



Guidelines for the
Environmentally-Safe
Disposal of
Pharmaceutical
Products

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This draft document was prepared by Ms. Megan Sheahan, a fourth-year student at the University of Wisconsin-Madison School of Pharmacy and intern with the Supply Chain Management System (SCMS). SCMS was established as a part of the United States President’s Emergency Plan for AIDS Relief (PEPFAR) in late 2005. SCMS’s team of public and private sector organizations strengthens existing supply chains to deliver a continuous flow of high-quality and affordable medicines and supplies throughout the developing world. With offices based in 17 countries, a key component of our work is centralized on identifying weaknesses within the global medicines supply chain and developing ways of appropriately addressing them.

Pharmaceutical Product Disposal

Introduction

The management and disposal of pharmaceutical products has been a consistent challenge throughout the world. With the marked increase in the distribution of pharmaceutical products in the developing world, pharmaceutical supply chains must address problems posed by the growing presence of expired and unusable products in order to ensure orderly drug distribution processes. Products disposed of improperly may contaminate the atmosphere and water supplies or harm communities through scavenging or diversion back to the market for resale (1) (2).

There are three overarching methods used for waste disposal: destruction (incineration), disposal deferral (immobilization with concrete or burial in engineered landfills) and environmental dispersal (direct discharge into water supply or landfills).

The Basel Convention is the most comprehensive global environmental treaty on hazardous and pharmaceutical waste products. Member countries are expected to minimize quantities of waste moved across borders, dispose of wastes as close as possible to the site of generation and minimize amounts of waste generated (3). If fully qualified incineration facilities are not available within a country, it becomes the country's responsibility to finance the export of waste to a demonstrably appropriate facility or resort to alternate methods of waste disposal.

Project Direction and Goals

The goals of this project are to initiate the development of a product-specific¹ guidance based on guidelines set forth by WHO and to identify current weaknesses within product disposal processes. This will allow us to provide tangible guidance for those in charge of local waste management processes and to identify the most prominent hindrances currently impeding proper waste disposal process so that further action can be taken.

Scales of Product Disposal

Large-scale Destruction²

Bulk product destruction occurs at central medical stores, distribution centers and large health care facilities. To ensure proper and environmentally-safe product destruction, high temperature incineration in facilities equipped with toxic fume removal mechanisms is generally the most recommended method. Alternate disposal options include product immobilization and return of the product to the manufacturer for disposal or chemical recovery.

Medium-scale Destruction

Non-bulk product destruction occurs most often in health care facilities. If high temperature incineration is not available then alternates are product immobilization, landfill disposal, discharge to sewage system and medium temperature incineration.

Small-scale Destruction

Although not often addressed, small quantities of expired or unusable medications may remain in the possession of patients or health care support staff. Methods of product disposal include return to the dispensing facility and crushing or dissolving the medication in water and dispersing it among undesirable waste.

¹ Each of the medicines on the WHO Model List of Essential Medicines, 15th Edition (9) will be included. Additional products used in the treatment of HIV/AIDS have also been added. We welcome recommendations for additional products.

² See Appendix 1 for complete descriptions of disposal methods.

Product Disposal Recommendations

General Guidelines³

Pharmaceutical Waste

- *Large-scale disposal*: High temperature incineration, return to manufacturer for product recovery and remanufacture
- *Medium-scale disposal*: High/medium temperature incineration, encapsulation, inertization, landfill disposal
- *Small-scale disposal*: Return to supplier for disposal, pre-treated product landfill disposal

Hazardous waste/Endocrine Disruptors

- *Large-scale disposal*: High temperature incineration, return to manufacturer for disposal
- *Medium-scale disposal*: High temperature incineration, return to manufacturer for disposal
- *Small-scale disposal*: Return to supplier for disposal

Genotoxic waste

- *Large-scale disposal*: High temperature incineration, return to manufacturer for disposal
- *Medium-scale disposal*: High temperature incineration, encapsulation
- *Small-scale disposal*: Return to supplier for disposal

Sharps

- *Large-scale disposal*: High temperature incineration
- *Medium-scale disposal*: High/medium temperature incineration, encapsulation
- *Small-scale disposal*: Return to supplier for disposal

Unit Dose Injectables

- *Large-scale disposal*: High temperature incineration
- *Medium-scale disposal*: High temperature incineration, encapsulation
- *Small-scale disposal*: Return to supplier for disposal

Large Volume Injectables

- *Large-scale disposal*: Landfill disposal, chemical decomposition followed by discharge into sewage
- *Medium-scale disposal*: Landfill disposal, chemical decomposition followed by discharge into sewage
- *Small-scale disposal*: Return to supplier for disposal

Controlled substances

- *Large-scale disposal*: High temperature incineration
- *Medium-scale disposal*: High/medium temperature incineration, encapsulation, inertization
- *Small-scale disposal*: Return to supplier for disposal, pre-treated product landfill disposal

Anti-infective products

- *Large-scale disposal*: High temperature incineration
- *Medium-scale disposal*: High temperature incineration, encapsulation, inertization
- *Small-scale disposal*: Return to supplier for disposal

Pressurized gas containers

- *Large-scale disposal*: Encapsulation, landfill disposal, return to manufacturer for disposal
- *Medium-scale disposal*: Encapsulation, landfill disposal
- *Small-scale disposal*: Return to supplier for disposal, landfill disposal

³ See Appendix 1 for waste category descriptions.

