Research Article

Parasitological and Microbiological Characteristics of Wastes Generated and Impact on Water Sources Next to Abattoir Facilities in Lurambi Sub County. Kakamega County

Ochieng Onunga George*, Owuor Ndonga Millicent Florence, Mario Kollenberg

Department of Biological Sciences, Masinde Muliro University of Science and Technology (MMUST), P.O Box 190 - 50100, Kakamega, Kenya.

Abstract | Slaughterhouse processes consist of several pollutants, including condemned meat parts, aborted fetuses, animal trimmings, horns, undigested ingesta (paunch contents), bones, and hairs. In contrast, liquid parts consist of blood, dissolved solids, urine, gut contents, and wastewater from slaughter operations and floor cleaning. It has been reported that Abattoir wastes can have negative impacts on the areas surrounding them by causing pollution and public health concerns. Therefore, this research was initiated with the main objective being to evaluate the Parasitological and Microbiological Characteristics of Wastes Generated and the Impact on Water Sources next to the Abattoir in Lurambi sub-county Kakamega County. Laboratory investigations were carried out for two months during the dry and wet seasons. Wastewater samples from five slaughterhouses and water samples from water sources next to the abattoirs were examined using standard procedures. The bacteria isolated *were E. coli, P. aeruginosa, K. pneumoniae, E. faecalis, and S. dysenteriae*. Bacterial concentrations cfu/100ml of abattoir effluents ranged from 3.17×10^6 of TC. $3.94x10^4$ of FC, $2.84x10^4$ of *E. faecalis*, $8.65x10^4$ of *E. coli*, and BOD of 828.04mg/l.Fungi isolated were., *Aspergillus n*iger, Fusarium oxysporum, Penicillium spp, Aspergillus fumigatus, Saccharomyces cerevisiae, Aspergillus flavus. Parasites isolated from samples of effluent and water were *Balantidium coli, Trichomonas hominis, Ancylostoma duodenale,* and *Ascaris lumbricoid*. It was concluded that the abattoir wastes were unsuitable for discharge to the environment and resulted in water pollution near abattoirs that may cause serious waterborne diseases. The baseline information obtained from the results can be used by government authorities such as National Environmental Management Authority and researchers.

Keywords | Abattoirs, Abattoir wastes, Bacteria, Fungi, Parasites

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***Correspondence** | Ochieng Onunga George, Department of Biological Sciences, Masinde Muliro University of Science and Technology (MMUST), P.O Box 190 - 50100, Kakamega, Kenya; **Email:** gonunga@gmail.com
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INTRODUCTION

Anthropogenic processes, including slaughterhouses, generate wastes that need to be handled properly to protect public health and surroundings while enhancing the perception of beauty (NEMA, 2014). Urban settlements, due to high population, rapid urbanization, and changing community affluence, generate large quantities of solid waste, which, if improperly disposed of, can impact negatively on the environment, particularly in cities and big towns (NEMA, 2014). In industrialized countries, the waste management system is tightly regulated and closely monitored, thus reducing its risk to public health (Rushton, 2003). Over the past 15-20 years, solid waste

management has been a greater success and lesser extent, wastewater management. Wastes generated by urban livestock markets, slaughterhouses, and related facilities have been neglected (World Bank, 2009). Most slaughterhouses in developing countries in Africa, such as Kenya, Nigeria, Uganda, etc., are owned by private individuals or local government authorities. The structures are operating above their original capacities and are in decrepit condition. If not appropriately treated and disposed of, the wastes from these facilities may cause public health and environmental disasters (World Bank, 2009).

It should be noted that the annual per capita meat consumption in developing countries is increasing due to the high population and increasing per capita income; thus, large numbers of livestock, especially cows and shoats, are being slaughtered to meet the market demand (FAO, 2010). The large number of animals slaughtered comes with increased waste that must be environmentally handled to avoid contamination. An abattoir is defined as an approved specialized facility properly designed for hygienic ante mortem inspection, slaughtering, and carcass processing of animal meat and meat products for consumption by humans (Alonge, 2005). Slaughter wastes comprise solid, liquid, and gas components. The solid waste is mostly made up of bones, condemned parts, paunch contents, hairs, undigested ingesta and in certain instances, aborted fetuses; the liquid part comprises wash wastewater, dissolved solids, urine, blood, and gut contents. Gas wastes are Odors and emissions from the processing and putrefaction of dumped wastes (Fearon et al., 2014). In developing countries, water supply infrastructure is poorly developed, and slaughtering operations require large water quantities; thus, most abattoirs are located next to underground and surface water bodies. Due to proximity to abattoir waste disposal sites, the quality of groundwater and surface water sources is affected by leachates which contaminate aquifers and introduce enteric pathogens, parasites, and nutrients into waterways (Adegbola et al., 2012; Hassan et al., 2014). The harmful risk of waste on water, air, and land often occurs when wastewater is improperly channelled into water bodies and when solid wastes heaps are left in open spaces unattended, thus acting as non-point sources of pollution when precipitation takes place. The water bodies also act as the easiest way for abattoirs to dispose of the wastes as they lack waste treatment facilities and are not connected to sewer lines. The management of abattoir waste disposal has become a major issue or problem in developing countries in Asia and Africa. In countries like Ghana, Cameroon, Nigeria, Rwanda, and Kenya it has been reported to cause air, water, and soil pollution and pose serious public health risks (Regina et al., 2017; Koech et al., 2012; Nwanta et al., 2008). This research was initiated with the main objective being to evaluate the Parasitological and Microbiological Characteristics of Wastes Generated and the Impact on Water Sources next to Abattoirs in Lurambi sub-county Kakamega County.

