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# CHARACTERIZATION OF PHARMACEUTICAL POLLUTION IN THE AQUATIC ENVIRONMENT OF NIGERIA AND THEIR POTENTIAL ECOTOXICOLOGICAL EFFECTS

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# Nigeria: Country facts

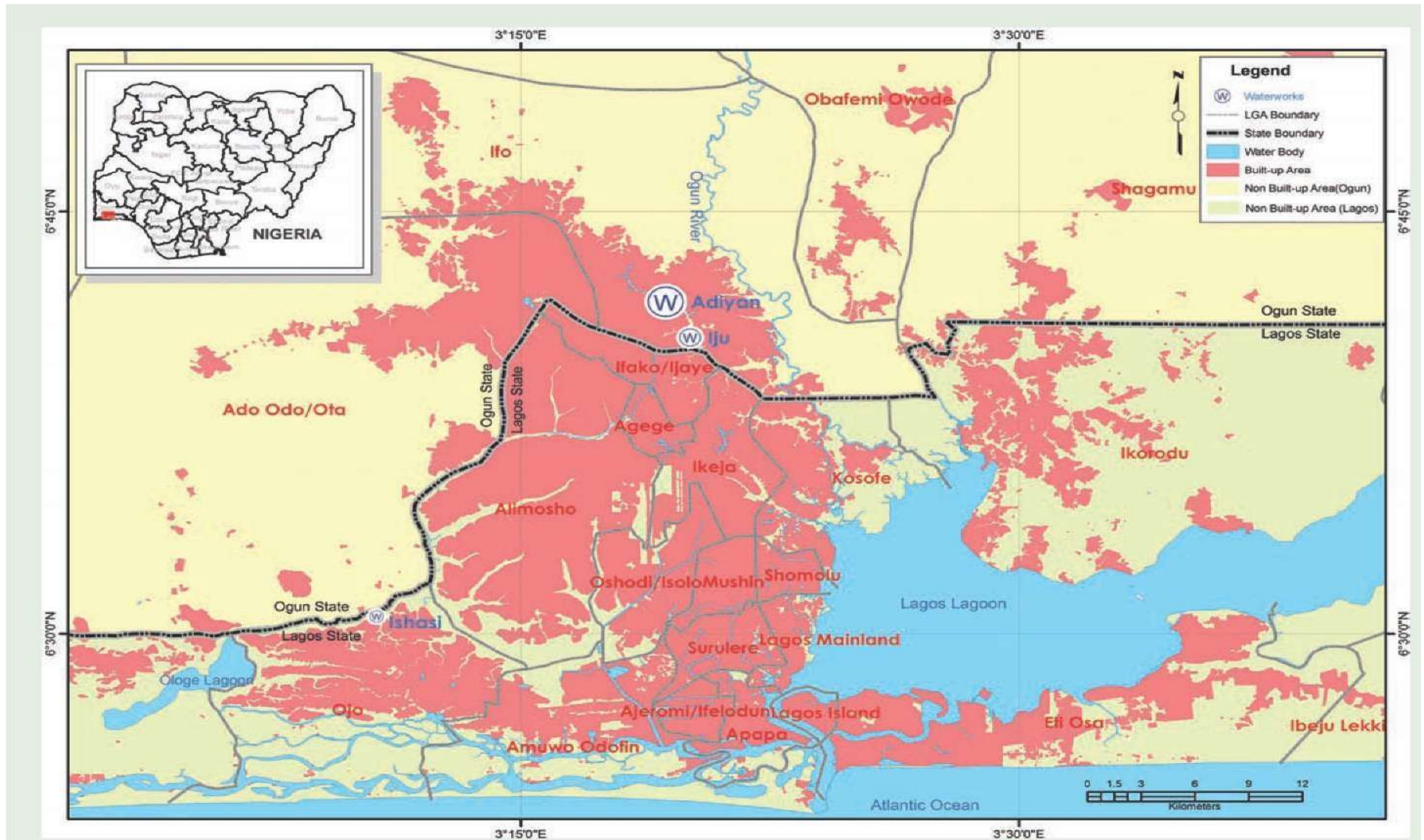
- Most populous country in Africa.
- Population estimated in 2014 at 178.7 million people<sup>1</sup>
- 45.3% of population live in the cities<sup>2</sup>
- Annual urban population growth of 5.5%<sup>3</sup>
- Only 31% of urban population has access to proper sanitation in 2014<sup>2</sup>

# Study locale: Lagos

- One of the two megacities in Africa apart from Cairo and Kinshasa<sup>4</sup>
- Mainly unplanned with several shanty communities and slums similar to Rio' favela's.
- Population estimate for 2012 was 21 million<sup>5</sup> with about 66% living in slums
- Waste management is at best ineffectual and in some communities nonexistent
- Environmental sewage and wastewater impaction is thus high.



