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Concentrated Animal Wastes as Urban Land Pollutants: A Case Study of Liarages in Some Southern Nigeria's Urban Agglomerations

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Abstract

The rising rural-to-urban migration across Nigeria is driving demand for more food and meat and thus the increasing influx of livestock such as cattle to abattoirs and thus the proliferation of liarages. This study was therefore initiated to 1) Qualitatively evaluate the potential impact of the selected liarages on their immediate vicinity and 2) Evaluate the extent and magnitude of the pollution associated with the liarages in terms of physico-chemical and microbiological properties of the environmental media in two southern Nigeria's agglomerations (Benin city, Edo and Warri, Delta States).

Soil and surface runoff water were collected from four randomly selected liarages and borehole water samples near each liarages in Warri. A general qualitative evaluation of the liarages was undertaken while samples collected were analyzed for physico-chemical and microbiological properties using standard analytical procedures.

The result shows that all the liarages were littered with concentrated foul-smelling animal wastes (solid and liquid) that were unpleasant to see in major urban centers. Also, they had poorly constructed sheds or shacks against the background of medium to high value residential homes that could lower property values in these urban agglomerations. Except for pH, the physico-chemical properties such as phosphate, nitrate, Organic carbon and turbidity were relatively high and declined in the down slope positions relative to the main liarages; Top soil samples had total coliform count ranging from 3.3×10^4 to $5.0\times10^4 \pm 2.12$; fecal coliform ranged from 2.6×10^3 to $2.8\times10^4 \pm 42.42$ while *E. coli* ranged from 2.1×10^3 to $7.7\times10^3 \pm 2.82$ across all sampled locations. Borehole water for drinking was slightly burdened with coliform bacteria ranging from $1.0\times10^1 \pm 0.07$ to $8.2\times10^1 \pm 3.53$. *Enterobacter spp* was the most frequently isolated microbial species identified in all the runoff water that could potentially contaminate surface water bodies. We conclude that liarages can negatively impact the urban landscape aesthetically as well as air, water, land/soil quality within the immediate vicinity and thus could lower property values. It is thereby recommended that liarages be regulated with respect to location and number, while engineered liarages with septic tanks is recommended as alternatives, with routine manure removal and use for growing horticultural crops in these major agglomerations.

Keywords: Liarages; Urban Pollution; Animal Waste; Environmental Sanitation; Southern Nigeria, Microbial Contamination

Introduction

The rising rural-to-urban migration across Nigeria is driving demand for more food and meat and thus the increasing influx of livestock such as cattle, goats, and sheep to abattoirs in many urban agglomerations across the country. Because of the need to be rested on the way to the market or slaughter, more liarages are being established mostly for cattle in these population centers. Although liarages resemble concentrated feeding operations (CAFOs) of the agriculturally-advanced countries of the world particularly because of the high density of animals in these confined spaces and the resultant large quantity of manure waste generated, they are however different in the Nigerian context. Liarages for large animals such as cattle in Nigeria are frequently located near abattoirs and markets in urban and peri-urban areas in mixed commercial and residential neighborhoods, with little or no provisions made for routine on-the-spot feeding of these animals while being held. It is common experience to see these animals being led outside the liarages within the urban settings by herdsmen for grazing in residential neighborhoods and returned to the liarages daily until sold or slaughtered. While awaiting slaughter however, the animals are usually left in open or semi-confined lots, with no provision for manure removal. Besides the frequent menace of these animals blocking narrow streets and alleys and obstructing traffic flow and often scaring pedestrians (particularly children) within the cities and grazing on economic and non-economic crops in vacant building lots within these agglomerations, the waste from the liarages are increasingly becoming a major source of urban pollution.

The cleanliness of abattoirs and liarages is known to pose difficult challenges to public health [1]. For example, the large quantity of manure attracts various insects and disease vectors such as flies, mosquitoes etc. The fecal wastes and other wastes (such as respiratory secretions, urine, etc) of several livestock usually consist of high density animal and human pathogens which are usually in the millions to billions per gram of wet weight feces or millions per ml of urine. These pathogens could therefore pose severe human risk to the public and animal health both on and off animal agriculture production facilities [2,3]. Furthermore,