MATERIALS AND METHODS

Description of the study area

Kakamega County is in the western region of Kenya, with Lurambi sub-county located at a Latitude is 0017' 49.992" N Longitude 340 45' 58.3524" E. Over the years, Lurambi Sub-County has experienced exponential growth both demographically and spatially due to being a nodal settlement and headquarters of Kakamega County. The research was done on five slaughterhouses in Lurambi sub-county Kakamega (Figure 1). As common in most Kenyan cities, slaughterhouses are located in different areas of Lurambi Township among residences with no regard for their compatibility (Plate 1-6). This is against the existence of legislation that governs the location and operations of slaughterhouses both at the national and county level (Meat control act, 2012, Kakamega county abattoir act, 2017).

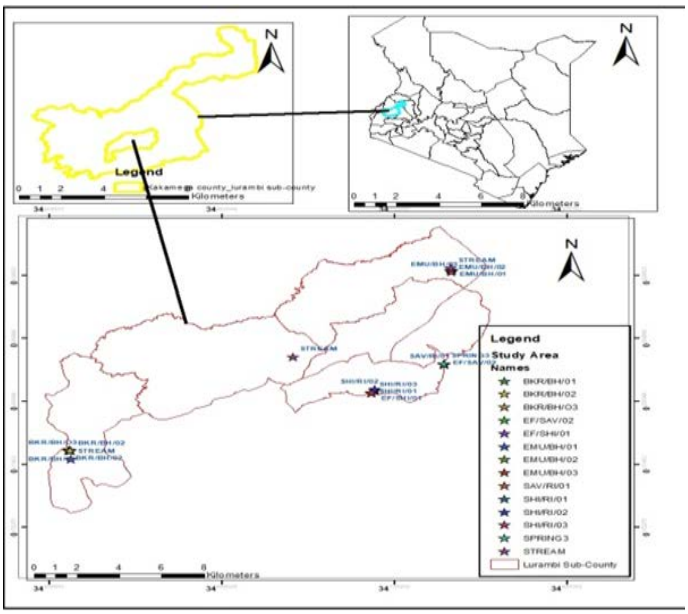

Figure 1: Map of study sites

Sample collection

Triplicate water sources and wastewater from abattoirs samples were collected from March to April 2021 (wet season) and December to February 2022 (dry season). Wastewater effluents were collected when it was entering the lagoons for Shirere and Savona abattoirs and at disposal pits for Bukura, Ejinja corner, and Emusala abattoirs. The water samples were collected from borehole/hand dung wells within the abattoirs (0-250m) and 250-500m early when abattoir operations were at their peak and labelled properly. The river water was collected from three (3) different points, namely, 50 meters upstream (before

mixing with the abattoir effluent), Point of discharge, and 50m downstream (after mixing with the abattoir effluent). Sampling was done between 6.00 am and 10.00 am when slaughtering operations and cleaning were done. Samples were preserved and analyzed in each case according to Standard Methods of Wastewater Analysis (APHA, 2017) and compared to WHO standards

Data analysis

The data obtained were analyzed using the ANOVA test at a 95% confidence level to test significant differences between the means. This was done using SPSS version 20.0.

Bacteriological Analysis

Media prepared per the manufacturer's directives for the analysis were Mac Conkey Agar, Nutrient Agar, and Blood

Plate 1: Emusala abattoir lagoon next to borehole

Plate 2: Shirere lagoon during dry

Plate 3: Shirere lagoon overflowing

Plate 4: Savona lagoon next to River

Plate 5: Broken Down Waste Pipe

Plate 6: Savona Lagoon Overflowing

Agar. The pour plate technique was employed to culture and enumerate bacteria in the water and effluent samples. Aliquots of 0.5ml of serially diluted samples were inoculated in triplicate plates of the prepared agar plates. At 37°C, the plates were incubated for 24 hours in an aerobic environment. The Stuart/Sc6+ colony counter was used to count the number of distinct colonies on the media plates. Colony-forming units per millilitre (CFU/ml) of the sample were used to illustrate this.

