Laundry, Dry Cleaning Services and Environmental Pollution: Waste Water Physical-Chemical Parameters in Kisumu City, Kenya

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Abstract
Laundry and dry cleaning practices are a global process that contributes to the length and life of apparel and textile products. However, this process results in waste waters that may have an adverse effect on the environment. To investigate this, this paper looks at the need to ensure sanitation and waste water management along the entire value chain in Kisumu City, Kenya, by determining the levels of waste water physical-chemical parameters disposed of laundry and dry cleaning practices in relation to environmental pollution. The conceptual framework borrowed ideas from the Expectation Disconfirmation Theory. Cross-sectional survey and experimental design were employed. Levels of waste water physical-chemical parameters from households and commercial laundry and dry cleaning outlets were collected and determined at Lake Victoria Environmental Management (LVEMP) Laboratory and at Safe Water and Aids Project (SWAP) Laboratory and further analyzed using SPSS. The study established that the levels of waste water chemical parameters disposed off from LDC services from both commercial and household LDC service providers had negative impact to the general environment and aquatic life.
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1. Introduction

Laundry and Dry Cleaning (LDC) services play an important role in the society by preventing apparel and textile products from deteriorating, hence prolonging their life, maintaining their appearance and promoting hygiene (Melita, Claudia & Lilieth, 2005). The selection of proper LDC products and the use of correct LDC procedures and equipment settings can increase the wear life of apparel and textile products (Rose & Carol, 2016). The Kenya Literature Bureau (2009) and Mugambi, Mbuthia and Chege (2004) outlined LDC procedures as; repair, sorting, spotting, soaking, washing/dry cleaning, rinsing, drying, finishing and storage. Selection of specific LDC procedures is dependent on the fabric construction method, fiber and its properties, and special finishes. Recommended measures of which when adhered to can help in reduction of risk that can otherwise cause harm to the textile and apparel products under treatment, are provided in the care symbols (Isabel & Nyaradzo, 2013). Today's home and commercial LDC practices, as well as the products used, are vastly different from those used in the past. LDC services are now routine jobs shared by men, women and children and fabrics are now made from both natural and synthetic fibers. Laundry products are chemically formulated for varied water qualities and temperatures and are scientifically developed for specific cleaning purposes (Rose & Carol, 2016).

A study by Morgan, Bowling, Bartram and Kayser (2017) revealed a knowledge gap in the way LDC of apparel and textile products are handled, with the Sustainable Development Goal (SDG) 6 projections and targets not being keenly followed. These disposal of LDC waste has an implication on the environment. It is important that LDC service providers should therefore dispose such waste appropriately. As such, those working in the textile and apparel cleaning industry need to understand the tenets of contributing safe and clean water, and reducing pollution agents by safe waste disposal.

1.1 Levels of Waste Water Physical-Chemical Parameters Disposal of Laundry and Dry Cleaning Practices – A Short Review

The waste water used for washing is responsible for the pollution of the environment. The Material Safety Data Sheets (MSDS) as well as sources provide sources of waste that when used can guide on the effluents from washing water. While some chemicals and materials are no longer used for the washing in the United States, they are still being used in the developing countries. All product ingredients and constituents can be both hazardous and non-hazardous (Rashed & Niyazi, 2017). There are five categories of chemicals used in dry cleaning including; dry cleaning solvents, chemicals used in the process of dry cleaning machine, garment treatment chemicals, pre-cleaning and spotting agents, and chemicals used in solvent and equipment maintenance (State Coalition for Remediation of Dry Cleaners, 2009).

1.1.1 Raw Materials Used in Laundry and Dry Cleaning

The raw materials used in laundry and dry cleaning include laundry and dry cleaning agents, detergents, soaps, and chemicals. Some common names in dry cleaning industry include turpentine spirits, kerosene, camphor oil, white gasoline, chloroform, benzene, petroleum solvents, perchlorethylene, carbon tetrachloride, glycol ethers and liquid carbon dioxide among others. The petroleum dry cleaning solvents are the most widely used solvents in dry cleaning. Raw white gasoline has been the dry cleaning solvent of choice for the United States. Stoddard solvent is a mixture of petroleum distillate fractions that has over two hundred compounds. The component is composed of between 30-50% straight- and branched-chained alkanes, around 30-40% cycloalkanes as well as between 10 and 20% alkyl aromatic compounds (Han, Abel, Akkanen & Werner, 2017).

Hydrocarbons, which are used for cleaning textiles, are also sources of environmental pollution and thus, the components can be marked as potential sources of environmental pollutants. The petroleum materials used for cleaning have a challenge in biodegradation. The bacteria that are introduced into the dry-cleaning system in water to feed on the petroleum solvent, oils and fatty acids produce sour smells. The bactericides and the antioxidants used for the cleaning system (especially the detergents) are a source of foul smells and end up creating an environmentally unconducive environment. The products used for petroleum dry-cleaning solvents include *Desolan NT* and *Vermicide* which have been used as "bacteriostatics" and for preventing development of rancid odours, respectively.

Carbon tetrachloride is also used for dry cleaning operations, a component that has high toxicity with a tendency to cause corrosion on machinery. Perchlorethylene has also been used by commercial cleaners and it is associated with formation of hydrochloric acid that caused corrosion on metals (Ling, Apisarnthanarak, Villanueva, Pandjaitan, & Yusof, 2015). Detergents used in laundry and dry cleaning perform different functions such as carrying moisture to aid in the removal of water soils, suspending soil after it has been removed from the fabric, and acting as a spotting agent to aid in penetrating the fabric to allow the solvent to remove the stains. The anionic, non-anionic, and cationic detergents are classified based on their charge as well as how they carry water (ibid).