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the consciousness of zoonoses (pathogenic microbes of animal origin) in animal wastes is now acknowledged as a public health issue, particularly as a result of the incidence of water borne disease outbreaks linked to manure with fecal contamination [3]. In addition, improperly managed fecal wastes are a source of non-point source pollution within metropolitan areas with potentially negative impact on the surrounding environmental media. Although soil degradation, urban air and water pollution and rapid urbanization are well documented environmental problems in Nigeria, the growing number of liarages in major urban agglomerations in recent times could be exacerbating the scope of environmental problems particularly in the densely populated state capitals or major commercial cities across Nigeria. Nitrate-N in manure and fertilizer runoff can act as endocrine disruptor [4], and thus could impact fish and amphibians in nearby and distant surface waters and wetlands. Although these negative impact of animal waste have been well documented in advanced countries such as the Unites States [5], there is paucity of local data or research on this growing problem particularly with respect to the extent of the contamination of the various environmental media-Soil/land, air, surface and groundwater in Nigeria. This study was therefore designed to: 1) Qualitatively evaluate the potential impact of the selected liarages on their immediate vicinity and 2) Evaluate the extent and magnitude of the pollution associated with the liarages in terms of physic-chemical and microbiological properties of the environmental media in two southern Nigeria's agglomerations.

Materials and Methods

Study area

This study was conducted in Benin City, Edo State and Warri, Delta state of Nigeria (Figure 1) using four randomly selected liarages in Ugbolokposa and Benin-Sapele Road in Warri, Delta state; Benin Technical College Road and Aduwawa Market in Benin City, Edo state. For all four locations, soil (0-15 cm and 15-30 cm depth) and surface runoff water samples were collected from the main liarages and 300 m away in the down slope position in order to ascertain the sphere of influence of the liarages or as reference point for the immediate environmental impact. Also, borehole water from nearby residence within the immediate vicinity of each liarage was collected in sterilized bottles for liarages in Warri located in Nigeria's Niger delta where the aquifer is near the surface. Soil samples obtained were placed in labeled Ziploc plastic bags and placed in a cooler to avoid contamination during physio-chemical and bacteriological analyses. Furthermore, a comprehensive qualitative description of the general features of liarages was done on each site.

Nitrate-N was determined for soil, water and runoff water samples by the Spectrophotometer method of America Society for Testing and Material (ASTM) D 3867 method [6], Turbidity of the water samples was determined by HACH Turbidity meter method of ASTM; water color was determined using Spectrotonic 20D+ spectrophotometer method of ASTM D1209. Suspended solids in water were determined by Gravimetry of ASTM D 1868, while Dissolved Oxygen was determined

Figure 1: Map of study area showing the sampled locations.

by Winkler's Modified America Public Health Association (APHA, 1995) method. Biological Oxygen Demand (BOD) was determined by Winkler's Modified APHA 1995 method while Chemical Oxygen Demand (COD) of the water samples was determined by scaled digestion and spectrometry. The pH and Electrical Conductivity was determined by the CND method as described by Ohimain et al. [6]. Organic Carbon was determined according to the method of chromic acid titration method [7]. Total soil N was determined by Kjeldahl digestion, and the resulting Ammonium ion measured colorimetrically [7-9]; while phosphorus was determined by Spectrotonic 20D+ Spectrophotometer [10].

For the microbial analysis, indicator organisms of public health significance were investigated. Quantification of bacteria pathogens of fecal pollution is a difficult task owing to the wholesomeness of bacteria in feces, hence indicator organism including total coliform, fecal coliform and *E. coli* have been used in monitoring fecal indicator organism for several decades [11]. Consequently, total coliform was assayed using m-Endo agar, fecal coliform with m-FC agar, *E. coli* with chromocult agar. Spread plate technique was used for the enumeration of the organisms. About 5 g of soil samples (also, 1 ml of liarage runoff water/wastewater and underground water) was dissolved in 9 ml of sterile distilled water followed by serial dilution. Nutrient agar was used for the isolation of other bacteria species and identified using biochemical techniques. One µl of respective diluents was inoculated onto the different media according to the method of [12] with modification.

Results and Discussions

Qualitative aspects of liarages

All four liarages are located near private residences and commercial buildings, also the liarages were virtually eyesores-as they were all characterized by concentrated cattle wastes with foul smell at close range, and poorly constructed sheds or shacks made of corrugated iron sheets as offices for the personnel managing the liarages (Figure 2). Used medicine vials were found on the bare soil in two of the liarages in Benin City, with several stagnant pool of water ideal for mosquitoes and other water-loving insects and birds. Furthermore, cattle egrets were frequently found in close association with the animals that were looking filthy as they lie on their own wastes on concentrated and decomposing wastes. The liarages were very unattractive generally and constitutes major urban land pollution that may lower the value of real estate in the respective neighborhoods where they are located. Outside of the liarages, the herds of cattle are often seen in residential neighborhoods, grazing (Figure 3) and constituting a menace within urban agglomerations with respect to traffic and scaring residents particularly children.