Bacterial Identification: By repeated sub-culturing, pure colonies were obtained for further characterization and identification using biochemical and microscopy tests. Colony morphology based on characteristic shape, size, colour, surface appearance, and texture was used to determine the bacteria type. Biochemical tests: Indole production, Gram's reaction, Catalase, Urease, Methyl red, Citrate test, Voges Proskauer, Glucose test, Lactose test, sucrose test, Motility test H_2S test, Gas test and Oxidase were employed on isolates for identification. Biochemical Oxygen Demand (BOD) was done according to APHA procedures on the water and wastewater samples

Fungal Analysis

The media prepared according to the manufacturer's directives for the analysis was potato dextrose agar (PDA). One millilitre (1ml) of each diluted sample was transferred into sterile triplicate Petri-dishes. Then cooled Potato Dextrose Agar (PDA) in a molten state was poured aseptically into a petri dish and swirled to distribute the samples evenly. The plates were allowed to be set undisturbed at 25°C for five days and examined for fungal growth. Distinct colonies on each plate were counted and expressed as Cfu/ml (colony forming units /millilitre). (APHA).

Fungal Identification: Using a sterile inoculating needle, different distinct representative colonies were transferred to a sterile solidified PDA (Spread technique) and placed in an incubator at 30°C for three days. Distinct colonies on each plate were counted and expressed as Cfu/ml (colony forming units /millilitre) (APHA). Based on macroscopic observations of colony morphology, colour, texture, shape, appearance, and microscopic characteristics of septation in mycelium, reproductive structures, structure and shape of conidia (Cheesebrough, 2009).

Parasitological analysis

The modified Bailenger method (MBM) (Rachel et al., 1996) was employed to analyse parasites. The equation n = ax / PV was used to quantify parasites.

Where

n represents number of eggs or (oocysts L^{-1} of wastewater

a represents counted number of eggs or oocysts

x is the volume of the final product (mL),

p is the volume examined (0.15mLfor MBM and 0.05ml for ZN),

v represents the original sample volume (L).

Parasite identification: Based on morphological and morphometric parasitological criteria, including size parasite identification was done. Using a calibrated microscope at magnifications of 100x, 400x, and 1000x, we distinguished between protozoan (oo)cysts and helminth eggs.

Table 1: Mean values of Bacteria, Fungi and Parasites of abattoir sites in Lurambi Sub County Kakamega County during Wet season

	Microbial counts							
Abattoir	**Sample type**	**Total coliform count (MP-N/100ml)**	**Faecal coliform (cfu/100ml)**	***Enterococci faecalis* (cfu/100ml)**	***Escherichia coli* (cfu/100ml)**	**BOD (mg/l)**	**Fungi (cfu/ml)**	**Parasites (Trophozoite/ eggs/ 100 g)**
Bukura	Effluent	8.17×10^5	4.37×10^4	1.97×10^4	2.03×10^3	2.63×10^3	6.80×10^3	1.10×10^2
	Bore hole 0-250m	6.07×10^2	37	28	11	12	1.88×10^3	28

	Bore hole 250- 500m	1.03 x10^2	1.30 x10^2	10	0	5	8.33	0
Ejinja corner	Effluent	4.73 x10^5	3.82 x10^4	3.41 x10^4	5.79 x10^5	2.63 x10^3	4.93 x10^5	1.27 x10^2
	Bore hole 0-250m	4.27 x10^2	26	13	8	12	18.33	25
	Bore hole 250- 500m	87	12	10	0	5	8.33	0
Shirere	Effluent	3.37 x10^5	3.20 x10^4	2.90 x10^4	6.13 x10^3	1.04 x10^2	5.71 x10^5	1.04 x10^2
	Lagoon	4.13 x10^5	3.90 x10^4	3.47 x10^4	6.87 x10^3	1.08 x10^2	7.0 x10^5	1.29 x10^2
	50m above upstream	2.77 x10^3	3.97 x10^2	2.43 x10^2	120	11	1.40. x10^2	87
	At point of discharge	5.40 x10^5	1.17 x10^4	1.13 x10^5	2.87 x10^3	28	6.24 x10^5	1.17 x10^2
	50m below point of discharge	6 x10^5	1.87 x10^4	1.63 x10^4	3.50 x10^3	11	6.43 x10^5	1.49 x10^2
Savona	Effluent	7.30 x10^5	3.60 x10^4	1.63 x10^4	1.87 x10^3	1.05 x10^2	2.15 x10^4	1.08 x10^2
	Lagoon	8 x10^5	4.30 x10^4	2.07 x10^4	2.10 x10^3	1.07 x10^2	6.24 x10^4	1.36 x10^2
	Bore hole 0-250m	4.67 x10^2	27	15	8	13	16.33	23.00
	Spring	3.54 x10^2	29	18	11	9	17.00	47.00
Emusala	Effluent	3.46 x10^5	3.25 x10^4	3.03 x10^4	6.10 x10^3	106	5.25 x10^5	1.08 x10^2
	Lagoon	4.03 x10^5	3.90 x10^4	3.6 x10^4	6.90 x10^3	5 x10^2	6.95 x10^5	1.57 x10^2
	Bore hole 0-250m	4.37 x10^2	24	12	8	12	18.33	23.00
	Bore hole 250- 500m	1.23 x10^2	14	9	0	5	4.67	`0.00