Pre-cleaning and spotting agents include the wet-side spotting agents, dry-side agents and the bleaches. Bleaches are either oxidizing or reducing bleaches. The garment treatment chemicals include the application of chemicals that do waterproofing, flame retardants, and stain repellents. The other group of raw materials include the surfactants, bleaching agents, minors, builders and enzymes that are used in dry cleaning industry. The types of laundry detergents include the heavy detergents, liquid detergents, power detergents, and ultra-detergents that can be used for dry cleaning (ibid).

1.1.2 Wastes Generated from the Raw Materials Used in Laundry and Dry Cleaning

Laundry detergents have an effect on the environment as pollutants as Bajpai and Tyagi (2007) reported. Much of the fresh water supplies have become polluted and dirty to consume. The environmentalists observe that people are being poisoned through consuming the poisoned water disposed-off from LDC processes. The chemicals are non-renewable and billions of tons are released into water daily, making water unsafe for human consumption. Laundry detergents that have concentrations of about 2 parts per million are capable of causing damage and death in fish, which can be translated to human consumption. When released into water, the phosphates that are used in detergents cause algal blooms that deplete oxygen in waterways as well as release toxins into the safe water. Accumulation of surfactants in both industries and household are toxic and when they accumulate, they become a challenge to biodegradation.

The anionic surfactant-based detergents (especially the sulphonates) are not degraded under the anaerobic conditions. The real environment conditions are more likely to be oxygen-limited than the rigorously anaerobic conditions (Han et al., 2017). Non-ionic surfactant-based detergents are more biodegradable. Washing inputs, processes and outputs in dry cleaning are important as they dictate the solid waste disposal and the potential for pollution. The outputs (solvents) from drycleaning include the remaining solvents, emitted VOCs (air emissions), lint, waste water, sludge and oil that when combined cause pollution on the environment. The wastes form washing detergents form a concern for pollution.

1.1.3 Constituents of Waste water

Waste water is return water after domestic and industrial use and can be classified into two main categories – organic and inorganic wastes. Organic wastes mainly come from domestic waste water, although industries also contribute a substantial amount. Some of these organic wastes are from vegetable and fruit packaging, oils and fat, dairy processing, meat packaging, tanning, paper, synthetic detergents, and fiber wood among others. Inorganic wastes originate from the industries such as chromium, mercury, cyanide and copper, and are very toxic to aquatic life (WASREB, 2008).

1.1.4 Effects of Wastes Eliminated by the Chemicals on the Environment

The effluent from washing water has been associated with pollution of water masses, and increased damage to aquatic life. The polluted water is passed into agricultural farms where it is used for crop farming, leading to contaminated crops, which end-up as food for human consumption. The focus on water waste is on the usage and the effect to other consumers who might inject food having the waste from LDC, or animals that might consume the pollutants and translate into food. Some detergents are associated with producing foul smell, polluting the air and consequently making the environment non-habitable (Han et al., 2017). Other solvents are corrosive in nature, a condition that makes them not suitable for washing machinery and other easily-corroded materials.

2. Research Methodology

An experiment was also carried out at Lake Victoria Environmental Management (LVEMP) Laboratory and at Safe Water and Aids Project (SWAP) Laboratory in Kisumu City, Kenya, where levels of waste water parameters were determined, analysed and then compared to the standard guidelines of the National Environment Management Authority (NEMA) in Kenya and World Health Organization (WHO) standards for discharge into environment and to the public sewer. The equipment used were; UV-spectrophotometer Hach methods and Atomic Absorption Spectrophotometer. Parameters used included: Zinc(Zn), Cadmium(CD), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Detergents, Mercury (Hg), Nitrate, Nitrite, Total Phosphate, pH, Total Dissolved Solids, Electrical Conductivity and Alkalinity. Table 1 shows the methods used to determine the levels of waste water chemical parameters from households and commercial outlets.

Table 1. Methods Used to Determine the Waste water Chemical Parameters Disposed from Household and Commercial LDC Outlets

Parameters	**Units**	**Methods**
Zinc (Zn)	Mg/l	Zincon 8009 - HACH
Cadmium(CD),	Mg/l	HACH8017
Chemical oxygen demand (COD)	Mg/l	Dichromate 8000
Biological oxygen demand (BOD),	BOD5	Digestion,BOD5
Detergent	MBAS	MBAS
Mercury (Hg),	Mg/l	Cold vapour 10065
Nitrate	Mg/l	HACH 8192
Nitrite	Mg/l	Ferosulphate 8153
Ammonia	Mg/l	Silicate 8155
Total Phosphate	Mg/l	HACH8048
PH	HACH pH meter units	HACH pH meter
Electrical conductivity	HACH EC meter units	HACH EC meter
Total dissolved solids (TDS)	HACH TDS meter units	HACH TDS meter
Alkalinity	Alkalinity meter units	Methyl orange method

Source: Lake Victoria Environmental Management and at Safe Water and Aids Project Laboratory, Kisumu City

3. Results

Table 2 shows the samples' results of parameters from 8 households and 4 commercial LDC Outlets. From Table 2, mean, standard deviation, minimum and maximum levels of parameters were derived as in Tables 3 and 4. Table 3 shows the mean, standard deviation, minimum and maximum effluent levels for different parameters/elements found in waste water in Kisumu City. The study's major concern was the maximum levels of discharge from the selected parameters. In the case of the households, the results were as follows: for nitrate it was 25.30 at Bandani, 27.20 at Korando B, 31.70 at Manyatta A, 26.30 at Nyalenda A with a grand maximum discharge level of 31.70; for ammonia, the level at Bandani was 0.03, Korando B 0.03, Manyatta A 0.03, Nyalenda A 0.03 with a grand maximum discharge level of 0.03; for phosphates, the levels were 0.38 at Bandani, 0.35 at Korando A, 0.42 at Manyatta A, 0.42 at Nyalenda A with a grand maximum level of discharge of 0.42.

