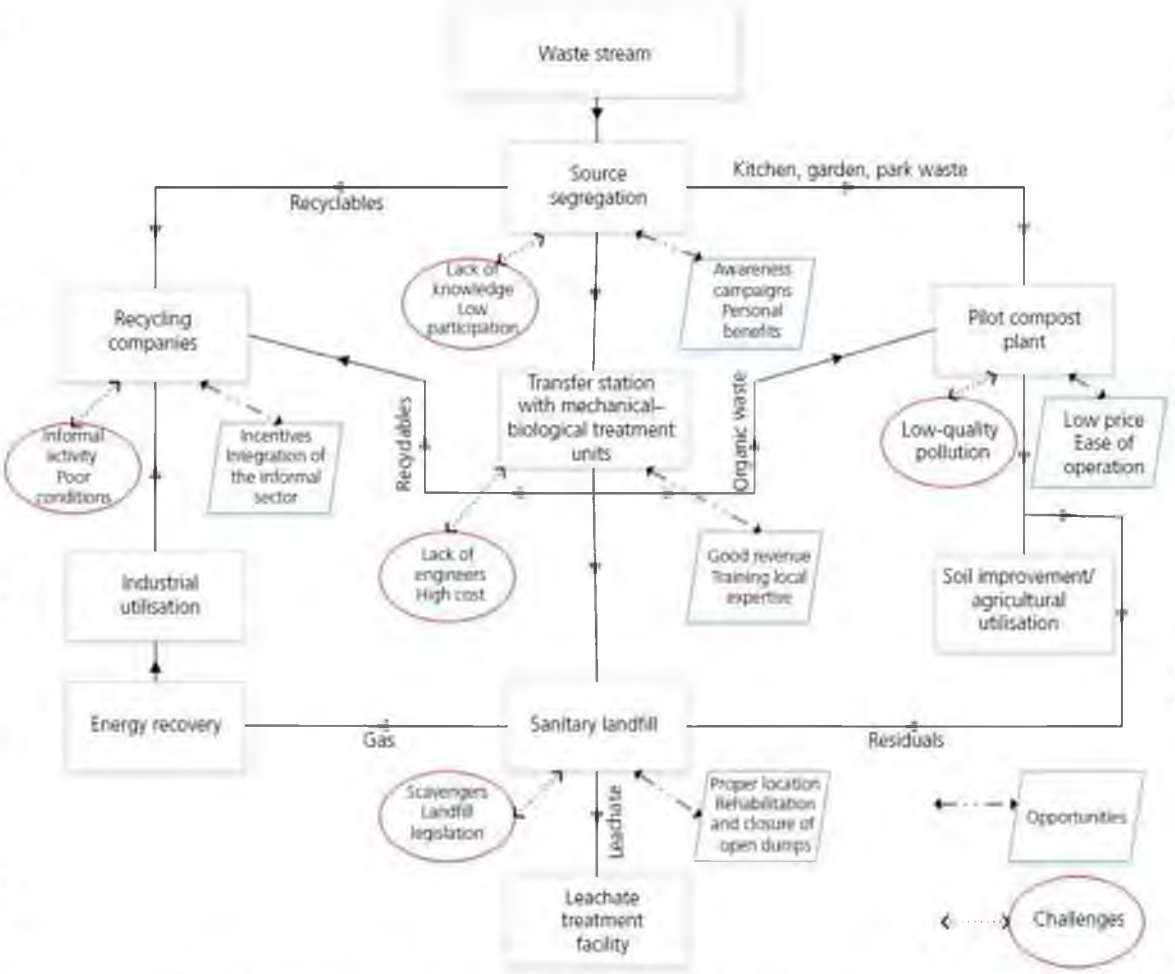

Figure 2. Proposed system framework for more effective and sustainable waste management in Homs, Syria.[79]

In conclusion to the analysis of waste management in war-torn Syria, there is hope for a more sustainable future if they are willing to put in the time, money, and effort. It is understandable that in the midst of war, most of the financial resources are concentrated on the efforts of the warfront, but as we all hope the conflicts wane and end, the financial funding need to be directed to the proper sectors in society.