Product-specific Guidelines

Medication ⁴	Formulation	Waste Type ⁵	Disposal method per scale of waste (See Appendix 2 for numeric correlations)			Toxic Fumes upon Incineration ^{6,7}
			Large	Medium	Small	
Abacavir	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, NH3
	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Abacavir/lamivudine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Acetazolamide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Acetylcysteine	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Acetylsalicylic acid	Tablets	Pharmaceutical	1	1,2,3,5,7	9,10	
Aciclovir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
	Eye Ointment	Pharmaceutical	1	1,2,5	9,10	NOx, NH3
Albendazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
Alcuronium	Injection	Pharmaceutical	1	1,2	9	NOx, Cl-
Allopurinol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Aluminium diacetate	Solution	Pharmaceutical	1	1,2,5	9,10	Al ³⁺
Amidotrizoate	Injection	Pharmaceutical	1	1,2	9	NOx, I-
Amikacin	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, NH3
Amiloride	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-, NH3
Amitriptyline	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Amlodipine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NH3, Cl-
Amodiaquine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Amoxicillin	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Amoxicillin + clavulanic acid	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
	Powder for Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, NH3
Amphotericin B	Injection	Pharmaceutical	1	1,2	9	NH3
Ampicillin	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Amprenavir	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Anti-D immunoglobulin	Injection	Pharmaceutical	1	1,2	9	Unknown
Antitetanus immunoglobulin	Injection	Pharmaceutical	1	1,2	9	Unknown
Antivenom immunoglobulin	Injection	Pharmaceutical	1	1,2	9	Unknown
Artemether + lumefantrine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Artesunate + amodiaquine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Ascorbic acid	Tablets	Pharmaceutical	1	1,2,3,5	9,10	

⁴ Based on the WHO List of Essential Medicines, 15th Edition (10).

⁵ See Appendix 1 for waste category descriptions.

⁶ Depending on product formulation, the following fumes are produced; see Appendix 3 for toxic fume level severity and proper management.

⁷ Incinerated hydrocarbon-based products produce carbon dioxide, carbon monoxide, water and ash.

Asparaginase	Powder for Injection	Genotoxic	1,9	1,2	9	NOx, SOx
Atazanavir	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx
Atenolol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Atropine	Injections	Pharmaceutical	1	1,2	9	NOx
	Eye Drops	Pharmaceutical	1	1,2,5	9,10	NOx
Azathioprine	Tablets	Genotoxic	1,9	1,2	9	NOx, SOx
Azithromycin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Barium sulfate	Suspension	Pharmaceutical	1	1,2,5	9,10	Ba ²⁺ , SO ₄ ²⁻
BCG vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Beclometasone	Aerosol	Pressurized Container	2,5,9	2,5	5,9	Cl-
Benzathine benzylpenicillin	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Benznidazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Benzoic acid + salicylic acid	Ointment	Pharmaceutical	1	1,2,5,7	9,10	
Benzoyl peroxide	Cream	Hazardous	1,9	1,9	9	
Benzyl benzoate	Application	Pharmaceutical	1	1,2,5	9,10	
Benzylpenicillin	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Betamethasone	Cream	Pharmaceutical	1	1,2,5	9,10	F-
Biperiden	Injection	Pharmaceutical	1	1,2	9	NOx
Bleomycin	Powder for Injection	Genotoxic	1,9	1,2	9	NOx, SOx, NH3
Bupivacaine	Injection	Pharmaceutical	1	1,2	9	NOx, Cl-
Caffeine citrate	Injections	Pharmaceutical	1	1,2	9	NOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx
Calamine lotion	Lotion	Pharmaceutical	1	1,2,5	9,10	ZnO
Calcium folinate	Tablets	Genotoxic	1,9	1,2	9	NOx, NH3
Calcium gluconate	Injection	Pharmaceutical	1	1,2	9	
Capreomycin	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Carbamazepine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Cefazolin	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Cefixime	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Ceftazidime	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Ceftriaxone	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Cetrimide + chlorhexidine	Solution	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-, Br-
Charcoal, activated	Powder	Pharmaceutical	1	1,2	9	
Chlorambucil	Tablets	Genotoxic	1,9	1,2	9	NOx, Cl-
Chloramphenicol	Capsules	Genotoxic	1,9	1,2	9	NOx, Cl-
	Oily Suspension for Injection	Genotoxic	1,9	1,2	9	NOx, Cl-
	Oily Liquid	Genotoxic	1,9	1,2	9	NOx, Cl-