As far as Nitrogen is concerned, the levels were 0.19 at Bandani, 0.25 at Korando A, 0.25 at Manyatta A, 0.25 at Nyalenda A with a grand maximum discharge level of 0.27; for TDS, the levels were 382 at Bandani, 388 at Korando A, 377 at Manyatta A, 422 at Nyalenda A with a grand maximum discharge level of 422. Regarding total alkalinity, the levels were 286 at Bandani, 234 at Korando A, 273 at Manyatta A, 288 at Nyalenda A with a grand maximum discharge level of 288 while for pH, the levels were 7.63 at Bandani, 8.22 at Korando A, 8.46 at Manyatta A, 7.90 at Nyalenda A with a grand maximum discharge level of 8.46. Concerning Zinc, the levels were 0.21 at Bandani, 0.28 at Korando A, 0.20 at Manyatta A, 0.27 at Nyalenda A with a grand maximum discharge level of 0.28. For electrical conductivity, the levels were 905 at Bandani, 901 at Korando A, 926 at Manyatta A, 887 at Nyalenda A with a grand maximum discharge level of 926. As far as the nitrates are concerned, the levels were 3.32 at Bandani, 3.22 at Korando A, 3.63 at Manyatta A, 3.85 at Nyalenda A with a grand maximum discharge level of 3.85 while for BOD, the levels were 33 at Bandani, 34 at Korando A, 42 at Manyatta A, 32 at Nyalenda A with a grand maximum discharge level of 42. Concerning COD, the levels were 330 at Bandani, 374 at Korando A, 427 at Manyatta A, 341 at Nyalenda A with a grand maximum discharge level of 427 while for detergents, the levels were 9.0 at Bandani, 9.0 at Korando A, 12.0 at Manyatta A, 11.0 at Nyalenda A with a grand maximum discharge level of 12.0. Regarding mercury, the levels were 0.02 at Bandani, 0.00 at Korando A, 0.02 at Manyatta A, 0.00 at Nyalenda A with a grand maximum level of discharge level of 0.02. For cadmium, the levels were 0.00 at Bandani, 0.02 at Korando A, 0.01 at Manyatta A, 0.00 at Nyalenda A with a grand maximum discharge of 0.02.

Table 2. Samples Results of Parameters from 8 Households and 4 Commercial LDC Outlets
Laboratory Results of LDC Waste from Household Service Providers

LOCATION	SAMPLING DATE	ANALYSES DATE	NITRATE	AMMONIA(NO3)	T. PHOSPHATE(TP)	T. NITROGEN(TN)	TDS	TOTAL ALKALINITY	PH	ZINC	E.CONDUCT	NITRITES	BOD	COD	DETERGENTS	MERCURY	CADMIUM
NYALENDA A1 1	13/02/2020	20/02/2020	26.2	0.0322	0.4234	0.2715	375	218	7.9	0.214	886	3.84	32	341	8	0	0
NYALENDA A2 1	13/02/2020	20/02/2020	26.3	0.0321	0.4233	0.2714	375	217	7.8	0.214	887	3.85	31	340	8	0	0
NYALENDA A3 1	13/02/2020	20/02/2020	26.3	0.0321	0.4233	0.2714	375	217	7.8	0.214	886	3.84	31	340	8	0	0
MANYATTA A 1	13/02/2020	20/02/2020	31.7	0.0216	0.3656	0.2279	369	198	8.46	0.122	926	3.62	41	427	11	0.01	0.01
MANYATTA A 2	13/02/2020	20/02/2020	31.6	0.0215	0.3657	0.2278	368	197	8.45	0.121	925	3.62	42	426	12	0.01	0.01
MANYATTA A 3	13/02/2020	20/02/2020	31.6	0.0215	0.3657	0.2278	368	197	8.45	0.121	925	3.63	42	426	12	0.01	0.01
BANDANI 1-1	13/02/2020	20/02/2020	25.3	0.0332	0.383	0.1925	280	220	7.62	0.109	871	3.32	33	330	8	0.02	0
BANDANI 1-2	13/02/2020	20/02/2020	25.2	0.0331	0.382	0.1923	279	219	7.63	0.108	872	3.31	32	329	9	0.02	0
BANDANI 1-3	13/02/2020	20/02/2020	25.2	0.0331	0.382	0.1923	279	219	7.62	0.109	872	3.32	32	329	9	0.02	0
BANDANI 2-1	13/02/2020	20/02/2020	24.2	0.0166	0.2813	0.1835	381	286	7.51	0.208	905	2.96	29	300	8	0	0
BANDANI 2-2	13/02/2020	20/02/2020	24.3	0.0165	0.2812	0.1834	382	286	7.52	0.209	904	2.95	28	301	7	0	0
BANDANI 2-3	13/02/2020	20/02/2020	24.3	0.0165	0.2812	0.1834	382	286	7.51	0.208	904	2.95	28	301	7	0	0
NYALENDA A 2-1	13/02/2020	20/02/2020	18.7	0.0188	0.3273	0.164	422	288	6.94	0.267	743	2.75	27	272	11	0	0
NYALENDA A 2-2	13/02/2020	20/02/2020	18.6	0.0189	0.3272	0.1639	421	287	6.95	0.268	744	2.76	26	271	10	0	0
NYALENDA A 2-3	13/02/2020	20/02/2020	18.6	0.0189	0.3272	0.1639	421	287	6.94	0.267	743	2.76	26	271	10	0	0
MANYATTA A 2-1	13/02/2020	20/02/2020	24.6	0.0268	0.42	0.2735	377	273	6.99	0.198	815	3.18	34	355	9	0.02	0
MANYATTA A 2-2	13/02/2020	20/02/2020	24.5	0.0267	0.419	0.2734	376	272	6.98	0.197	814	3.17	35	354	8	0.01	0
MANYATTA A 2-3	13/02/2020	20/02/2020	24.5	0.0267	0.419	0.2734	376	272	6.98	0.197	814	3.17	34	354	9	0.01	0
KORANDO B 1-1	13/02/2020	20/02/2020	27.1	0.0325	0.2562	0.1722	338	233	8.22	0.276	759	2.38	34	373	8	0	0.02
KORANDO B 1-2	13/02/2020	20/02/2020	27.2	0.0324	0.2561	0.1721	337	234	8.21	0.275	759	2.38	34	374	9	0	0.02
KORANDO B 1-3	13/02/2020	20/02/2020	27.2	0.0324	0.2561	0.1721	337	234	8.21	0.275	760	2.39	34	373	8	0	0.02
KORANDO B2-1	13/02/2020	20/02/2020	17.9	0.0255	0.3514	0.2463	327	198	8.11	0.263	900	3.21	25	198	6	0	0
KORANDO B2-2	13/02/2020	20/02/2020	17.8	0.0254	0.3513	0.2462	326	199	8.12	0.262	901	3.22	24	198	6	0	0
KORANDO B2-3	13/02/2020	20/02/2020	17.8	0.0254	0.3513	0.2462	326	198	8.12	0.262	901	3.21	24	199	7	0	0