Funding is needed to build more effective and less harmful facilities to treat and dispose of wastes. Funding is needed to employ more experienced professionals to undertake the supervision of waste management. Funding is needed to train more workers to do their jobs properly. There should also be investment in the education of the public in terms of waste control and management and how their lives, the environment, ecosystem, and the biota all depend on how the people's waste treatment and disposal management systems are. Recycling should also be at the forefront of the waste management rehabilitation efforts. In short, there are ways to improve waste management, which in turn takes care of the population, the environment, the ecosystem, and the biota, but it will take a team effort of the whole country to obtain.[79]

The state of the Democratic Republic of the Congo (DRC) is similar to the previously discussed Syria: scarcity of high quality medical care and waste treatment due to war. Something different about DRC is that the area is known to have many more diseases that people can contract. To add on to this problem is the low numbers and accessibility of medical laboratories – even if a person is able to go to a clinic near them, this does not mean all their medical issues can be definitively diagnosed and treated in that same clinic. Hospital personnel need to draw blood and send it off to a facility that has proper medical laboratories to run the necessary tests. Another issue in DRC is the inability to execute proper waste management – this can be attributed to poverty brought on by war, causing civilians to find meager ways of making a little bit more money to survive. They do this by rummaging through waste landfills, which is dangerous because many medical care facilities do not separate their wastes properly before disposing of them, perhaps due to insufficient education on the matter or absence of the necessary space, containers, or disposal facilities. Diseases spread in such a way, land and water contamination increases, and pollution destroys the surrounding environment. There needs to be a huge effort from the

government and the people to turn this negative cycle around, but for the time being, many non-profit organizations have taken it upon themselves to try to start making the positive changes [68,70,71].

The healthcare system in the Congo has always had its fair share of problems. In the 1980s, leadership of the Congo cut the budgets for education and health. Since then, the healthcare system has had to make ends meet themselves.[93] Because the healthcare facilities do not get any financial support from the health ministry, they have to rely on medical consultation fees and medication prescriptions. The money they earn from the medical consultations and prescription of medication are the way they pay the medical facility staff, buy equipment and medication, and maintain their medical facility in general.[71] War has ravaged the country since the 1990s till the early 2000s, but with various parties wishing for more power, healthcare continues to be overlooked.[94]

The healthcare system in the Congo has essentially fallen apart, ranking at 179 out of 191 countries that were surveyed by the World Health Organization.[95] As mentioned previously, the government did not fund the medical sector, which resulted in a lot of medical facilities falling apart both financially and physically, not enough medication in stock to distribute to those who need it, and many of the healthcare workers' salaries went unpaid because there simply was not enough revenue made by the facilities to pay the workers and have enough to keep the medical institutions working.[95] Due to the inaccessibility to proper healthcare, the Congo is known to have a relatively high infant mortality rate and young children under five mortality rate.[96] Mortality rate, in general, has been very high due to the multiple consequences of the wars. Civilians couldn't afford to pay for their consultations or the medications they needed, people were violently killed by shootings, stabbings, or getting hit with explosions or by the shrapnel from the explosives. Women were raped and murdered. In the areas of the frontlines of the

war, people ran to hide in forests or whatever kinds of safe space they could find. Many in these types of situations suffered from parasites and mosquito borne diseases. Constantly living in those kinds of conditions meant that most of these people became malnourished and more easily succumbed to various diseases such as malaria, cholera, or tuberculosis. AIDS and meningitis were also prevalent.[71] As of the early 2000s, as many as 75% of the population in the Democratic Republic of the Congo still have no access to formal healthcare.[97,98]