Table 2: Mean values of Bacteria, Fungi and Parasites of abattoir sites in Lurambi Sub County Kakamega County during Dry season

		Microbial counts						
Abattoir	**Sample type**	**Total coliform count (cfu/100ml)**	**Faecal coliform (cfu/100ml)**	***Enterococci faecalis* (cfu/100ml)**	***Escherichia coli* (cfu/100ml)**	**BOD (mg/l)**	**Fungi (cfu/ml)**	**Parasites (Trophozoite/ Larvae per 100g)**
Bukura	Effluent	1.01 x10^6	6.53x10^4	3.78 x10^4	3.073 x10^3	3.101 x10^3	7.81 x10^3	1.22 x10^2
	Bore hole 0-250m	7.20 x10^2	44	30	19	13	20	20
	Bore hole 250- 500m	1.30 x10^2	15	13	0	6	7.33	0
Ejinja corner	Effluent	5.78. x10^6	4.62 x10^4	4.13 x10^4	6.52 x10^5	2.831 x10^3	58.06	1.32 x10^2
	Bore hole 0-250m	4.91 x10^2	31	22	12	13	14	20
	Bore hole 250- 500m	1.13 x10^2	13	12	0	6	7.67	0

Shirere	Effluent	4.33. x10^6	3.97 x10^4	2.9 x10^4	6.90 x10^3	1.10 x10^2	6.46 x10^3	1.26 x10^2
	Lagoon	5.1 x10^6	4.47 x10^4	4.10 x10^4	7.58 x10^3	115	7.78 x10^5	1.43 x10^2
	50m above point of discharge	3.8 x10^3	5.06 x10^2	3.60 x10^2	19	12	21	1.03 x10^2
	At point of discharge	6.82 x10^5	2.50 x10^4	2.17 x10^4	3.633 x10^3	33	3.90 x10^3	1.14 x10^2
	50m below point of discharge	7.1 x10^5	2.88 x10^4	2.58 x10^4	4.58 x10^3	12	2.8 x10^3	1.69 x10^2
Savona	Effluent	8.59. x10^5	47733.33	27833.33	2876.67	1.11 x10^2	6.52 x10^3	1.31 x10^2
	Lagoon	8.87 x10^5	5.50 x10^4	3.30 x10^4	3.16 x10^3	1.12 x10^2	2966.67	1.60 x10^2
	Bore hole 0-250m	5.85 x10^2	34	20	12	13	19	30
	Spring	5.10 x10^2	31	19	8	9	6.67	64
Emusala	Effluent	4.80 x10^6	4.58 x10^4	4.16. x10^4	7.78 x10^3	1.11 x10^2	7.13 x10^5	1.25 x10^2
	Lagoon	5.19 x10^6	4.58 x10^4	4.21 x10^4	7.48 x10^4	1.14 x10^2	7.89 x10^5	1.82. x10^2
	Bore hole 0-250m	5.42 x10^2	29	19	12	13	1.83 x10^3	18
	Bore hole 250- 500m	1.77 x10^2	18	11	0	7	8	0

Table 3: Morphological Identification of Bacteria Isolates in Abattoirs in Lurambi Sub County Kakamega County

Sample type	Morphological characteristics
Effluent	Small circular Colonies, white, raised. Smooth edges
	Small circular colonies, white, smooth edges
	large milky flat colonies, rough edges
	circular, white/cream, entire edges, smooth
Lagoon	small circular white colonies raised smooth edges
	small circular white colonies smooth edges
	large milky flat colonies, rough edges
	circular, white/cream, entire edges, smooth
Borehole water	small circular white colonies raised smooth edges
	Small circular colonies, white, raised. rough edges
	large milky flat colonies, rough edges
	circular, white/cream, entire edges, smooth
River water	small circular white colonies raised rough edges
	small circular white colonies raised smooth edges
	circular, white/cream, entire edges, smooth
	large milky flat colonies, rough edges
Spring	small circular white colonies raised smooth edges
	circular, white/cream ,entire edges, smooth
	large milky flat colonies, rough edges