Laboratory Results of LDC Waste from Commercial Service Providers

LOCATION	SAMPLING DATE	ANALYSES DATE	NITRATE	AMMONIA(NO3)	T. PHOSPHATE(TP)	T. NITROGEN(TN)	TDS	TOTAL ALKALINITY	PH	ZINC	E.CONDUCT	NITRITES	BOD	COD	DETERGENTS	MERCURY	CADMIUM
BELLAIRE-1	13/02/2020	20/02/2020	37.7	0.0321	0.528	0.9987	1653	1208	5.24	0.436	1432	0.92	36	310	0.9	0	0
BELLAIRE 2	13/02/2020	20/02/2020	37.6	0.0315	0.528	0.9986	1652	1207	5.23	0.435	1430	0.95	34	330	0.8	0	0
BELLAIRE 3	13/02/2020	20/02/2020	37.6	0.0331	0.528	0.9986	1652	1207	5.23	0.435	1431	0.65	46	320	0.8	0.01	0
FLUSH 1	13/02/2020	20/02/2020	49.7	0.0185	0.6567	1.1819	1521	1403	9.31	0.192	1635	0.48	32	320	0.8	0	0.01
FLUSH 2	13/02/2020	20/02/2020	49.6	0.0189	0.6566	1.1819	1520	1402	9.31	0.193	1632	0.49	36	360	0.9	0	0
FLUSH 3	13/02/2020	20/02/2020	49.6	0.0187	0.6566	1.1818	1520	1402	9.31	0.192	1632	0.45	34	330	0.92	0	0
WHITE ROSE 1	13/02/2020	20/02/2020	38.7	0.0324	0.981	0.7505	1541	1626	9.99	0.238	800	3.65	46	420	0.9	0.01	0
WHITE ROSE 2	13/02/2020	20/02/2020	38.6	0.0354	0.982	0.7506	1540	1625	9.98	0.237	880	3.68	42	440	0.8	0	0.01
WHITE ROSE 3	13/02/2020	20/02/2020	38.6	0.0324	0.982	0.7505	1540	1625	9.98	0.237	877	3.67	40	440	0.9	0	0
BLUE SEAL 1	13/02/2020	20/02/2020	46.9	0.0254	0.9658	0.795	1624	1457	4.89	0.313	786	2.95	44	330	0.9	0	0
BLUE SEAL 2	13/02/2020	20/02/2020	46.8	0.0224	0.9657	0.794	1623	1456	4.94	0.312	800	2.94	46	320	0.8	0.01	0.01
BLUE SEAL 3	13/02/2020	20/02/2020	46.8	0.0254	0.9657	0.794	1623	1456	4.89	0.312	887	2.98	42	300	0.8	0	0

Source: Lab Analysis Results

Table 3. Means, Standard Deviation, Minimum and Maximum Levels of Different Physical-Chemical Parameters of Household Waste water Discharge