Many nonprofit organizations have been helping with the healthcare shortages in the Congo since the 1980s, but ultimately, that is not the best sustainable route for the country to continue on.[71] If the country continues to rely on outside help instead of rebuilding its own healthcare system back up, they will never be able to walk out of the shambles that they are in at the moment. Relying on international nonprofit health organizations will only prolong the country's fight to stand back up on its own feet. It is not a sustainable and effective way of healthcare.[71]

With that being said, work on the ground still needs to continue, whether it be from the hands of international nonprofit organizations or from the Congolese themselves. A study was done by Van Herp and team to get a better overall understanding of the state of the healthcare system in the Democratic Republic of the Congo. They surveyed healthcare workers, looked at the mortality rates and accessibility of healthcare in different areas of the country, factored in the reasons for inaccessibility, and looked at the exposure of the people to violence in their areas.

In figure 3, it shows there is a consistent increase in the mortality as the distance to the frontlines of the war closes in. The exposure to violence also consistently increases as the distance to the frontlines decrease. It can also be seen that the access to healthcare decreases as the distance to the frontlines decrease. Therefore, it can be deducted that the closer the frontlines, the higher the violence and mortality, and

the lower the accessibility to healthcare is, but the further away from the frontlines, the lower the mortality and violence, but the more accessible it is to healthcare.[94]