	Powder for Injection	Genotoxic	1,9	1,2	9	NOx, Cl-
Chlorhexidine	Solution	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
Chlorine base compound	Powder	Pharmaceutical	1	2	9	Cl-
Chloroquine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, POx, Cl-
Chloroxlyenol	Solution	Pharmaceutical	1	1,2,5	9,10	Cl-
Chlorphenamine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Chlorpromazine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, Cl-
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, Cl-
Cholera vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Ciclosporin	Capsules	Genotoxic	1,9	1,2	9	NOx
	Concentrate for Injection	Genotoxic	1,9	1,2	9	NOx
Ciprofloxacin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-
Cisplatin	Powder for Injection	Genotoxic	1,9	1,2	9	NH3, Cl-, Pt
Clindamycin	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
Clofazimine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Clomifene	Tablets	Endocrine Disruptor	1,9	1,9	9	NOx, Cl-
Clomipramine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Clotrimazole	Cream	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
	Vaginal Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Cloxacillin	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, Cl-
Coal tar	Solution	Pharmaceutical	1	1,2,5,7	9,10	
Codeine	Tablets	Controlled Substance	1	1,2,3	9,10	NOx, POx, SOx
Condoms		Non-Health Care	5	5	5	
Copper-containing device		Pharmaceutical	1	1,2	9	
Co-trimoxazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, NH3
Cyclophosphamide	Tablets	Genotoxic	1,9	1,2	9	NOx, POx, Cl-
	Powder for Injection	Genotoxic	1,9	1,2	9	NOx, POx, Cl-
Cycloserine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Cytarabine	Powder for Injection	Genotoxic	1,9	1,2	9	NOx, NH3
Dacarbazine	Powder for Injection	Genotoxic	1,9	1,2	9	NOx, NH3
Dactinomycin	Powder for Injection	Genotoxic	1,9	1,2	9	NOx

Dapsone	Tablets	Pharmaceutical	1	1,2,3,5	9,10	SOx, NH3
Darunavir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Daunorubicin	Powder for Injection	Genotoxic	1,9	1,2	9	NH3, Cl-
Deferoxamine	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Dexamethasone phosphate	Injection	Pharmaceutical	1	1,2	9	POx, F-
Dextran 70	Injection	Pharmaceutical	1	4,5	9	
Dextrose	Injection	Pharmaceutical	1	4,5	9	
Diaphragms		Non-Health Care	5	5	5	
Diazepam	Tablets	Controlled Substance	1	1,2,3	9,10	NOx, Cl-
Diclofenac	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Didanosine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx
	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx
Diethylcarbamazine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Digoxin	Tablets	Pharmaceutical	1	1,2,3,5,7	9,10	
	Injection	Pharmaceutical	1	1,2	9	
	Oral Solution	Pharmaceutical	1	1,2,5,7	9,10	
Diloxanide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Dimercaprol	Injection	Hazardous	1,9	1,9	9	SOx
Diphtheria antitoxin	Injection	Pharmaceutical	1	1,2	9	Unknown
Diphtheria vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Dithranol	Ointment	Pharmaceutical	1	1,2,5,7	9,10	
DL-methionine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Dopamine	Injection	Pharmaceutical	1	1,2	9	NOx, Cl-, NH3
Doxorubicin	Powder for Injection	Genotoxic	1,9	1,2	9	NOx, Cl-, NH3
Doxycycline	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-, NH3
Efavirenz	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-, Cl-
	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-, Cl-
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, F-, Cl-
Efavirenz + emtricitabine + tenofovir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, F-, Cl-
Eflornithine	Injection	Pharmaceutical	1	1,2	9	NOx, F-, NH3
Emtricitabine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, F-
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, F-
Emtricitabine + tenofovir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, F-
Enalapril	Injection	Pharmaceutical	1	1,2	9	NOx
Ephedrine	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, H2SO4
Epinephrine	Injection	Hazardous	1	1,9	9	NOx
Ergocalciferol	Capsules	Pharmaceutical	1	1,2,3,5,7	9,10	
	Tablets	Pharmaceutical	1	1,2,3,5,7	9,10	
	Oral Solution	Pharmaceutical	1	1,2,5,7	9,10	

	Iodized Oil	Pharmaceutical	1	1,2,5,7	9,10	
Ergometrine	Injection	Pharmaceutical	1	1,2	9	NOx
Erythromycin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Estradiol cypionate	Injection	Endocrine Disruptor	1,9	1,9	9	
Ethambutol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Ethanol 70%	Solution	Pharmaceutical	1	1,2	9	
Ethinylestradiol	Tablets	Endocrine Disruptor	1,9	1,9	9	
Ethinylestradiol + levonorgestrel	Tablets	Endocrine Disruptor	1,9	1,9	9	
Ethinylestradiol + norethisterone	Tablets	Endocrine Disruptor	1,9	1,9	9	
Ethionamide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Ethosuximide	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx
Etoposide	Capsules	Genotoxic	1,9	1,2	9	
	Injection	Genotoxic	1,9	1,2	9	
Factor IX complex concentrate	Dried	Pharmaceutical	1	1,2	9	Unknown
Factor VIII concentrate	Dried	Pharmaceutical	1	1,2	9	Unknown
Ferrous sulfate	Tablets	Pharmaceutical	1	1,2,3,5	9,10	SOx
Fluconazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-
	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-
Flucytosine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-
	Injection	Pharmaceutical	1	1,2	9	NOx, F-
Fluorescein	Eye Drops	Pharmaceutical	1	1,2,5,7	9,10	
Fluorouracil	Injection	Genotoxic	1,9	1,2	9	NOx, F-
	Ointment	Genotoxic	1,9	1,2	9	NOx, F-
Fluoxetine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-, F-
	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-, F-
Fluphenazine	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, HCl, F-
Folic acid	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Fosamprenavir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, POx, SOx, NH3
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, POx, SOx, NH3
Furosemide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-, NH3
	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, Cl-, NH3
Gentamicin	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Gentian violet	Powder for Oral Susp/Soln	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
Glibenclamide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
Glucose	Injection	Pharmaceutical	1	4,5	9	