Table 4: Biochemical Characteristics of Bacteria Isolated In Abattoirs Lurambi Sub County (Kakamega County)

Grams reaction	Catalase	Citrate	Indole	urease	MR	V/P	Glucose	lactose	Sucrose	Motility	H2S	Gas	Micro organism
- rods	+	-	+	-	+	-	+	+	-	+	-	+	*Escherichia coli*
- rods	+	+	-	-	+	-	+	+	+	+	-	-	*Psedomonas aerugenosa*
- rods	+	+	+	-	+	-	+	+	+	-	-	+	*Klebsiella pneumoniae*
+ ve cocci	-	-	-	-	-	+	+	+	+	-	-	-	*Enterococcus faecalis*
- rods	+	+	+	-	+	-	+	-	-	-	-	+	*Shigella dysenteriae*

Table 5: Bacteria Identified at Bukura, Ejinja and Emusala Abattoirs in Lurambi Sub County Kakamega County.

Abattoir	Sample type	Code	Micro organism
BUKURA	Effluent	BBEW-1	*Escherichia coli*
		BBEW-2	*Pseudomonas aerugenosa*
		BBEW-3	*Klebsiella pneumoniae*
		BBEW-4	*Enterococcus faecalis*
	Borehole 0-250m	BB1W-1	*Enterococcus faecalis*
		BB1W-2	*Escherichia coli*
		BB1W-3	*Shigella dysenteriae*
	Borehole 250-500m	BB2W-1	*Klebsiella pneumoniae*
		BB2W-2	*Escherichia coli*
EJINJA	**Effluent**	EJEW-1	*Pseudomonas aerugenosa*
		EJEW-2	*Escherichia coli*
		EJEW-3	*Klebsiella pneumoniae*
		EJEW-4	*Enterococcus faecalis*
	Borehole 0-250m	EJB1W-1	*Escherichia coli*
		EJB1W-2	*Shigella dysenteriae*
		EJB1W-3	*Klebsiella pneumoniae*
		EJB1W-4	*Enterococcus faecalis*
	Borehole 250-500m	EJB2W-1	*Escherichia coli*
		EJB2W-2	*Klebsiella pneumoniae*
		EJB2W-3	*Enterococcus faecalis*
EMUSALA	Effluent	EMEW-1	*Pseudomonas aerugenosa*
		EMEW-2	*Klebsiella pneumoniae*
		EMEW-3	*Escherichia coli*
		EMEW-4	*Enterococcus faecalis*
	Borehole 0-250m	EMB1W-1	*Shigella dysenteriae*
		EMB1W-2	*Enterococcus faecalis*
		EMB1W-3	*Escherichia coli*

	Borehole 250-500m	EMB2W-1	*Escherichia coli*
		EMB2W-2	*Enterococcus faecalis*
		EMB2W-1	*Escherichia coli*
		EMB2D-2	*Enterococcus faecalis*
	Lagoon	EMLW-1	*Pseudomonas aerugenosa*
		EMLW-2	*Escherichia coli*
		EMLW-3	*Klebsiella pneumoniae*

Table 6: Bacteria Identified at Shirere and Savona abattoir sites in Lurambi Sub County Kakamega County

Abattoir	Sample type	Code	Micro organism
SHIRERE	Effluent	SHEW-1	*Pseudomonas aerugenosa*
		SHEW-2	*Klebsiella pneumoniae*
		SHEW-3	*Enterococcus faecalis*
		SHEW-4	*Escherichia coli*
	50m above Upstream	SHWU-1	*Shigella dysenteriae*
		SHWU-2	*Escherichia coli*
		SHWU-3	*Enterococcus faecalis*
		SHWU-4	*Klebsiella pneumoniae*
	At point of discharge	SHOW-1	*Shigella dysenteriae*
		SHOW-2	*Escherichia coli*
		SHOW-3	*Klebsiella pneumoniae*
		SHOW-4	*Enterococcus faecalis*
	River 50m below point of discharge	SHWE-1	*Shigella dysenteriae*
		SHWE-2	*Klebsiella pneumoniae*
		SHWE-3	*Escherichia coli*
		SHWE-4	*Enterococcus faecalis*
	Lagoon	SHLW-1	*Escherichia coli*
		SHLW-2	*Pseudomonas aerugenosa*
		SHLW-3	*Klebsiella pneumoniae*
		SHLW-4	*Enterococcus faecalis*
SAVONA	Effluent	SAEW-1	*Escherichia coli*
		SAEW-2	*Pseudomonas aerugenosa*
		SAEW-3	*Klebsiella pneumoniae*
		SAEW-4	*Enterococcus faecalis*
	Bore hole (0-250m)	SAB1W-1	*Klebsiella pneumoniae*
		SAB1W-2	*Escherichia coli*
		SAB1W-3	*Shigella dysenteriae*
		SAB1W-4	*Enterococcus faecalis*
	Spring	SASW-1	*Escherichia coli*
		SASW-2	*Enterococcus faecalis*
		SASW-3	*Klebsiella pneumoniae*
	Lagoon	SALW-1	*Escherichia coli*
		SALW-2	*Enterococcus faecalis*
		SALW-3	*Klebsiella pneumoniae*