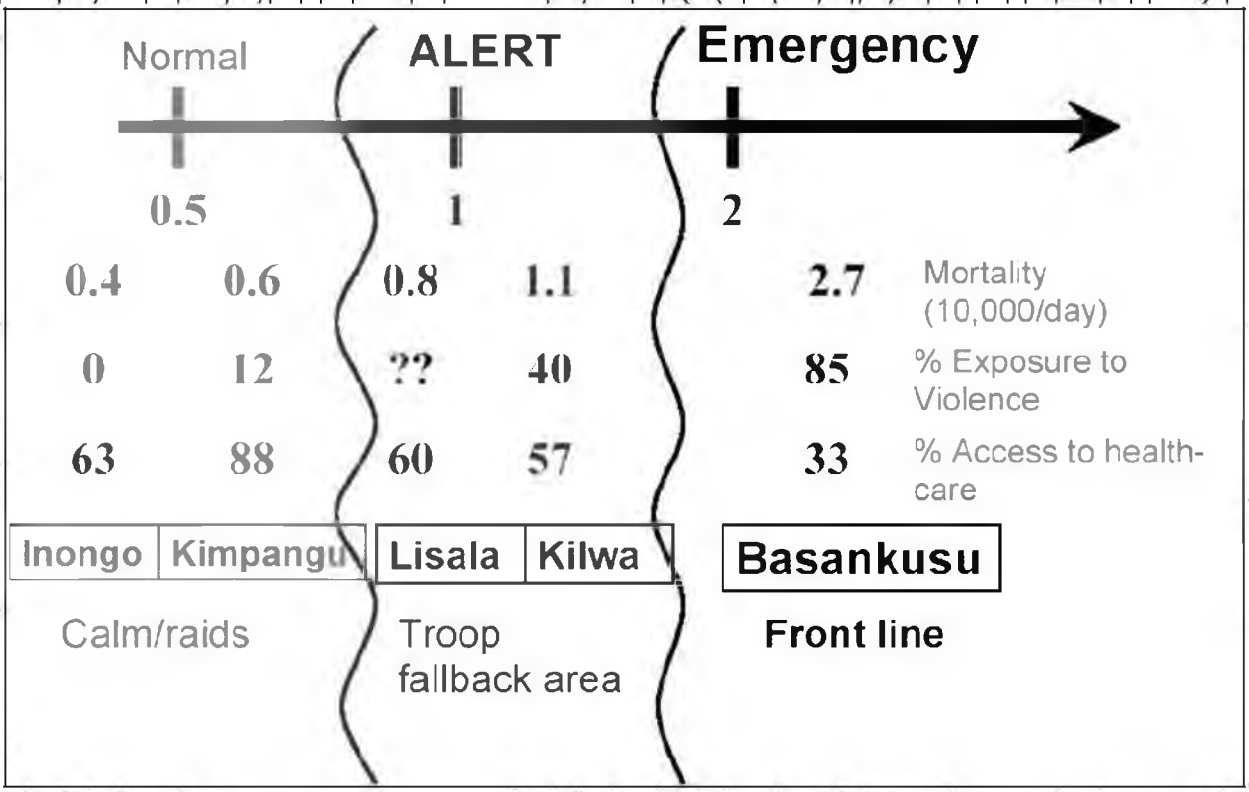

Figure 3. A overview of the mortality, exposure to violence, and access to healthcare in different areas of the country.[94]

In Table 2 below, the survey concluded that the most common reason for people not to have accessibility to proper healthcare is because of the inability to pay the cost of consultation and the inability to pay for their medications.[94] Since these are the two main ways in which medical facilities obtain revenue, it is no wonder they have such a hard time keeping their facilities up and running when most of the people cannot afford to pay for any treatments.

Table 2. Reasons for inaccessibility to proper healthcare [94]

	Basankusu (n=912)	Lisala (n=907)	Kimpangu (n=907)	Kilwa (n=901)	Inongo (n=960)

# households with (or equal) 1 person ill in past 6 months	884 (96.9%)	869 (95.8%)	793 (87.3%)	841 (93.3%)	891 (99%)
# sick who did not seek consultation outside family	322 (36.4%)	207 (23.8%)	160 (20.2%)	237 (28.2%)	198 (22.2%)
Reasons given (often more than one reason)					
Inability to pay for consultation	255 (79.2%)	162 (78.3%)	83 (51.9%)	192 (81.0%)	160 (80.8%)
Inability to pay for medicine	252 (78.3%)	156 (75.4%)	54 (33.8%)	177 (74.7%)	151 (76.3%)
Lack of medicines	151 (46.9%)		2 (1.3%)	14 (5.9%)	23 (11.6%)
Transport/distance	138 (42.9%)	4 (1.9%)	9 (5.6%)	38 (16.0%)	6 (3.0%)
Lack of health personnel	76 (23.6%)	1 (0.5%)		18 (7.6%)	9 (4.5%)
No confidence in health personnel	28 (8.7%)	1 (0.5%)	1 (0.6%)	2 (0.8%)	15 (7.6%)
Insecurity	20 (6.2%)	2 (1.0%)		2 (0.8%)	1 (0.5%)
Consultation not regarded as necessary	17 (5.3%)	18 (8.7%)	87 (54.4%)	23 (9.7%)	90 (45.5%)

While the health care system in the Democratic Republic of the Congo is in shambles and is depending on outside sources of help in that area, the country's medical waste management system is looking quite dire as well.[99] In some previous studies of the medical waste management systems in the Congo, it was

shown that there are high levels of medical waste mismanagement and no substantial strategy to combat this problem.[100] In a recent study done by Mwamba H and team, more can be learned concerning the current situation of the medical waste management system in the Congo.

The study looked at four different hospitals in the Democratic Republic of the Congo and analyzed many different aspects of healthcare from size of the facility to the services offered, to the types of wastes produced, and to the personal protection equipment distributed to its workers.[99] In the four hospitals, the survey found that there were thirty different services offered, such as general medicine, internal medicine, pediatric department, pharmacy, surgery department and dentistry department, to name a few. Nurses produce the more medical waste at 56.6%, while doctors produced around 18.1%, and the rest produced by the technicians, laboratory assistants, midwives, pharmacists, anesthetists, and incinerator operators.[99] Out of these wastes produced, 17.2% was considered anatomical waste, 41.4% was considered infectious waste, and 51.7% was considered pharmaceutical waste.[99] Anatomical waste could be anything from teeth to umbilical cords to fetuses. Infectious waste were mostly culture tubes and culture slides from the microbiology department. Pharmaceutical waste were either antibiotics, empty drug containers, or different types of solute vials that have been used up and simply thrown away. Of course, there were other types of wastes like general paper towels, plastic cups, sharps, radiological films, and bloodied swabs and gauze, but the majority of the medical wastes produced were the three mentioned already above.[99]