# Lagos lagoon





# Makoko: Lagos slum





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# Scope of proposed study

- To gather information about pharmaceutical use, disposal, routes of ingress , environmental fates and ecotoxicological implications of these on human and aberrant recipient species health.
- Limited study
- Prelude to larger initiatives and integral to Emerging Pollutants in Wastewater Reuse in Developing countries

# Main and specific objectives of study

1. Set up a database on existing data in Nigeria
  - a. Gather pharmaceutical measurements in the aquatic environment
  - b. Gather data on pharmaceutical consumption
2. Fill gaps in the database with own measurements
3. Investigate potential ecotoxicological effects of exposure to pharmaceuticals

# Preliminary findings

## Presence

- 12 of 37 pharmaceutical substances were detected at concentrations of up to 8.84 µg/l.
- Chloramphenicol, Diclofenac, Erythromycin, Sulfamethoxazole were found at concentrations exceeding ecotoxicological predicted no-effect concentrations (PNEC)
- Diclofenac was found in ten sludge samples at up to 1100 µg/kg dry weight, which exceeds the highest measured concentration of 560 µg/kg reported in sludge samples worldwide



# Preliminary findings

- 4 out of the 12 pharmaceutical substances (Acetylsalicylic acid, Beta-Sitosterol, Clofibrilic acid, Sulfadiazine) detected in the present study have not previously been measured/not been reported in African countries.

## Results of the Analyses of some Water Samples from Nigeria.

Pharmaceutical Substances	Therapy Group	Analytical Methods		Water Samples from Nigeria					
		Method Number	LOD	AJIDO	RIVER OWO	AMUWO-Odofin	OJO	LIVERPOOL	ISOLO
			[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]
16-alpha-Hydroxyestrone	Estrogens	5	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
17-alpha-Ethinylestradiol	Estrogens	5	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acetylsalicylic acid	Analgesics	1	0.02	< 0.02	<b>0.13</b>	<b>0.10</b>	<b>0.03</b>	< 0.02	< 0.02
Beta-Sitosterol	Phytosterol	5	0.02	<b>0.47</b>	<b>0.06</b>	<b>0.37</b>	<b>0.24</b>	<b>0.18</b>	<b>0.67</b>
Bezafibrate	Lipid-lowering drugs	1	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Carbamazepine	Antiepileptic drugs	2	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chloramphenicol	Antibiotics	3	0.01	< 0.01	< 0.01	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.36</b>
Chlortetracycline	Antibiotics	4	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Clarithromycin	Antibiotics	3	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Clofibric acid	Lipid-lowering drugs	1	0.02	< 0.02	< 0.02	< 0.02	<b>0.04</b>	< 0.02	< 0.02
Diazepam	Psychiatric medication	2	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Diclofenac	Analgesics	1	0.02	< 0.02	< 0.02	<b>0.07</b>	<b>0.04</b>	<b>0.03</b>	<b>0.27</b>
Doxycycline	Antibiotics	4	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Erythromycin	Antibiotics	3	0.06	< 0.06	< 0.06	<b>0.06</b>	< 0.06	< 0.06	<b>1.00</b>
Erythromycin-A dihydrate	Antibiotics	3	0.06	< 0.06	< 0.06	<b>0.12</b>	< 0.06	< 0.06	<b>0.48</b>
Estradiol	Estrogens	5	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Estriol	Estrogens	5	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Estrone	Estrogens	5	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Etofibrate	Lipid-lowering drugs	2	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Fenofibrate	Lipid-lowering drugs	2	0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Fenoprofen	Analgesics	1	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Gemfibrozil	Lipid-lowering drugs	1	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Ibuprofen	Analgesics	1	0.02	< 0.02	<b>0.04</b>	<b>0.57</b>	<b>0.22</b>	<b>0.11</b>	<b>8.84</b>
Indometacin	Analgesics	1	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Ketoprofen	Analgesics	1	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Mestranol	Estrogens	5	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Naproxen	Analgesics	1	0.02	<b>0.03</b>	< 0.02	<b>0.02</b>	< 0.02	< 0.02	<b>0.02</b>