Table 7: Morphological identification of Fungi

MACROSCOPY	MICROSCOPY	IDENTIFICATION
Upper surface olive green, white edges, granular surface, green coloration on reverse	conidiophores thick walled, hyaline roughened, erect long aseptate with vesicle short conidial chains	*Aspegillus flavus*
widely spread colonies, black, smooth white edges, spongy surface, brown on reverse side	conidiophores long erected, smooth walled, hyaline with globes conidial heads	*Aspergillus niger*
colony widely spread, dark green, smooth white edges, spongy surface, brown on reverse	Conidiophores long, narrow at base smooth walled hyaline	*Aspergillus fumigatus*
Pale pink in colour, fluffy white growth, dark violet on reverse side	macroconidia canoe shaped, single celled, oval shape	*Fusarium oxysporum*
White cream, smooth, ellipsoidal in shape	Oval yeasts budding presence	*Saccharymyoces cerevisae*
White cream yellow colour, reverse colour white to cream yellow	conidiophores, simple branched terminated by clusters of flask shaped philades	*Penicillium species*

Table 8: Fungi Identified at Bukura, Ejinja and Shirere Abattoir sites in Lurambi Sub County Kakamega County

Abattoir	Sample type	Identification
BUKURA	**Effluent**	*Aspegillus flavus*
		Aspergillus niger
		Aspergillus fumigatus
		Fusarium oxysporum
	Borehole 0-250m	*Saccharymyoces cerevisae*
		Aspergillus fumigatus
		Fusarium oxysporum
	Borehole 250-500m	*Saccharymyoces cerevisae*
EJINJA	**Effluent**	*Saccharymyoces cerevisae*
		Penicillium species
		Aspergillus fumigatus
		Fusarium oxysporum
	Borehole 0-250m	*Saccharymyoces cerevisae*
		Penicillium species
	Borehole 250-500m	*Aspergillus niger*
SHIRERE		*Saccharymyoces cerevisae*
	Effluent	*Aspegillus flavus*
		Aspergillus niger
		Aspergillus fumigatus
	50m above upstream	*Aspergillus niger*
		Saccharymyoces cerevisae
	At point of discharge	*Aspergillus niger*
		Penicillium species
		Saccharymyoces cerevisae
	River 50m below point of discharge downstream	*Aspergillus niger*
		Penicillium species
		Saccharymyoces cerevisae

	Lagoon	*Fusarium oxysporum*
		Aspegillus flavus
		Aspergillus niger
		Aspergillus fumigatus

Table 9: Fungi Identified at Savona and Emusala Abattoir sites in Lurambi Sub County Kakamega County

Abattoir	Sample type	Identification
SAVONA	Effluent	*Aspegillus flavus*
		Aspergillus niger
		Aspergillus fumigatus
		Fusarium oxysporum
	Bore hole (0-250m)	*Saccharymyoces cerevisae*
		Penicillium species
		Aspergillus niger
	Spring	*Saccharymyoces cerevisae*
		Penicillium species
		Aspergillus niger
	Lagoon	*Aspegillus flavus*
		Aspergillus niger
		Aspergillus fumigatus
		Fusarium oxysporum
EMUSALA	Effluent	*Aspegillus flavus*
		Aspergillus niger
		Aspergillus fumigatus
		Fusarium oxysporum
	Borehole 0-250m	*Saccharymyoces cerevisae*
		Penicillium species
		Aspergillus niger
	Borehole 250-500m	*Penicillium species*
		Aspergillus niger
	Lagoon	*Aspegillus flavus*
		Aspergillus niger
		Fusarium oxysporum
		Aspergillus fumigatus