Quantitative aspects of liarages

Physico-chemical properties: The physico-chemical properties of the top 15 cm soil samples obtained from the study sites relative to locations 300 m down slope from the major liarages is presented in Figure 4. The samples were overlain by cow manure and stagnant rainwater mixed with urine as can be seen in Figure 1 and thus manure was scraped off to obtain samples analyzed. The pH of the top soils for all study locations ranged from slightly acid to alkaline (6.6-8.3), with a mean of 7.4, while those taken 300 m down slope from the main liarages as reference ranged from 6.2-7.3 with a mean of 6.8. Animal manures are known to have high amount of dissolved KCl and NaCl which could have influenced the high pH recorded in these locations; however, there were no significant differences between the pH of the main liarages and the reference locations 300 m down slope in all cases [13,14].

Figure 2: Pictorial view of a liarage in Ogbolokposa neighborhood in Warri, Delta state.

Figure 3: Pictorial view of cattle feeding outside a liarage in a Benin city neighborhood, Edo state, Nigeria.

Although the soil salinity were within the non-saline range in all cases, the electrical conductivity ranged from 0.280-0.70 dS/m, with a

mean of 0.452 dS/m at the main liarages compared to a mean of 0.204 dS/m and a range of 0.120-0.340 dS/m at the reference points. The phosphate concentration of the top 15 cm ranged from 13.2-17.3 mg/kg at the main liarages with a mean of 12.4 mg/kg, while 300 m down slope values ranged from 7.3-12.4 mg/kg with a mean of 8.0 mg/kg. Except for soil pH, phosphate, Organic carbon, electrical conductivity and Nitrate-N declined slightly relative to the main liarages in the respective down slope position.

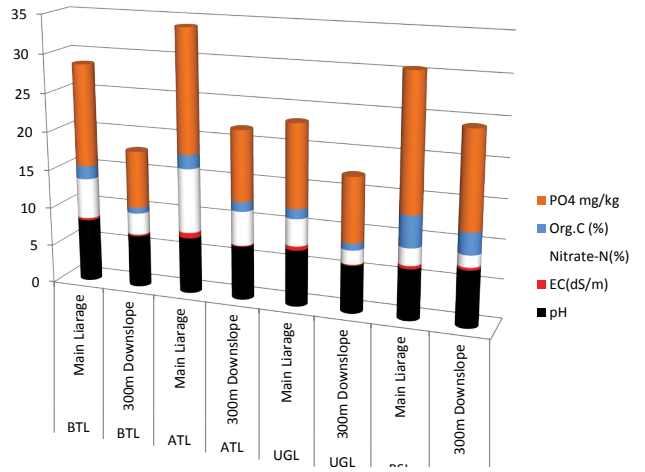

Figure 4: Physicochemical parameters of top soil samples collected from Liarages (BTL-Benin Technical College Road Liarage; ADL-Aduwawa Market Liarage; UGL-Ugbolokposa Liarage; BSL- Benin-Sepele Road Liarage).

The physico-chemical properties of surface runoff water collected from the liarages are shown in Table 1. Nitrate-N concentration, Phosphate-P and Organic Carbon were similarly higher at the main liarages than the reference points 300 m down slope. The NO_3-N concentration ranged from 2.2-5.5% and a mean of 4.6% at the main liarages, while the reference had a mean of 2.7% with a range of 1.5-4.4%. The PO_4-P concentration also followed the same trends, with a range of 10.7-17.3 mg/kg and a mean of 12.4 mg/kg at the main liarages compared to 8.0 mg/kg and ranging from 7.3-12.48.0 mg/kg 300 m away. Mean turbidity of the runoff water at the liarages was 54 NTU compared to 19.8 NTU for surface water taken 300 m down slope. This rapid decline is not unexpected since the particle load from the main liarage is much higher and declines as some of the sediments are deposited along its flow path; however, the values obtained did show the sphere of influence or impact of the liarages on the immediate environment nearby.

Groundwater samples taken from boreholes within the neighborhood of the liarages in Delta state is shown in Table 2. Although most of the water quality parameters evaluated were within the Standard Organization of Nigeria's (NSO) specifications for table water, the mean pH of water obtained from the boreholes within the neighborhood of two liarages in Delta state were slightly lower (6.2 *vs.* 6.5-6.8); the same was observed for Phosphate (0.3 versus 0.0) (Table 3).