Glutaral	Solution	Pharmaceutical	1	1,2,5,7	9,10	
Glyceryl trinitrate	SL Tablet	Hazardous	1	1,9	9	NOx
Griseofulvin	Tablets	Hazardous	1,9	1,9	9	Cl-
Haemophilus influenzae type b vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Haloperidol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-, Cl-
	Injection	Pharmaceutical	1	1,2	9	NOx, F-, Cl-
		Pressurized Containers				
Halothane	Inhalation		2,5,9	2,5	5,9	F-, Br-, Cl-
Heparin sodium	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Hepatitis A vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Hepatitis B vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Human normal immunoglobulin	Injection	Pharmaceutical	1	1,2	9	Unknown
Hydralazine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, Cl-
						NOx, SOx, Cl-, NH3
Hydrochlorothiazide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	
Hydrocortisone	Cream	Pharmaceutical	1	1,2,5,7	9,10	
Hydroxocobalamin	Injection	Pharmaceutical	1	1,2	9	NOx, POx, NH3
Ibuprofen	Tablets	Pharmaceutical	1	1,2,3,5,7	9,10	
	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Imipenem + cilastatin	Injection	Pharmaceutical	1	1,2	9	
Immunoglobulin	Injection	Pharmaceutical	1	1,2	9	
Indinavir	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx
Influenza vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Insulin injection	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Intermediate-acting insulin	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Intraperitoneal dialysis solution	Injection	Pharmaceutical	4	4,5	9	
Iodine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	I-
Iohexol	Injection	Pharmaceutical	1	1,2	9	NOx, I-
Ipratropium bromide	Inhalation	Pharmaceutical	1	2,5	9	NOx, Br-
Isoniazid	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Isoniazid + ethambutol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Isosorbide dinitrate	SL Tablet	Pharmaceutical	1	1,2,3,5	9,10	NOx
Ivermectin	Tablets	Hazardous	1,9	1,9	9	
Japanese encephalitis vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
		Controlled Substance				
Ketamine	Injection		1	1,2	9	NOx, Cl-
Ketoconazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Lamivudine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3

	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, NH3
Lamivudine/stavudine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Lamivudine/stavudine + efavirenz	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-, F-
Lamivudine/stavudine + nevirapine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Lamivudine/zidovudine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Lamivudine/zidovudine + abacavir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Lamivudine/zidovudine + efavirenz	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-, F-
Lamivudine/zidovudine + nevirapine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Levamisole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
Levodopa + carbidopa	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Levonorgestrel	Tablets	Endocrine Disruptor	1,9	1,9	9	
Levonorgestrel-releasing implant	Implant	Endocrine Disruptor	1,9	1,9	9	
Levothyroxine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, I-, NH3
Lidocaine	Injection	Pharmaceutical	1	1,2	9	NOx
Lidocaine + epinephrine	Injection	Pharmaceutical	1	1,2	9	NOx
Lithium carbonate	Tablets	Pharmaceutical	1	1,2,3,5,7	9,10	
Loperamide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Lopinavir + ritonavir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx
Magnesium hydroxide	Oral Solution	Pharmaceutical	1	1,2,5	9,10	
Magnesium sulfate	Injection	Pharmaceutical	1	4,5	9	SOx
Mannitol	Injection	Pharmaceutical	1	4,5	9	
Measles vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Mebendazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Medroxyprogesterone acetate	Injection	Endocrine Disruptor	1,9	1,9	9	
Medroxyprogesterone acetate + estradiol cypionate	Injection	Endocrine Disruptor	1,9	1,9	9	
Mefloquine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-, Cl-
Meglumine antimoniate	Injection	Pharmaceutical	1	1,2	9	NOx
Melarsoprol	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Meningococcal meningitis vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Mercaptopurine	Tablets	Genotoxic	1,9	1,2	9	NOx, SOx
Metformin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-, NH3

Methadone	Oral Solution	Controlled Substance	1	1,2	9,10	NOx, Cl-
Methotrexate	Tablets	Genotoxic	1,9	1,2	9	NOx, NH3
	Powder for Injection	Genotoxic	1,9	1,2	9	NOx, NH3
Methyldopa	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Methylrosanilinium chloride	Solution	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
	Tincture	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
Methylthioninium chloride	Injection	Pharmaceutical	1	1,2	9	SOx, Cl-
Metoclopramide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-, NH3
	Injection	Pharmaceutical	1	1,2	9	NOx, Cl-, NH3
Metronidazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
	Injection	Pharmaceutical	1	1,2	9	NOx, Cl-
Miconazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
	Cream	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
	Gel	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
Mifepristone	Tablets	Endocrine Disruptor	1,9	1,9	9	NOx
Misoprostol	Vaginal Tablets	Pharmaceutical	1	1,2,3,5,7	9,10	
Morphine	Tablets	Pharmaceutical; Controlled Substance	1	1,2,3,5	9,10	NOx, SOx, Cl-
	Injection	Pharmaceutical; Controlled Substance	1	1,2	9	NOx, SOx, Cl-
	Oral Solution	Pharmaceutical; Controlled Substance	1	1,2	9,10	NOx, SOx, Cl-
Multivitamin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
	Oral Solution	Pharmaceutical	1	1,2,4,5	9,10	NOx, SOx, Cl-
Mumps vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Naloxone	Injection	Pharmaceutical	1	1,2	9	NOx
Nelfinavir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Powder for Oral Susp/Soln	Pharmaceutical	1	1,2,5	9,10	NOx, SOx
Neomycin sulfate + bacitracin	Ointment	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, NH3
Neostigmine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Nevirapine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx
Niclosamide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Nicotinamide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Nifedipine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx

Nifurtimox	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
Nitrofurantoin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Nitrous oxide	Inhalation	Pressurized Containers	9	9	9	NOx
Norethisterone	Tablets	Endocrine Disruptor	1,9	1,9	9	
Norethisterone enantate	Oily Solution	Endocrine Disruptor	1,9	1,9	9	
Nystatin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, NH3
Ofloxacin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-
Oral rehydration salts	Powder for Oral Susp/Soln	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, Cl-
Oxamniquine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx
Oxygen	Inhalation	Pressurized Containers	9	9	9	
Oxytocin	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
P-aminosalicylic acid	Granules	Pharmaceutical	1	1,2,5	9,10	NH3
	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NH3
Paracetamol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx
Paromomycin	Injection	Pharmaceutical	1	1,2	9	NH3, SOx
Penicillamine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NH3, SOx
	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NH3, SOx
Pentamidine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Permethrin	Cream	Pharmaceutical	1	2,5	9	Cl-
	Lotion	Pharmaceutical	1	2,5	9	Cl-
Pertussis vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Phenobarbital	Injection	Hazardous, Controlled Sub.	1,9	1,9	9	NOx
	Oral Liquid	Hazardous, Controlled Sub.	1,9	1,9	9	NOx
	Tablets	Hazardous, Controlled Sub.	1,9	1,9	9	NOx
Phenoxyethylpenicillin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Powder for Oral Susp/Soln	Pharmaceutical	1	1,2,5	9,10	NOx, SOx
Phenytoin sodium	Capsules	Hazardous	1,9	1,9	9	NOx
	Tablets	Hazardous	1,9	1,9	9	NOx
	Injection	Hazardous	1,9	1,9	9	NOx
	Oral Solution	Hazardous	1,9	1,9	9	NOx
Phytomenadione	Injection	Pharmaceutical	1	1,2	9	

	Tablets	Pharmaceutical	1	1,2,3,5,7	9,10	
Pilocarpine	Eye Drops	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
Pneumococcal vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Podophyllum resin	Solution	Pharmaceutical	1	1,2,5	9,10	
Poliomyelitis vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Potassium chloride	Solution	Pharmaceutical	1	1,2,5	9,10	Cl-
Potassium ferric hexacyano-ferrate(II) -2H2O	Powder for Oral Susp/Soln	Hazardous	1,9	1,9	9	Fe, CN-
Potassium iodide	Saturated Solution	Pharmaceutical	1	1,2,5	9,10	I-
Potassium permanganate	Aqueous Solution	Hazardous	1,9	1,9	9	K2O
Povidone iodine	Solution	Pharmaceutical	1	1,2,5	9,10	NOx, I-
Praziquantel	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Prednisolone	Tablets	Pharmaceutical	1	1,2,3,5	9,10	
	Injection	Pharmaceutical	1	1,2	9	POx
Primaquine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, POx, NH3
Procainamide	Injection	Pharmaceutical	1	1,2	9	NOx, Cl-, NH3
Procaine benzylpenicillin	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Procarbazine	Capsules	Genotoxic	1,9	1,2	9	NOx, Cl-
Proguanil	Tablets	Hazardous	1,9	1,9	9	NOx, Cl-
Promethazine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
Propranolol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Propylthiouracil	Tablets	Hazardous	1,9	1,9	9	NOx, SOx
Protamine sulfate	Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Pyrantel	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Oral Liquid	Pharmaceutical	1	1,2,5	9,10	NOx, SOx
Pyrazinamide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Pyridostigmine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Br-
	Injection	Pharmaceutical	1	1,2	9	NOx, Br-
Pyridoxine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Pyrimethamine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, Cl-
Quinidine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
Quinine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Injection	Pharmaceutical	1	1,2	9	NOx, Cl-
Rabies immunoglobulin	Injection	Pharmaceutical	1	1,2	9	Unknown
Rabies vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Raltegravir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, F-
Ranitidine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
	Oral Liquid	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, Cl-
	Injection	Pharmaceutical	1	1,2	9	NOx, SOx, Cl-
Retinol	Capsules	Pharmaceutical	1	1,2,3,5,7	9,10	
Ribavirin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
	Injection	Pharmaceutical	1	1,2	9	NOx, NH3
Riboflavin	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx

Rifampicin	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx
Rifampicin + isoniazid	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Rifampicin + isoniazid + ethambutol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Rifampicin + isoniazid + pyrazinamide	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Rifampicin + isoniazid + pyrazinamide + ethambutol	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, NH3
Ringer lactate	Solution	Pharmaceutical	4	4	9	
Ritonavir	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx
Rotavirus vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Rubella vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Salbutamol	Inhalation	Pharmaceutical	1	2,5	9	NOx, SOx
Salicylic acid	Tablets	Pharmaceutical	1	1,2,3,5	9,10	Phenol
Saquinavir	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Selenium disulfide	Suspension	Hazardous	1	1,9	9	Se, SOx
Senna	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx
Silver sulfadiazine	Cream	Pharmaceutical	1	1,2,5	9,10	NOx, SOx, NH3
Simvastatin	Tablets	Pharmaceutical	1	1,2,3,5,7	9,10	
Sodium calcium edetate	Injection	Pharmaceutical	1	1,2	9	NOx
Sodium chloride	Solution	Pharmaceutical	1	1,2,5	9,10	Cl-
Sodium hydrogen carbonate	Injection	Pharmaceutical	1	4,5	9	
Sodium lactate	Injection	Pharmaceutical	1	4,5	9	
Sodium nitroprusside	Injection	Pharmaceutical	1	1,2	9	CN-, NOx
Sodium stibogluconate	Injection	Pharmaceutical	1	1,2	9	
Sodium thiosulfate	Injection	Pharmaceutical	1	1,2	9	SOx
	Solution	Pharmaceutical	1	1,2,5	9,10	SOx
Sodium valproate	Tablets	Pharmaceutical	1	1,2,3,5	9,10	
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	
Spectinomycin	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, Cl-
Spironolactone	Tablets	Pharmaceutical	1	1,2,3,5	9,10	SOx
Stavudine	Capsules	Pharmaceutical	1	1,2,3,5	9,10	NOx
	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx
Streptokinase	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Streptomycin	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx, NH3
Sulfadiazine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3
Sulfadoxine + pyrimethamine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, NH3, Cl-
Sulfasalazine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
	Suppository	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx

Suramin sodium	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, SOx
Suxamethonium	Injection	Pharmaceutical	1	1,2	9	NOx, Cl-
	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, Cl-
Talc	Powder	Pharmaceutical	1	1,2,5	9,10	Mg, Si
Tamoxifen	Tablets	Genotoxic	1,9	1,9	9	NOx
Tenofovir	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, POx, NH3
Tenofovir disoproxil fumarate	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, POx, NH3
Tenofovir/emtricitabine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, POx, NH3, F-
Testosterone	Injection	Endocrine Disruptor	1,9	1,9	9	
Tetanus vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Tetracaine	Eye Drops	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-
Tetracycline	Eye Ointment	Pharmaceutical	1	1,2,5	9,10	NOx, Cl-, NH3
Thiabendazole	Oral Solution	Pharmaceutical	1	1,2,5	9,10	NOx, SOx
Thiamine	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-, NH3
Thiopental	Powder for Injection	Controlled Substance	1	1,2	9	NOx, SOx
Timolol	Eye Drops	Pharmaceutical	1	1,2,5	9,10	NOx, SOx
Tinidazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx
Triclabendazole	Tablets	Pharmaceutical	1	1,2,3,5	9,10	NOx, SOx, Cl-
Tropicamide	Eye Drops	Pharmaceutical	1	1,2,5	9,10	NOx
Tuberculin, purified protein derivative	Injection	Pharmaceutical	1	1,2	9	Unknown
Typhoid vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Vancomycin	Powder for Injection	Pharmaceutical	1	1,2	9	NOx, Cl-, NH3
Varicella vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Vecuronium	Injection	Pharmaceutical	1	1,2	9	NOx, Br-
Verapamil	Tablets	Pharmaceutical	1	1,2,3,5	9,10	CN-, NOx, Cl-
	Injection	Pharmaceutical	1	1,2	9	CN-, NOx, Cl-
Vinblastine	Injection	Genotoxic	1,9	1,2	9	NOx, SOx
Vincristine	Injection	Genotoxic	1,9	1,2	9	NOx, SOx
Warfarin	Tablets	Hazardous	1,9	1,9	9	
Water for injection	Injection	Pharmaceutical	1	4,5	9	
Yellow fever vaccine	Injection	Pharmaceutical	1	1,2	9	Unknown
Zidovudine	Capsules	Hazardous	1,9	1,9	9	NOx
	Tablets	Hazardous	1,9	1,9	9	NOx
	Solution	Hazardous	1,9	1,9	9	NOx
Zinc sulfate	Oral Liquid	Pharmaceutical	1	1,2,5	9,10	SOx, Zn ²⁺
	Tablets	Pharmaceutical	1	1,2,3,5	9,10	SOx, Zn ²⁺

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Appendix 1: WHO Categories of Health Care Waste⁸

Chemical waste

Chemical substances; includes laboratory reagents, solvents, disinfectants that are expired or no longer needed.

Endocrine Disruptors

Substances that interfere with the endocrine system; includes pharmaceutical formulations and pharmaceutical-containing devices.

Genotoxic waste

Substances capable of causing damage to DNA; includes cytostatic drugs, genotoxic chemicals.

Hazardous Waste

Waste suspected to display at least one of the following properties: ignitability, corrosivity, reactivity, toxicity.

High content of heavy metals

Waste with high content of heavy metals; includes batteries, broken thermometers, blood pressure gauges.

Infectious waste

Waste suspected to contain pathogens; includes laboratory cultures, waste from isolation wards, tissues (swabs), materials or equipment that have been in contact with infected patients, excreta.

Pathological waste

Human tissues or fluids; includes products that have been in contact with human fluids.

Pharmaceutical waste

Pharmaceuticals; includes pharmaceuticals that are expired or no longer needed, items contaminated by or containing pharmaceuticals (bottles, boxes).

Pressurized containers

Pressurized containers; includes gas cylinders, gas cartridges, aerosol cans.