Oxytetracycline	Antibiotics	4	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Pentoxifylline	Vasculardilatation	2	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phenacetin	Analgesics	2	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phenazone	Analgesics	2	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Roxithromycin	Antibiotics	3	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sulfadiazine	Antibiotics	3	0.01	< 0.01	< 0.01	<b>0.02</b>	< 0.01	< 0.01	<b>0.04</b>
Sulfadimidine	Antibiotics	3	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sulfamethoxazole	Antibiotics	3	0.01	< 0.01	< 0.01	<b>0.65</b>	<b>0.14</b>	<b>0.09</b>	<b>1.50</b>
Tetracycline	Antibiotics	4	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Trimethoprim	Antibiotics	3	0.01	< 0.01	< 0.01	<b>0.12</b>	< 0.01	< 0.01	<b>0.40</b>

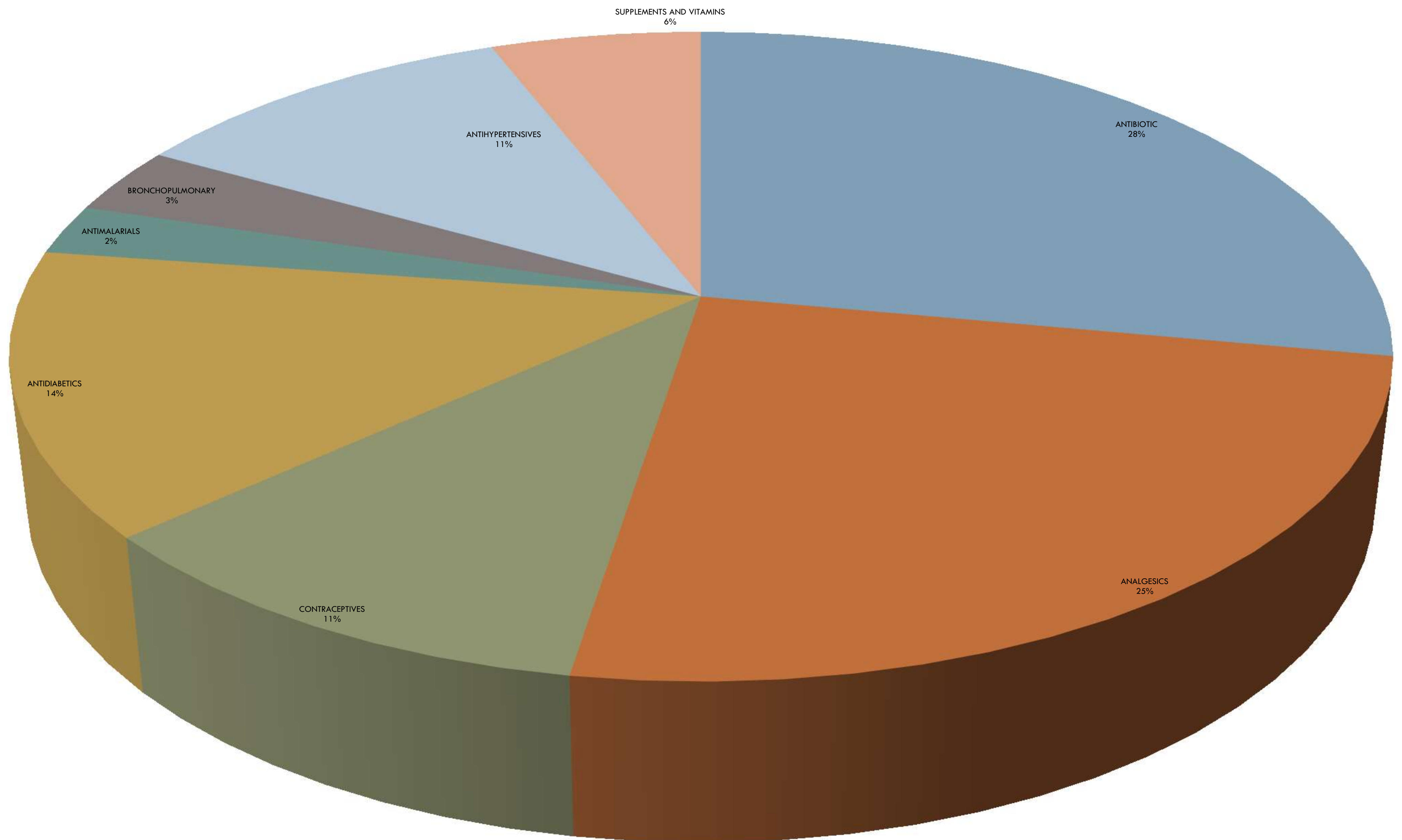


# Preliminary findings

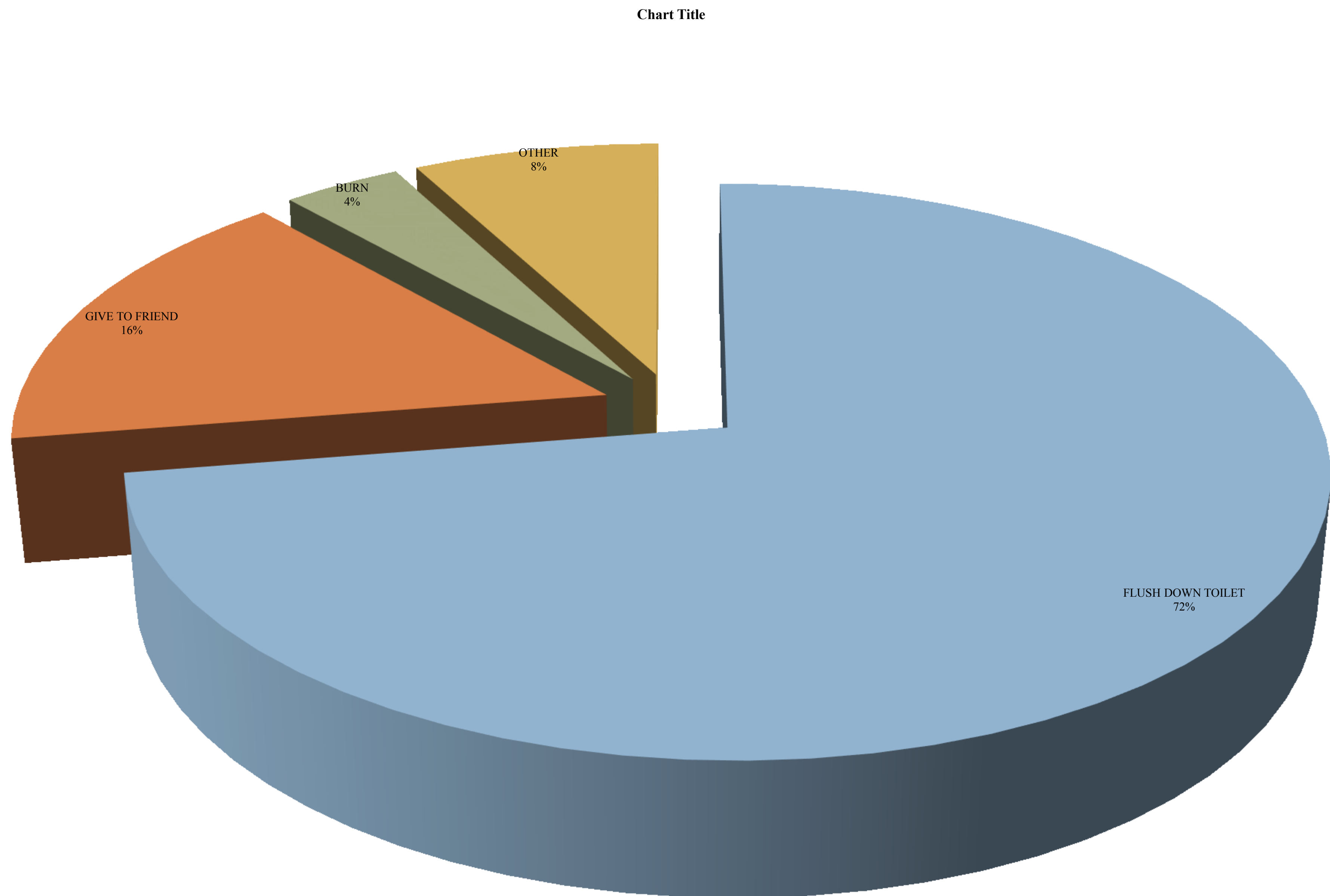
## Household usage and disposal

- Non prescription drug use prevalent
- Antibiotics (28%) and NSAIDs (25%) were drug categories most used without prescriptions
- 72.5% of respondents flushed away unused medications, 15.9% gave away, 3.8% burnt and remainder disposed in trash or dumped in surface water

# Household drug use by category



# Chart illustrating household disposal modes for unused medicines



# Hospital waste management survey

- Five general hospitals within the 5 administrative divisions of Lagos state were surveyed