It was found that there were not an adequate separation of the different types of wastes produced in the hospitals – only around 25% of the waste were separated and sorted according to their types. The usual color coding system that hospitals use were not used in any of the hospitals in the study (red=anatomical waste, orange=animal waste, yellow=bloods and fluids). Containers for sharp waste such as scalpels were

not used and there was no designated container for laboratory wastes. In most of the hospitals, the anatomical wastes were simply placed in plastic bags and thrown into plastic garbage cans, some with lids, and others without lids. Wastes considered infectious were also put in bags while liquid infectious wastes did not have their proper containers, but were just diluted in bleach and then dumped into the sewage system. Glass slides used in laboratories were disinfected and autoclaved so that they can be reused.[99]

One positive point is that the medical wastes in all the hospitals were collected daily. Though, this is the only positive because after the medical wastes are all collected, they are transported either by hand, trolley, or wheelbarrow out to a designated spot a little ways away from the hospital. Only one of the hospitals had a secure medical waste holding facility and a well-functioning incinerator working onsite. The other three hospitals did not have secure medical waste holding facility, the waste were dumped in an open pit next to the incinerators that did not work properly anymore. These hospital landfills can accumulate all sorts of different medical wastes, which can have the potential to leak into the soil and contaminate the environment surrounding the hospital. A big reason for the inadequate sorting, treatment, and disposal of the medical wastes in these four hospitals is because few workers are trained to actually understand and manage medical waste.[99] It is also important to note here that the religion of certain areas play a role in the types of medical waste produced and collected. For example, one of the hospitals is in an area populated mostly by those who have the Muslim faith. In their culture, it is common for families to want to take their family member's anatomical parts (such as umbilical cords, teeth, or fetuses) to be buried in their cemetery.[99,101]

In conclusion, the medical waste management system in the Congo also needs a lot of improvement in order to become efficient, effective, and not so harmful to the surrounding environment. Because the Congo government does not give any

funding to the healthcare sector, it is hard for the medical facilities to give more budget to the medical waste treatment and disposal system. The same reason explains why hospitals do not sort their medical wastes as fervently as they should, and it is because the more detailed the medical wastes are sorted, the more types of treatment and disposal methods are needed to dispose of all the various types of wastes. The hospitals barely have enough money to pay their employees or upkeep the physical structure of the hospital, they cannot afford to invest so much finances into providing multiple medical waste disposal methods.[102,103]

Unfortunately, because of the lack of funding, the way medical wastes are collected and handled and the way they are disposed create hazards for many involved. There are infectious risks for hospital personnel and patients alike. For the hospitals that transport medical wastes by hand are much more prone to work accidents, such as getting pricked with a used needle or stabbed with a used scalpel. The open storage of the medical waste, which were really just landfills next to the hospitals, pose great threats to hospital workers and the biota in the area. Scavenging animals may come upon the disposed medical wastes, rummage through the bags thinking there is food within, and ingest or get hurt by the contents of the medical waste bags.[99] The medical waste in landfills can seep into the soil or any water source nearby and contaminate the premises. Human health would be at risk in the area, biota and the ecosystem would certainly be affected by the pollution as well. Even with functioning incinerators, the by-products from burning all the different kinds of medical waste would cause serious pollution, myriads of health problems for the population, and destroy the habitats and ecosystem near the area.[99]

It is no surprise that war-torn countries have more medical and waste problems and a harder time implementing the necessary solutions. Although many non-profit organizations and countries can step in to help a little, a real turnaround can only happen if people from every level and sector of the country work together to make

the changes. Medical care needs will only increase as war rages on, which means medical wastes production will continue to multiply. There needs to be proper separation, disposal, and treatment for medical wastes because of the potential hazards they may cause to people and the environment.