Radioactive waste

Radioactive substances; includes unused liquids from radiotherapy or laboratory research, contaminated glassware, packages or absorbent paper, urine and excreta from patients treated or tested with unsealed radionuclides, sealed sources.

Sharps

Sharps waste; includes needles, blades, broken glass, ampoules.

⁸ Based off WHO guidelines (13).

Appendix 2: Methods of Product Disposal

1. High Temperature Incineration

- *Process description:* Incineration is a high temperature dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter and results in a very significant reduction of waste volume and weight. Incinerators designed especially for treatment of health care waste should operate at temperatures between 900 and 1200°C and be equipped with mechanisms to remove toxic byproducts. Specific incinerators include pyrolytic incinerators, rotary kilns, municipal incinerators and cement kilns with byproduct removal mechanisms (1).
- *Compatible products:* Solids, semisolids, powders, liquids, controlled substances, sharps, infectious waste, pathological waste, hazardous waste, cytotoxic waste
- *Incompatible products:* Pressurized gas containers, large amounts of reactive chemical waste, halogenated plastics (PVC)
- *Precautions:* Destruction of products needs to be done at a qualified location. Under the Basel Convention, many challenges exist for countries without these facilities to export products across national boundaries for disposal. Without pre-qualified incinerators, the paucity of facilities in developing countries often makes this an unrealistic option.

2. Waste Immobilization: Encapsulation

- *Process description:* Encapsulation involves immobilizing pharmaceuticals in a solid block within a plastic or steel drum. Drums should be cleaned prior to use and should not have contained explosive or hazardous materials previously. They are filled to 75% capacity with solid and semi-solid pharmaceuticals. The remaining space is filled with cement, cement/lime, plastic foam or bituminous sand. The drums are sealed, placed at the base of a landfill and covered with fresh waste (4).
- *Compatible products:* Solids, semisolids, powders, liquids, controlled substances, sharps, injectables, cytotoxic waste
- *Incompatible products:* Pressurized gas containers, hazardous waste
- *Precautions:* Caution should be taken to avoid cuts to hands when placing pharmaceuticals in the drums and when transferring drums to the final waste site.

3. Waste Immobilization: Inertization

- *Process description:* Inertization is a variant of encapsulation and involves removing the packaging materials, paper, cardboard and plastic from pharmaceutical products. Pharmaceutical products (65%) are ground and a mix of water (5%), cement (15%) and lime (15%) is added to form a homogenous paste. The paste is transported by a concrete mixer truck to a landfill and decanted into the normal urban waste (4). Alternatively, a homogeneous mass is formed and cubes or pellets are produced on site and transported to a suitable storage site (1).
- *Compatible products:* Solids, semisolids, powders, controlled substances
- *Incompatible products:* Product packaging, pressurized gas containers, hazardous waste, cytotoxic waste, liquids, injectables
- *Precautions:* This method of waste destruction may be hazardous to individuals unless sufficient protective equipment is available. High potential for chemical reactions and chemical dust escape.

4. Discharge to Sewer

- *Process description:* Some liquid pharmaceuticals can be diluted with water and flushed into the sewers in small quantities without serious public health or environmental affect (4).
- *Compatible products:* Chemically-inert diluted liquids, syrups and intravenous fluids
- *Incompatible products:* Solids, semisolids, powders, controlled substances, sharps, hazardous waste, cytotoxic waste, antibiotics
- *Precautions:* Products must be well diluted prior to being discharged to the sewer and should be approved by the local water treatment facility prior to disposal. The assistance of a hydrogeologist or sanitary engineer may be required in situations where sewers are in disrepair or have been damaged. Product packaging must be properly disposed of in a landfill or with sharps materials.

5. Landfill Deposit

- *Process description:* To landfill means to place waste directly into a land disposal site without prior treatment or preparation. Three types of landfills are recognized (4):
 - Open uncontrolled non-engineered dump: This form of a landfill is the most common, but least recommended form of waste disposal. When it is not possible to immobilize the waste pharmaceuticals, then untreated wastes must be covered rapidly with large quantities of municipal waste to prevent scavenging. Discarding waste with insufficient isolation from the aquifer or other watercourses can lead to environmental pollution, risking contamination of drinking water.
 - Engineered landfill: This form of landfill has minimal protections in place to prevent loss of chemicals into the aquifer.
 - Highly engineered sanitary landfill: An appropriate landfill site designed to prevent loss of chemicals in the aquifer. Consists of an evacuated pit isolated from watercourses and above the water table. Each day's solid waste is compacted and covered with soil to maintain sanitary conditions.
- *Compatible products:* Solids, semisolids, powders, liquids, pressurized gas containers
- *Incompatible products:* Controlled substances, sharps, infectious waste, pathological waste, hazardous waste, cytotoxic waste
- *Precautions:* Small quantities of products must be well interspersed with regular municipal waste. All personal identifiers ought to be removed prior to disposal. Landfills may not be secure sites and precautions against scavenging and the spread of disease must be considered prior to disposal. If necessary to dispose of controlled substances in a landfill, mix ground medications with water, coffee grinds, saw dust or other undesirable forms of waste.

6. Chemical Decomposition

- *Process description:* Chemical inactivation is tedious and time consuming. If done, stocks of the chemicals used in the treatment must be available at all times. This method may be practical for disposal of a small quantity of antineoplastics drugs (4).
- *Compatible products:* Cytotoxic waste
- *Precautions:* This method is not recommended unless special chemical expertise is readily available.