- Waste types generated were in the following categories: general, infective, anatomic, sharps and pharmaceutical.
- Facilities for waste treatment and waste segregation using international colour coded containers was inadequate at best



# Hospital waste management survey

- All wastes, liquid and solid were either not or inadequately pre-treated
- Liquid wastes were pumped directly into the lagoon directly in the majority of cases
- All the locations surveyed failed to meet international best standards for collection, segregation, pre-treatment, and final disposal.

	A	B	C	D	E
<b>Institutional HCWM strategy</b>					
Specific HCWM training	X	X	X	X	X
Monitoring quality of HCWM	Poor	Poor	Poor	Poor	Poor
Dedicated HCW quantity/type records	N/A	N/A	N/A	N/A	N/A
<b>Waste collection and segregation</b>					
Conformance with international HCW colour coding conventions	Fair	Fair	Fair	Fair	Fair
Quality of waste segregation	Poor	Poor	Poor	Poor	Poor
Availability of waste containers/ receptacles	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate
Appropriateness of containers for waste categories	Poor	Poor	Poor	Poor	Poor
Safety clothing and equipment	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate
Onsite treatment	X	X	X	X	X
Extra mural waste dumping	Yes	Yes	Yes	Yes	Yes
<b>HCW storage</b>					
Dedicated HCW storage facility	Yes	Yes	Yes	Yes	Yes