SAMPLE SOURCE	STATISTICS	NITRATE	AMMONIA(NO3)	T. PHOSPHATE(TP)	T. NITROGEN(TN)	TDS	TOTAL ALKALINITY	PH	ZINC	ECONDUCT	NITRITES	BOD	COD	DETERGENTS	MERCURY	CADMIUM
Bandani	Mean	24.75	0.02	0.33	0.19	330.50	252.67	7.57	0.16	888.00	3.14	30.33	315.00	8.00	0.01	0.00
	Std	0.53	0.01	0.06	0.00	56.05	36.52	0.06	0.05	17.90	0.20	2.25	15.71	0.89	0.01	0.00
	Minimum	24.20	0.02	0.28	0.18	279.00	219.00	7.51	0.11	871.00	2.95	28.00	300.00	7.00	0.00	0.00
	Maximum	25.30	0.03	0.38	0.19	382.00	286.00	7.63	0.21	905.00	3.32	33.00	330.00	9.00	0.02	0.00
Korando B	Mean	22.50	0.03	0.30	0.21	331.83	216.00	8.17	0.27	830.00	2.80	29.17	285.83	7.33	0.00	0.01
	Std	5.11	0.00	0.05	0.04	6.05	19.36	0.05	0.01	77.41	0.45	5.31	95.85	1.21	0.00	0.01
	Minimum	17.80	0.03	0.26	0.17	326.00	198.00	8.11	0.26	759.00	2.38	24.00	198.00	6.00	0.00	0.00
	Maximum	27.20	0.03	0.35	0.25	338.00	234.00	8.22	0.28	901.00	3.22	34.00	374.00	9.00	0.00	0.02
Manyatta A	Mean	28.08	0.02	0.39	0.25	372.33	234.83	7.72	0.16	869.83	3.40	38.00	390.33	10.17	0.01	0.01
	Std	3.89	0.00	0.03	0.02	4.41	41.08	0.81	0.04	60.80	0.25	4.05	39.44	1.72	0.00	0.01
	Minimum	24.50	0.02	0.37	0.23	368.00	197.00	6.98	0.12	814.00	3.17	34.00	354.00	8.00	0.01	0.00
	Maximum	31.70	0.03	0.42	0.27	377.00	273.00	8.46	0.20	926.00	3.63	42.00	427.00	12.00	0.02	0.01
Nyalenda A	Mean	22.45	0.03	0.38	0.22	398.17	252.33	7.39	0.24	814.83	3.30	28.83	305.83	9.17	0.00	0.00
	Std	4.18	0.01	0.05	0.06	25.38	38.34	0.49	0.03	78.33	0.60	2.79	37.80	1.33	0.00	0.00
	Minimum	18.60	0.02	0.33	0.16	375.00	217.00	6.94	0.21	743.00	2.75	26.00	271.00	8.00	0.00	0.00
	Maximum	26.30	0.03	0.42	0.27	422.00	288.00	7.90	0.27	887.00	3.85	32.00	341.00	11.00	0.00	0.00
Total	Mean	24.45	0.03	0.35	0.22	358.21	238.96	7.71	0.21	850.67	3.16	31.58	324.25	8.67	0.01	0.00
	Std	4.28	0.01	0.06	0.04	41.06	35.99	0.53	0.06	66.45	0.44	5.21	65.84	1.66	0.01	0.01
	Minimum	17.80	0.02	0.26	0.16	279.00	197.00	6.94	0.11	743.00	2.38	24.00	198.00	6.00	0.00	0.00
	Maximum	31.70	0.03	0.42	0.27	422.00	288.00	8.46	0.28	926.00	3.85	42.00	427.00	12.00	0.02	0.02

Source: Lab Analysis Results

Table 4 shows the mean, standard deviation, minimum and maximum levels of different physical- chemical parameters of commercial waste water discharges. Similarly, for the commercial LDC service providers, as illustrated in Table 4, the results were as follows: For nitrate it was 37.70 at Bellaire, 46.90 at Blue Seal, 49.70 at Flush, 38.70 at White Rose with a grand maximum discharge level of 49.70, for ammonia the level at Bellaire was 0.03, Blue Seal, 0.02, Flush, 0.02, White Rose 0.04 with a grand maximum discharge level of 0.04. Regarding Total phosphates, the levels were 0.53 at Bellaire, 0.97 at Blue Seal, 0.66 at Flush, 0.98 at White Rose with a grand maximum level of discharge of 0.98. For Total nitrogen, the levels were 1.00 at Bellaire, 0.79 at Blue Seal, 1.18 at Flush, 0.75 at White Rose with a grand maximum discharge level of 1.18. Concerning TDS, the levels were 1653 at Bellaire, 1624 at Blue Seal, 1521 at Flush, 1541 at White Rose with a grand maximum discharge level of 1653.

For total alkalinity, the levels were 1208 at Bellaire, 1457 at Blue Seal, 1403 at Flush, 1626 at White Rose with a grand maximum discharge level of 1626. Concerning pH, the levels were 5.24 at Bellaire, 4.94 at Blue Seal, 9.31 at Flush, 9.99 at White Rose with a grand maximum discharge level of 9.99. For Zinc, the levels were 0.44 at Bellaire, 0.31 Blue Seal, 0.19 at Flush, 0.24 at White Rose with a grand maximum discharge level of 0.44. In regard to electrical conductivity, the levels were 1432 at Bellaire, 887 at Blue Seal, 1635 at Flush, 880 at White Rose with a grand maximum discharge level of 1635 while for nitrites, the levels were 0.95 at Bellaire, 2.98 at Blue Seal, 0.49 at Flush, 3.86 at White Rose with a grand maximum discharge level of 3.68.