7. Medium Temperature Incineration

- *Process description:* This form of incineration generally takes place in a single-chamber incinerator. Atmospheric emissions may include acid gases such as sulfur dioxide, hydrogen chloride hydrogen fluoride, black smoke, fly ash, carbon monoxide, nitrogen oxide, heavy metals, and volatile organic chemicals. Temperature ranges between 300-400°C. Used only in the absence of high temperature incinerators (1).
- *Compatible products:* Infectious waste, sharps, product packaging; minimal amounts of pharmaceutical solids, semisolids, powders
- *Incompatible products:* Sealed glass vials or aerosolized containers, halogenated products, PVC-containing plastic, pressurized gas containers, cytotoxic waste, inorganic compounds; substantial amounts of pharmaceutical solids, semisolids, powders
- *Precautions:* If burned in a single-chamber incinerator, pharmaceutical waste ought to be diluted with municipal waste. If no environmental protection controls are in place, it is necessary to minimize the amount of waste disposed of in this manner. Since medium temperature incinerators produce greater amounts of toxic releases, caution must be taken to avoid by-products and fumes produced (5). Drum/brick incinerators only reach 200°C and are unable to destroy many chemicals and pharmaceuticals. Restrict use to emergency situations only (1).

8. Open Container Incineration

- *Process description:* Open-air burning should take place in the pit of final disposal where the residues will be buried. Processes must be closely supervised by the person responsible for waste management in the health care facility. The area within which the burning is carried out should be fenced off to prevent animals and unauthorized persons from entering. Burning is generally incomplete, non-uniform and produces large quantities of toxic pollutants (1). Restrict use to emergency situations only.
- *Compatible products:* Product packaging, paper and cardboard
- *Incompatible products:* Sealed glass vials or aerosolized containers, halogenated products, PVC-containing plastic, pressurized gas containers, infectious waste, sharps , cytotoxic waste, pharmaceutical solids, semisolids, powders, liquids
- *Precautions:* Open-air burning must take place downwind of and as far as possible from the community or health care facility. Appropriate safety measures should be in place to protect from fly-away ashes and fume inhalation. No burning should take in an unsafe environment or where there is potential for fire spreading.

9. Return to Manufacturer/Supplier

- *Process description:*
 - Large & medium-scale product disposal
 - Manufacturers will sometimes be willing to accept expired products for the purposes of product disposal or chemical recovery and remanufacture.
 - Small-scale product disposal
 - If patients or health care support staff possess medications they are unable to dispose of safely, it is recommended to bring products back to the original provider so that appropriate disposal procedures may be followed.

- *Compatible products:* Bulk products, cytotoxic waste, hazardous waste, products with chemical recovery potential
- *Precautions:*
 - Large & medium-scale product disposal
 - Cost is often an issue with the shipment and destruction process of pharmaceutical and hazardous waste. If provided to a health care facility via a wholesaler or distributor, products are rarely able to be returned. Product return may be possible only if health care facilities received products directly from the manufacturer. The regulations set forth by the Basel Convention makes the transfer of waste material across national borders a complicated process.
 - Small-scale product disposal
 - Clinics and hospitals that supply medications to patients or health care support staff must be prepared to take back unused or expired products from these individuals and follow appropriate product destruction procedures.

10. Pre-treated Product Landfill Disposal

- *Process description:* Patients are rarely educated on how to handle unused or expired medications. Medications disposed of in normal waste or stored in homes may lead to a variety of unnecessary hazards. In order to dispose of medications properly, all identifying personal information from medication containers should be removed. Unused and expired medications should be removed from their packaging and poured into a sealable plastic bag. If the medication is a solid, it should be crushed and dissolved in water. Prior to disposal, kitty litter, saw dust, coffee grounds or similar materials making it less appealing for pets and scavengers may be added (6).
- *Compatible products:* Solids, semisolids, powders, liquids
- *Incompatible products:* Pressurized gas containers, sharps, injectables, cytotoxic waste, hazardous waste
- *Precautions:* In the home environment, unused medications should not be flushed down a toilet or poured down a drain.

Appendix 3: Toxic Fume Production

The combustion of organic compounds produces mainly gaseous emissions, including steam, carbon dioxide, nitrogen oxides, particulate matter, solid residues in the form of ashes and other toxic substances (1). Products undergoing incineration should be burned in an enclosed high temperature facility equipped with mechanisms to remove or neutralize toxic fumes and byproducts. If these mechanisms are not in place, toxic fumes and byproducts have varying impacts on nearby communities and the environment.

One method of assessing potential hazards of chemical fumes has been developed by the National Institute for Occupational Safety and Health (NIOSH). The “immediately dangerous to life or health air concentration values” system, defined as any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects, can be used to estimate the comparative hazards of toxic fumes (7). Originally designed for the assessment of respirators, these values display the relative degrees of hazard created when pharmaceutical products are burned in unprotected environments.

CO ₂	40,000 ppm	SO ₂	100 ppm	F-	25 ppm
CH ₃ CH ₂ OH	3,300 ppm	HS	100 ppm	NO ₂	20 ppm
CO	1,200 ppm	HCl	50 ppm	Cl-	10 ppm
NH ₃	300 ppm	HBr	30 ppm	Br-	3 ppm
NO	100 ppm	HF	30 ppm	I-	2 ppm

[ppm = parts per million]