Adequate security against unauthorised access	Poor	Poor	Poor	Poor	Poor
Storage area safety and compliance with national and international rules?	Poor	Poor	Poor	Poor	Poor
Container adequacy (capacity, lidded/not lidded, wheeled, etc)	Poor	Poor	Poor	Poor	Poor
<b>Onsite HCW collection and transport</b>					
Collection frequency	Adequate	Adequate	Adequate	Adequate	Adequate
Transport equipment quality and adequacy	Poor	Poor	Poor	Poor	poor
Safety	Poor	Poor	Poor	Poor	Poor
HCW treatment	X	X	X	X	X
Final HCW waste disposal					
Collection frequency	Adequate	Adequate	Adequate	Adequate	Adequate
Transport equipment quality and adequacy	Poor	Poor	Poor	Poor	poor
Safety	Poor	Poor	Poor	Poor	poor
Appropriateness of final disposal sites	Poor	Poor	Poor	Poor	poor
Safety of collection staff and public	Poor	Poor	Poor	Poor	poor
Eco-friendliness of final disposal	Poor	Poor	Poor	Poor	poor

Treatment	X	X	X	X	X
<b>Hospital waste water</b>					
Adequacy/integrity of piping	Fair	Fair	Fair	Fair	Fair
Structural quality of holding facilities (septic tank, soak away, etc)	Poor	Poor	Poor	Poor	poor
Onsite treatment	X	X	X	X	X
Frequency of spills and overflows	Frequent	Frequent	Frequent	Frequent	Frequent
Appropriateness of collection vehicles	Poor	Poor	Poor	Poor	Poor
Safety (collection personnel)	Poor	Poor	Poor	Poor	Poor
Final disposal sites	SW	SW	SW	SW	SW
Eco safety	Poor	Poor	Poor	Poor	Poor

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