Microbial properties

The presence of microbial pathogens in polluted, untreated and treated waters poses a significant health risk to the public [15]. Different microbial pathogens have different infectious dose; bacteria could cause infection when more than 10^3 cells are ingested [16,17]. Coliforms in

Properties	Location*											
	BTL		ADL		UGL		BSL		Mean		Range	
	Main Site	300m DS**	Main Site	300m DS	Main Site	300m DS	Main Site	300m DS	Main Site	300m DS	Main Site	300m DS
pH	6.6	6.8	6.8	6.3	5.6	6.3	7.4	7.2	6.6	6.7	5.6-7.4	6.3-7.2
EC (µs/cm)	538	280	1348	162	1362	519	1475	228	1180.8	297.3	538-1475	162-519
TURB (NTU)	14.4	10.1	110.9	44.3	15.8	11.9	75.6	12.9	54.175	19.8	14.4-110.9	10.1-44.3
T D S (mg/l)	268	139	671	81	617	259	748	115	576	148.5	268-748	81-259
TSS (mg/l)	19.4	13.7	39.3	21.8	50.4	22.9	103.8	45.4	53.2	25.6	19.4-103.8	13.7-45.4
DO (mg/l)	5.8	4.8	5.9	6.1	5.2	4.2	3.9	4.4	5.2	4.875	3.9-5.9	4.2-6.1
BOD (mg/l)	19.7	11.3	64.4	48.8	78.3	26.7	76.5	63.6	59.725	37.6	19.7-78.3	11.3-63.6
COD (mg/l)	68.8	38.4	238.4	176	298.6	96	283.2	229	222.25	134.8	68.8-298.6	96-228.8
NO_3-N (mg/l)	0.68	0.22	5.75	0.64	6.38	2.15	5.11	1.9	4.48	1.228	0.68-6.38	0.22-2.15
PO_4 (mg/l)	1.33	0.74	1.46	0.93	4.22	3.19	2.58	0.83	2.3975	1.423	1.33-4.22	0.74-3.19
*BTL-Benin Technical Road Lairage; ADL-Aduwawa Lairage; UGL-Ugbolokposa Lairage; BSL-Benin Sepele Road Lairage.												

Table 1: Some physico-chemical properties of surface runoff water near liarages in Warri and Benin city.

Properties	Location				
	UGL	BSL	Mean	Range	NIS/SON Standard
pH	6.4	6	6.2	6.0-62	6.5-6.8
EC (µs/cm)	139	126	132.5	126-139	<1000
TURB (NTU)	ND	ND	ND	ND	<5.0
TDS (mg/l)	70	63	66.5	63-70	<500
TSS (mg/l)	ND	ND	ND	ND	0
BOD (mg/l)	2.1	1.1	1.6	1.1-2.1	0
COD (mg/l)	14.4	32	23.2	14.4-32.0	0
NO_3-N (mg/l)	0.58	0.14	0.4	0.14-0.58	50
PO_4 mg/l	0.32	0.21	0.3	0.21-0.32	0
*UGL-Ugbolo kposa Lairage; BSL-Benin Sepele Road Lairage.					

Table 2: Borehole groundwater quality parameters of some liarages in Delta state, Nigeria.

particular have low infectious dose and resistant in the environment-hence determination of the number of pathogenic organisms in water and the environmental samples is imperative.

For topsoil (0-15 cm) samples collected from the liarages (Table 4), the total coliform count ranged from 3.3×10^4 to $5.0 \times 10^4 \pm 2.12$ cfu/g; fecal coliform ranged from 2.6×10^3 to $2.8 \times 10^4 \pm 42.42$ cfu/g while *E. coli* ranged from 2.1×10^3 to $7.7 \times 10^3 \pm 2.82$ cfu/g across all sampled locations. Although this result is not unexpected, it does pose potential threat to any open water systems nearby; this is particularly relevant in Warri in view of its estuarine nature and the presence of several wetlands. On the other hand, soil samples collected at 15-30 cm depth had total coliform ranging from $2.0 \times 10^3 \pm 0.14$ to $3.6 \times 10^3 \pm 0.28$ cfu/g, fecal coliform of $1.9 \times 10^2 \pm 0.21$ to $2.8 \times 10^3 \pm 9.89$ cfu/g while *E. coli* ranged from $3.9 \times 10^2 \pm 0.49$ to $5.6 \times 10^2 \pm 0.63$ cfu/g.

In the surface runoff water samples, total coliform range from $1.6 \times 10^3 \pm 21.2$ to $5.7 \times 10^3 \pm 84$, fecal coliform was $4.2 \times 10^2 \pm 28$ to $7.8 \times 10^2 \pm 49.49$ and *E. coli* was between $2.5 \times 10^2 \pm 35.3$ and $3.9 \times 10^2 \pm 42.42$ as shown in Table 5.