For BOD, the levels were 46 at Bellaire, 46at Blue Seal, 36 at Flush, 46 at White Rose with a grand maximum discharge level of 46. Concerning COD, the levels were330 at Bellaire, 330 at Blue Seal, 360 at Flush, 440 at White Rose with a grand maximum discharge level of 440 while for detergents, the levels were 0.90 at Bellaire, 0.90 at Blue Seal, 0.92 at Flush, 0.90 at White Rose with a grand maximum discharge level of 0.92. As far as mercury is concerned, the levels were 0.01 at Bellaire, 0.01 at Blue Seal, 0.00 at Flush, 0.01 at White Rose with a grand maximum level of discharge level of 0.01 and finally for cadmium, the levels were 0.00 at Bellaire, 0.021at Blue Seal, 0.01 at Flush, 0.01 at White Rose with a grand maximum discharge of 0.01.

Table 4. Mean, Standard Deviation, Minimum and Maximum Levels of Different Physical- Chemical Parameters of Commercial Waste Water Discharges

Sample Source	Statistics	NITRATE	AMMONIA (NO3)	T. PHOSPHATE(TP)	T. NITROGEN(TN)	TDS	TOTAL ALKALINITY	PH	ZINC	E.C	NITRITES	BOD	COD	DETERGENTS	MERCURY	CADMIUM
BELLAIRE	Mean	37.63	0.03	0.53	1	1652.33	1207.33	5.23	0.44	1431	0.84	38.67	320	0.83	0	0
	Std	0.06	0	0	0	0.58	0.58	0.01	0	1	0.17	6.43	10	0.06	0.01	0
	Minimum	37.6	0.03	0.53	1	1652	1207	5.23	0.44	1430	0.65	34	310	0.8	0	0
	Maximum	37.7	0.03	0.53	1	1653	1208	5.24	0.44	1432	0.95	46	330	0.9	0.01	0
BLUE SEAL	Mean	46.83	0.02	0.97	0.79	1623.33	1456.33	4.91	0.31	824.33	2.96	44	316.67	0.83	0	0
	Std	0.06	0	0	0	0.58	0.58	0.03	0	54.72	0.02	2	15.28	0.06	0.01	0.01
	Minimum	46.8	0.02	0.97	0.79	1623	1456	4.89	0.31	786	2.94	42	300	0.8	0	0
	Maximum	46.9	0.03	0.97	0.8	1624	1457	4.94	0.31	887	2.98	46	330	0.9	0.01	0.01
FLUSH	Mean	49.63	0.02	0.66	1.18	1520.33	1402.33	9.31	0.19	1633	0.47	34	336.67	0.87	0	0
	Std	0.06	0	0	0	0.58	0.58	0	0	1.73	0.02	2	20.82	0.06	0	0.01
	Minimum	49.6	0.02	0.66	1.18	1520	1402	9.31	0.19	1632	0.45	32	320	0.8	0	0
	Maximum	49.7	0.02	0.66	1.18	1521	1403	9.31	0.19	1635	0.49	36	360	0.92	0	0.01
WHITE ROSE	Mean	38.63	0.03	0.98	0.75	1540.33	1625.33	9.98	0.24	852.33	3.67	42.67	433.33	0.87	0	0
	Std	0.06	0	0	0	0.58	0.58	0.01	0	45.35	0.02	3.06	11.55	0.06	0.01	0.01
	Minimum	38.6	0.03	0.98	0.75	1540	1625	9.98	0.24	800	3.65	40	420	0.8	0	0
	Maximum	38.7	0.04	0.98	0.75	1541	1626	9.99	0.24	880	3.68	46	440	0.9	0.01	0.01
Total	Mean	43.18	0.03	0.78	0.93	1584.08	1422.83	7.36	0.29	1185.17	1.98	39.83	351.67	0.85	0	0
	Std	5.39	0.01	0.2	0.18	57.63	155.79	2.41	0.1	371.24	1.42	5.22	51.49	0.05	0	0
	Minimum	37.6	0.02	0.53	0.75	1520	1207	4.89	0.19	786	0.45	32	300	0.8	0	0
	Maximum	49.7	0.04	0.98	1.18	1653	1626	9.99	0.44	1635	3.68	46	440	0.92	0.01	0.01

Source: Lab Analysis Results

Table 5 shows the comparison of the study results from households' effluents discharges while Table 6 illustrates the comparison of the study results from commercial effluents discharges.

Table 5. Comparison of the Study Results from Households Effluents Discharges from Nyalenda A, Manyatta A, Korando B and Bandani with NEMA/WHO Standards

PARAMETERS	UNIT	(NEMA/WHO STANDARDS) DISCHARGE INTO ENVIRONMENT	(NEMA/WHO STANDARDS) DISCHARGE INTO PUBLIC SEWER	RANGE OF RESULTS FROM THE LAB	EFFECTS TO THE ENVIRONMENT
PH	pH Scale	6.5-8.5	6-9	7.63 - 8.46	All the analyzed parameters were within the NEMA/ WHO standards for both public sewer and environmental discharges. Very high pH or very low pH (acidic) is not preferred due to corrosions and danger to aquatic lives.
BOD	mgO/l	30	500	32 – 42	Most of the analyzed parameters were above the discharge levels to the environment hence further treatment is necessary before discharge
COD	mgO/l	50	1000	330 – 428	Almost all of the analyzed parameters were above the discharge levels to the environment hence further treatment is necessary before discharge to the environment.
NITRATE	mg/l	20	20	25.30 – 31.70	High level of nitrates was associated with a lot of dissolved organic matter within the laundry effluent. The high presence of nitrates is due to the use of detergents and disinfectants in the laundry. High levels of nitrate can be carcinogenic.
NITRITE	mg/l	1	20	3.22 - 3.85	The guideline values of nitrite were not fixed since nitrite is unstable and easily converted to nitrate, though high levels above 1mg/l can result to high levels of nitrate which is carcinogenic.
TOTAL PHOSPHATE	mg/l	-	30	0.35 - 0.42	All the analyzed parameters were within both the NEMA/WHO standards for both public sewer and environmental discharges