Conclusions:

With the continuous development of the different aspects of society, the medical sector is one that is often overlooked or underappreciated. It is a hugely important part of society that can have enormous impact on lives, the environment, ecosystem, and the biota. It is crucial that everyone recognizes the influence the medical sector can have in all aspects of life.

As the literature review has already shown, there are many different types of medical waste disposal methods. Among them, incineration, autoclaving, cobalt-60 electron beams, and landfills are the most common and popular methods in the world. Incinerators can handle large quantities of wastes all at once and can make sure the wastes are burned to nothing but ashes, but in the process, produces lots of harmful by-products such as dioxins and furans that pollute the atmosphere. They are part of the source of the global warming and greenhouse effect issues. Although it is one of the most used methods of medical waste disposal, there should be more investments into making sure the by-products it produces can be more safely contained in order to protect the people, the environment, ecosystems, and biota.

Autoclaving is rarely seen in as large-scale operation. They are a relatively effective method of medical waste disposal, but the problem with this method is that it can only handle small-scale disposal treatments at a time. Another issue with this method is that it does not always completely disinfect and sterilize all the waste. There have been studies that show microorganisms growing on supposedly disinfected and sterilized waste that were put through the autoclaves. Though not the

most effective on its own, other studies have show that this method is made much more effective when used along with a shredder and perhaps even using some ultraviolet irradiation treatment on the waste after the autoclave process. But using the shredder to crunch the waste into smaller items, the autoclave's high temperature and steam can reach more surfaces of the wastes. After the wastes are done autoclaving, using some intervals of ultraviolet irradiation would further disinfect and sterilize the waste, making sure no microorganisms grow back in the following days.

Cobalt-60 electron beams is one of the most common methods of medical waste disposal in the modern age. This is due to the high energy gamma rays it uses to effectively kill microorganisms. It has a deep penetrative ability so can be used in larger-scale operations to treat items in plastic bags and containers. This method is very promising, but unfortunately, there would need to be a lot more investment and research into prolonging or recycling the cobalt pencils. The source of cobalt is no perpetual, so if there is a desire to continue using this method, a way to recycle and reuse the cobalt pencils is necessary. Another issue with this method is its high financial budget, not just for the building of the waste treatment and disposal facility, but also for the upkeep and maintenance and the training of all the workers who work in the facilities. This method is used more in the developed countries because of it high financial demand, making it almost unattainable to the developing countries who are barely getting by with their treatment methods.

The last commonly used medical waste treatment and disposal method is landfills. Compared to all the other methods, this is probably one of the most harmful to the people, environment, ecosystem, and biota. This method does not require much financial investment, not as much training for workers, and not as sophisticated as the other methods. That is why many developing countries use this method. There are not as many stringent rules and regulations to the landfills, and

even if there were, many are not executed well. The waste in landfills are a mixture of municipal household waste, industrial waste, e-waste, and medical wastes because most areas that use landfills do not do well in waste sorting. This is a big problem because all the nonhazardous wastes and hazardous wastes are all mixed together in giant hills. There is high risk of cross contamination between the different types of waste. If left to sit in the landfill, most of the waste will start to decompose. The toxic liquids can leach into the soil, groundwater, and enter the water sources. This can potentially contaminate the soil and water in the vicinity (agricultural land, municipal apartments, forests, marshes, etc) and cause many pollution problems down the road. Animals and people who scavenge for food or items to sell to recycling companies are also at high risk of getting hurt while rummaging through the piles and piles of waste. If the landfill is not properly managed and all the different types of waste are mixed together, people and animals can accidently get cut or pricked with a used needle and catch infectious diseases. Landfills can also get out of control and encroach into the natural habitats of the biota. Animals can get displaced and vegetation could die from the pollution. Not to mention the odors from landfills are foul, to say the least.