Table 10: Frequency of occurrence of fungi

Name of isolates	Number of colonies Of isolates	Frequency of occurrence %
Aspegillus flavus	7	12.07
Aspergillus niger	9	15.52
Aspergillus fumigatus	15	25.86
Fusarium oxysporum	8	13.79
Saccharymyoces cerevisae	11	18.97
Penicillium species	8	13.79
	58	100

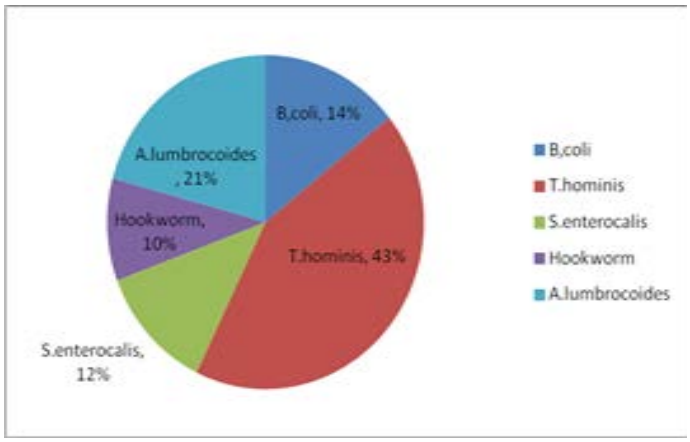

Figure 2: Parasites Distribution in Abattoir Effluent.