Source: Lab Result Analysis

Table 6. Comparison of the Study Results from Commercial Effluents Discharges from Bellaire, Blue Seal, Flush and White Rose with NEMA/WHO Standards

PARAMETERS	**UNIT**	**(NEMA/WHO STANDARDS) DISCHARGE INTO ENVIRONMENT**	**(NEMA/WHO STANDARDS) DISCHARGE INTO PUBLIC SEWER**	**RANGE OF RESULTS FROM THE LAB**	**EFFECTS TO THE ENVIRONMENT**
PH	pH SCALE	6.5-8.5	6-9	4.94-9.9	Acidic or basic effluents were not fit to be discharged into the environment or public sewer. Very high pH or very low pH (acidic) is not preferred due to corrosions and danger to aquatic lives.
Detergent (MBAS)	mgCaCO3/l	Nil	15	0.90 – 0.92	All the analyzed parameters were within the discharge levels to both the sewer and environment hence further treatment is not necessary before discharge.
BOD	mgO/l	30	500	36 – 46	All the analyzed parameters were above the discharge levels to the environment hence further treatment is necessary before discharge
COD	mgO/l	50	1000	330 – 360	Almost all of the analyzed parameters were above the discharge levels to the environment hence further treatment is necessary before discharge to the environment.

Mercury(Hg)	mg/l	0.0	0.05	0.01	All the analyzed parameters were within both the NEMA/WHO standards for both public sewer and environmental discharges. Mercury is a very toxic element which poses threat to utero and early life. Toxic to the central and peripheral nerverse system. It can also cause neurological and behavioral disorders
Cadmium(Cd)	mg/l	0.01	0.05	0.00 -0.01	All the analyzed parameters were within both the NEMA/WHO standards for both public sewer and environmental discharges. High levels of cadmium results to kidney problems and it's also carcinogenic.
Nitrate (NO3)	mg/l	20	20	0.49 – 3.68	All the analyzed parameters were within both the NEMA/WHO standards for both public sewer and environmental discharges
Total Phosphate(TP)	mg/l	30	30	0.53 - 0.98	All the analyzed parameters were within both the NEMA/WHO standards for both public sewer and environmental discharges

Source: Lab Result Analysis

Waste waters always contain some elements which could either have high levels of discharge or low levels of discharge to the environment or to the public sewer. When the levels of discharge are higher than that of NEMA/WHO standards, the effects to the environment is negative and if within NEMA/WHO, the effects is positive hence good to the environment. The findings for the household effluent discharge levels were as follows: PH values were between (7.63 – 8.46) of the parameters and were found to be within both NEMA/WHO standards for both public sewer and environmental discharges; BOD values were between (32 - 42) of all the analyzed parameters and were found to be above the discharge levels to the environment hence further treatment was necessary before discharge; COD values were between (330 - 428) of all the analyzed parameters were above the discharge levels to the environment and further treatment was necessary before discharge to the environment; nitrate values were between (25.30-31.70) which was found to be of high when compared with NEMA/WHO hence was found to be associated with a lot of dissolved organic matter within the laundry effluent. The high presence of nitrates was due to the use of detergents and disinfectants in the LDC. High levels of nitrate could be carcinogenic; the guideline values of nitrite had not been fixed since nitrite was unstable and could be easily be converted to nitrate, though high levels of nitrite values were between (3.22– 3.85) and was found to be above 1mg/l could result to high levels of nitrate which is carcinogenic; and lastly total phosphate values were between(0.35-0.42) and were found to be within both the NEMA/WHO standards for both public sewer and environmental discharges.

Similarly, the effluents from the commercial LDC services were analysed and the findings were as follows: PH values ranged from (4.94-9.99). Out of the effluents discharged were all analysed and the parameters were found to be acidic or basic that was not fit to be discharged into the environment or public sewer. Very high pH or very low pH (acidic) was not preferred due to corrosions and danger to aquatic lives; detergents (MBAS) parameters analyzed were between (0.90–0.92) and were found to be within the discharge levels standards for both sewer and environment hence no further treatment was necessary before discharge. BOD values were between (36-46) of all the analyzed parameters and were found to be above the discharge levels to the environment hence further treatment was necessary before discharge; COD values were between (330-360) discharged levels and that almost all of the analyzed parameters were above the discharge levels to the environment hence further treatment was necessary before discharge to the environment; mercury(Hg) values were between (0.00-0.01) of all the analyzed parameters and were found to be within both NEMA/WHO standards for both public sewer and environmental discharges. Mercury is a very toxic element which poses threat to utero and early life. In addition, it is toxic to the central and peripheral perverse system and could also cause neurological and behavioral disorders.

Cadmium (CD) values were between (0.0-0.01) of all the analyzed parameters and were found to be within both the NEMA/WHO standards for both public sewer and environmental discharges. High levels of cadmium could results to kidney problems and it's also carcinogenic; nitrate (NO_3) was established to be of high levels which were between (37.70-49.70), that could be associated with a lot of dissolved organic matter within the LDC effluent. The high presence of nitrates was due to the use of detergents and disinfectants in the laundry. High levels of nitrate can be carcinogenic; and lastly total phosphate values were between (0.53-0.98) of all analyzed parameters were within both the NEMA/WHO standards for both public sewer and environmental discharges.