Every country, and even every city, has their own needs. Governments need to take more action in looking into the best and most fit method of medical waste treatment and disposal to serve their communities effectively but also taking into consideration the ramifications the methods could have on the environment. Developed countries need to invest in more sustainable development methods and continue to educate the population concerning the do's and don'ts of medical waste treatment and disposal. Developing countries need to have strong and trained leadership to come together and figure out an effective and efficient system of waste management in order to bring their countries out of the edge of environmental crises.

Society needs to be more careful with how they dispose of the unwanted or unused pharmaceutical drugs. Most people do not mean any harm when they simply throw the drugs away in the trash or flush the drugs down the toilet. But everyone must be educated. Simply throwing the drugs with normal waste could potentially be delivering the drugs into landfills where it can leach into the soil and waters nearby and cause adverse effects in soil and water organisms. Simply throwing the drugs down the toilet means that the drugs will travel through the sewage treatment process, and depending on the solubility and biodegradability of the drug, end up back in someone's drinking water. Although people may argue small amounts will not hurt anyone, if enough people think that way and do the action, the waters will end up having a much higher concentration of pharmaceutical drugs than one can imagine. This also means the cities should probably invest in high performance sewage treatment equipment.

War-torn countries are at a disadvantage compared to other countries. When war breaks out, the budget will be altered with more money going into the war efforts. This is true for the war-torn countries of Syria and the Democratic Republic of Congo.

With most of the money going into the war effort and being taken by corruption, Syria is left with a struggling healthcare system and medical waste treatment system. No funding means there are no proper healthcare facilities and no proper medical waste treatment and disposal facility. Syrians would be lucky to even have proper healthcare in these trying times, much less a proper medical waste treatment and disposal facility. Much of Syria's healthcare is dependent on outside help, but the outside can only do so much. The war destroyed many healthcare facilities, many healthcare workers were forced to leave their homes, and many were killed. Healthcare facilities have had to become temporary, often borrowing school buildings, farms, or finding mountains with large enough caves to set up. Many

civilians die from inaccessibility to healthcare. Since many of the facilities are now temporary, most personnel do not even think about medical waste separation because there are many other things to worry about. In many situations, there most likely is not enough space or containers to use for waste sorting.

The Democratic Republic of Congo also is in a rough spot in their healthcare and medical waste treatment systems. Early on, due to corruption, the country's budget cut healthcare and education. All of the hospitals in the Congo need to rely on themselves to make enough money to pay their workers, maintain their hospitals, and buy medicine. The money is earned through patient consultation fees and prescription drugs that the patients need to buy. But because of the war, everyone is struggling with money. Patients do not have access to healthcare anymore due to their inability to pay for the consultations and the prescription medication they need. This results in the hospitals not being able to earn any revenue. So, the Congo has been relying on international nonprofit organizations to meet the needs of healthcare. Unfortunately, this is not a sustainable system because the country itself needs to coordinate, plan, and execute their own healthcare system so that they are no longer always relying on others.

The medical waste treatment is also in shambles in the Congo. With no funding, most of the disposal facilities are broken down, so the hospitals resort to throwing all the medical waste in a landfill close by to their hospital. This causes environmental problems such as leaching, soil and water contamination, atmospheric pollution, foul odors, and people and animal are at risk of hurting themselves if scavenging to working with unsorted medical wastes.

In conclusion, medical waste can impact people, the environment, the ecosystem, and the biota in huge ways. To continue developing and progressing forward, each person needs to do their part in properly handling, sorting, treating, and disposing of wastes, but especially medical wastes. The consequences can be

many and great, but if some effort, time, and money are invested in medical waste treatment, research in developing new and better ways of waste disposal, and education and training of healthcare and medical waste treatment personnel (and the general public), the future will look brighter and head towards more sustainable and environmentally protected ways.

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