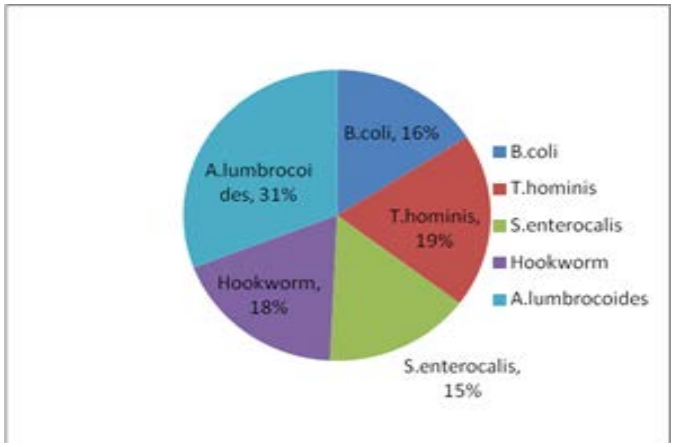

Figure 3: Parasites Distribution in River Shikamulunga

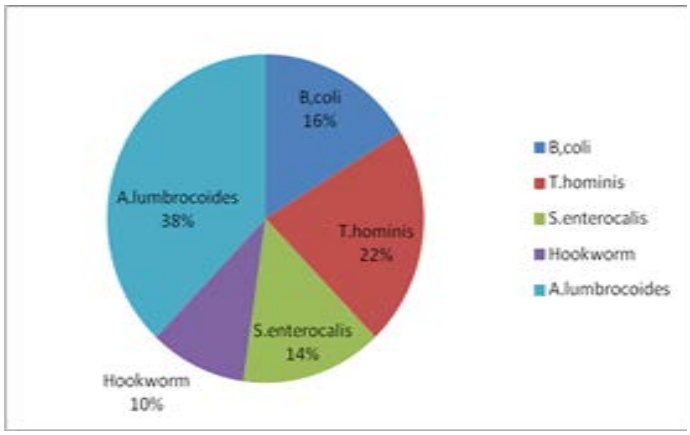

Figure 4: Parasites Distribution in Spring Water

RESULTS AND DISCUSSION

Bacteria, fungi, viruses, helminths and protozoan parasites are the major microbial pathogens associated with water contamination. The major sources of these pathogens are Animal and human faeces, and their presence in water is due to faecal contamination (WHO, 2006). The study's findings in the wet season (Table 1) and dry season (Table 2) show the microbial counts from wastewater samples and water samples from the various sites. The total bacterial count of wastewater samples from abattoirs revealed an average of 4.6 × 10 Cfu/ml and an average fungal count of 5.2 × 10 Cfu/ml. This is higher for the wastewater according to World Health Organization's standard limit (1 × 10^2 Cfu/ml). Bacterial counts in Boreholes, River Shikalamunga, and Savona spring water show high numbers of total viable coliform, faecal coliforms, Enterococci faecalis, Escherichia coli and BOD, which corresponded with similar studies were done by Nafarnda et al. (2012) and Coker et al. (2001). The mean BOD values of slaughter wastes at 11840mg/l were extremely high. The World Health Organization (WHO) permissible limit is 80mg/L (BOD) for discharged abattoirs wastewater into surface water. (WHO 2009). While high BOD values indicate contaminated water, low BOD values suggest clean water. Since the rate at which dissolved oxygen depletes in a stream increases with increasing BOD affects aquatic life. The morphological and biochemical characteristics of bacteria are shown in Table 3 and Table 4 from the various samples. The bacteria isolated were *Escherichia coli, Pseudomonas aeruginous, Klebsiella pneumoniae, Enterococcus faecalis*, and *Shigella dysenteriae*, which is similar to studies were done by Abdullah et al. (2020) and Neboh et al. (2013). The distribution of fungal isolates and fungal counts are presented in the wet season (Table 1) and dry season (Table 2), Table 8, Table 9, and Table 10. From analysis, most fungi isolated are dermatophytes, well known common spoilage organisms in the beef industry. Fungi species isolated from the samples and frequency of occurrence *were Aspergillus flavus-12.07%, Aspergillus fumigatus-25.86%, Aspergillus niger-15.52%, Fusarium oxysporum-13.79%, Penicillium spp-13. 79 %). Saccharomyces cerevisiae—18.97%.* This is similar to studies by Dauda et al. (2016), Rabah et al. (2008) and Adesemoye et al. (2006), who studied the microbiological qualities of abattoir wastewater in Minna Niger State, Lagos and Sokoto in Nigeria, respectively. The parasites isolated from various samples are shown in Figures 2,3, and 4: *Balantidium coli, Trichomonas hominis, Strongyle enterocolitis, hookworm*, and *Ascaris lumbricoides* from abattoir effluents, spring water and borehole water. *Ascaris lumbricoides* was the major parasite isolated from water samples with abattoir effluent showing a higher percentage of *Balantidium coli.* Borehole water contained only *Ascaris lumbricoides* at 100%. This is similar to studies done by Udoh SJ et al. (2019), Hatam-Nahavandi et al. (2015); and Adeyeba et al. (2002). Abattoir waste has a complex composition that is disposed of indiscriminately and is harmful to the environment. The treatment of waste is necessary to reduce its impact on the environment and enhance the quality of life. The number of microbes, both bacteria, fungi and parasites, showed a marked difference in effluent and lagoon where it is supposed to undergo treatment in Shirere, Savona and Emusala abattoir. These values were high, indicating that no treatment of waste was occurring. The lagoons had

no outlets and, during the rainy season, were overflowing into the nearby river streams. The lagoons were acting as holding grounds for wastes and other vermin. There were significant differences for Total coliform count, faecal coliform *E. faecalis, E. coli* and BOD of effluent and lagoon at $p<0.05$. The high microbial contents may have been due to wastewater's high organic content and alkalinity. This is due to its components, such as manure, blood, fat, and undigested feeds of the abattoir effluent stream (Nafarnda et al., 2012).

CONCLUSION AND RECOMMENDATION

Foodborne and waterborne diseases are common illnesses in the developing world whose common source is microbiological contamination of water bodies. The meat processing industry in Kenya and Kakamega, in particular, is on an upward trend, and more animals will be slaughtered to meet the demand for meat, and this will result in issues of abattoir waste management being raised from time to time. The study shows that all the abattoirs generate a significant amount of waste, including wastewater, animal blood, urine, carcass, bones, hoofs, animal faeces, hides and skin, and intestinal contents (i.e. paunch manure). The findings showed that these wastes have a profound impact on the quality of the water sources within the vicinity of the abattoirs. Moreover, all five abattoirs have confirmed harmful bacteria, fungi, and parasites. The bacteria isolated were *Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae, Enterococcus faecalis,* and *Shigella dysenteriae*. Fungi identified in the samples were *Fusarium oxysporum, Aspergillus flavus, Aspergillus fumigatus, Saccharomyces cerevisiae, Aspergillus niger,* and *Penicillium spp*. Parasites isolated from samples of effluent and water were *Balantidium coli, Trichomonas hominis, Ancylostoma duodenale*, and *Ascaris lumbricoides.* The bacteria, fungi, and parasites identified are associated with waterborne diseases. The abattoir wastes are discharged into streams, rivers and some leaches to underground waters resulting into serious public health hazard. The waste generated, when properly managed, will aid in the reduction of sanitation and health challenges to neighbourhoods around abattoirs and in turn produce benefits such as biogas and manures.

Given that the research findings of this work and that the release of untreated abattoir wastes may continue unabated. It is recommended that sensitization of stakeholders through environmental education on the implications of poor waste management of abattoir for both workers and residents be done. Abattoirs enveloped by urban growth should be relocated.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

NOVELTY STATEMENT

The water sources next to abattoirs were polluted with abattoir wastes due to presence of fungi,bacteria and parasites.

AUTHOR'S CONTRIBUTION

All authors contributed to the writing of this manuscript.

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