From these findings, it was concluded that most parameters from households were above the effluent discharge standards of NEMA/WHO hence were either acidic or basic or carcinogenic or corrosive or toxic which could be unsuitable both human, aquatic life and even to the environment while almost all the parameters from the commercial outlets were found to be within the effluents discharge standards of NEMA/WHO. These findings agree with what is in the literature review where we find Han et al. (2017) associating waste water effluent with pollution and damage to aquatic life. They noted that the polluted water when passed into agricultural farms contaminates crops which usually end-up as food for human consumption hence endangers life.

Detergents were also found to be associated with the production of foul smell, polluting the air and consequently making the environment non-habitable. Other elements /parameters were also found to be corrosive when produced above NEMA/WHO standards, a condition that makes them not suitable to be discharged directly to the environment without being treated. Most of the household's parameters were found to be above the effluents standards by NEMA/WHO hence could have negative impact to the environment whereas most sampled parameters from the commercial outlets were found to be within the effluents standards by NEMA/WHO and could impact the environment positively.

4. Discussion

Waste waters contained some elements which could either have high levels of effluent discharge or low levels of effluent discharge to the environment or to the public sewer. When the levels of discharge were higher than that of NEMA/WHO standards, the effects to the environment were negative and when the effluents discharge levels were within NEMA/WHO, the effects were positive hence good to the environment.

The effluent discharge levels for the households were: PH values were between (7.63 – 8.46) of the sampled parameters and were found to be within both NEMA/WHO standards for both public sewer and environmental discharges. BOD values were between (32 - 42) of all the analysed sampled parameters and were found to be above the discharge levels to the environment hence further treatment was necessary before discharge. COD values were between (330 - 428) of all the analyzed sampled parameters and were above the discharge levels to the environment and further treatment was necessary before discharge to the environment while nitrate values were between (25.30-31.70) which was found to be higher when compared with NEMA/WHO hence was found to be associated with a lot of dissolved organic matter within the laundry effluent.

The high presence of nitrates could have been due to the use of detergents and disinfectants in the LDC. High levels of nitrate could be carcinogenic; the guideline values of nitrite had not been fixed since nitrite was unstable and could be easily be converted to nitrate, though high levels of nitrite values were between (3.22– 3.85) and was found to be above 1mg/l which could result to high levels of nitrate which was carcinogenic; and lastly total phosphate values were between(0.35-0.42) and were found to be within both the NEMA/WHO standards for both public sewer and environmental discharges.

Similarly, the effluents from the commercial LDC services were analyzed and the findings were: PH values were between (4.94-9.99) of the effluents discharge were all analyzed and the sampled parameters were found to be acidic or basic that was not fit to be discharged into the environment or public sewer. Very high pH or very low pH (acidic) was not preferred due to corrosions and danger to aquatic lives; detergents (MBAS) parameters analyzed were between (0.90–0.92) and were found to be within the discharge levels standards for both public sewer and environment hence no further treatment was necessary before discharge. BOD values were between (36-46) of all the analyzed sampled parameters and were found to be above the discharge levels to the environment hence further treatment was necessary before discharge.

COD values were between (330-360) discharged levels and that almost all of the analyzed sampled parameters were above the discharge levels to the environment hence further treatment was necessary before discharge to the environment; mercury(Hg) values were between (0.00-0.01) of all the analyzed sampled parameters and were found to be within both NEMA/WHO standards for both public sewer and environmental discharges. Mercury is a very toxic element which poses threat to utero and early life, toxic to the central and peripheral perverse system. It could also cause neurological and behavioral disorders; Cadmium (CD) values were between (0.0-0.01) of all the analyzed sampled parameters and were found to be within both the NEMA/WHO standards for both public sewer and environmental discharges. High levels of cadmium could result to kidney problems and it is also carcinogenic; nitrate (NO_3) was established to be of high levels which were between (37.70-49.70) that could be associated with a lot of dissolved organic matter within the LDC effluent. The high presence of nitrates was due to the use of detergents and disinfectants in the laundry. High levels of nitrate can be carcinogenic; and lastly total phosphate values were between (0.53-0.98) of all analyzed sampled parameters and were within both the NEMA/WHO standards for both public sewer and environment. Most parameters from households were above the effluent discharge standards of NEMA/WHO hence were either acidic or basic or carcinogenic or corrosive or toxic which was unsuitable for human life, aquatic life and even to the environment. Almost all the parameters from the commercial LDC outlets were found to be within the effluents discharge standards of NEMA/WHO hence could not affect the environment.

5. Conclusion and Recommendations

This paper has demonstrated that the levels of waste water chemical parameters disposed off from LDC services from both commercial and household LDC service providers had negative impact to the general environment and aquatic life. The low and/or high PH values of the effluents was dangerous to the aquatic lives due to their corrosive nature, while chemicals like nitrate, cadmium, and nitrite that were discharged above the minimum standards set by NEMA and WHO were carcinogenic, and both biological oxygen demand (BOD) and chemical oxygen demand (COD), were also discharged in great quantities that was detrimental to the environment. The use of LDC agents, detergents, and disinfectants were posing a threat to the environment. Before discharge into a public sewer, the effluent should be further treated to mitigate against further adverse effects on the environment. Most of the analyzed parameters for the household did not meet NEMA/WHO standard of effluent discharge to the environment hence further measures need to be taken to neutralize them while most of the analyzed parameters for commercial LDC meet NEMA/WHO standards. There is thus a need for all government agencies, policy makers and stakeholders to ensure commercial and household LDC service providers are not only aware of the requisite policies and regulations aimed at protecting the environment, but also actively implement them.

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