Table 5 shows the microbial isolates from runoff water that could contaminate surface water bodies near the liarages: *Enterobacter spp, Bacillus spp* and *Micrococcus spp* were the most frequently isolated microbial species identified in all the runoff water samples evaluated from the liarages in Edo and Delta States. However, *Enterobacter spp* was not detected 300 m down slope from the two liarages in Ugbolokposa and Benin-Sapele Road liarages. *Klebsiella Spp* was isolated only from Adolor College Road liarage in Benin City, while *Pseudomonas Spp* was only isolated from the runoff water from Benin-Technical Road liarage in Benin City [18]. Only the surface runoff water from the two liarages in Warri had *Serratia spp* as none were isolated in Benin City.

The foregoing results thus show that liarage runoff water and underground water were highly burdened with coliform bacteria and other pathogenic organisms. Although coliforms are normal microflora in animal intestines, the high coliform burden observed in the samples depicts poor hygienic condition of the liarage. During rainfall events, the topsoil and the lairage runoff water (which consist of urine and other waste) would be washed off along with flood into the environment as it discharges into the nearby river or water body. Studies have shown that most rivers flowing through heavily urbanized and industrialized areas in Nigeria are contaminated with microbial pathogens [15] which are associated with high disease burden. The contamination of the underground water observed in the study may be as a result of infiltration of the liarage runoff through the soil pore spaces into the underground water or it could also result from pit toilets common in the area. This may have been facilitated by the shallow aquifer found in studied location (Delta state) which might have hastened the contamination of the underground water by the surface runoff. Areas with shallow aquifers are highly prone to risk of contamination of underground water [19]. The underground water when used for potable purpose could result in disease outbreak. Microbial contamination of ground water have led to several outbreak of disease in the U.S [19], however because of underreporting and lack of proper diagnosis, many of these disease outbreaks are seldom reported in Nigeria.

Although liarages may be a good source of organic manure for growing crops, we observed in this study that there may be the need to treat the organic waste (by sterilization) prior to use for crop production;

	0-15cm				15-30cm				p-value
	BTL	ADL	UGL	BSL	BTL	ADL	UGL	BSL	
Total Coliform	5.0 × 104 ± 2.12d	3.3 × 104 ± 2.12b	4.1 × 104 ± 5.65c	4.0 × 103 ± 0.14a	3.6 × 103 ± 0.28a	2.1 × 103 ± 021a	2.5 × 103 ± 0.35a	2.0 × 103 ± 0.14a	0
Fecal coliform	1.5 × 104 ± 35.35b	2.4 × 104 ± 49.49c	2.8 × 104 ± 42.42c	2.6 × 103 ± 1.41a	1.9 × 103 ± 4.94a	2.8 × 103 ± 9.89a	1.9 × 102 ± 0.21a	1.9 × 102 ± 0.21a	0
E. coli	7.5 × 103 ± 7.07c	7.7 × 103 ± 2.82c	7.1 × 103 ± 13.43c	2.1 × 103 ± 2.82b	5.6 × 102 ± 0.63a	5.0 × 102 ± 0.35a	3.9 × 102 ± 0.49a	3.9 × 102 ± 0.49a	0

*BTL-Benin Technical Road Lairage; ADL-Aduwawa Lairage; UGL-Ugbolokposa Lairage; BSL-Benin Sepele Road Lairage Values are in duplicate of mean ± standard deviation; Values which carry similar alphabets across rows show no significant difference while values which carry different alphabets across rows show significant difference ($p<0.05$).

Table 3: Indicator organisms in top soil samples.

Indicator Organisms	Runoff water			Borehole water			p-value
	BTL	ADL	UGL	BSL	UGL	BSL	
Total Coliform	5.0 × 103 ± 21.21c	1.6 × 103 ± 21.21b	2.5 × 103 ± 35.35b	5.7 × 103 ± 84.85c	1.1 × 101 ± 0.21a	1.0 × 101 ± 0.07a	0
Fecal coliform	7.8 × 102 ± 49.49d	6.4 × 102 ± 98.99c	5.5 × 102 ± 70.71bc	4.2 × 102 ± 28.28b	8.1 × 101 ± 12.02a	8.2 × 101 ± 3.53a	0
E. coli	3.9 × 102 ± 42.42b	3.9 × 102 ± 113.13b	3.5 × 102 ± 56.56b	2.5 × 102 ± 35.35b	2.5 × 101 ± 5.65a	2.0 × 101 ± 4.24a	0.001

Table 4: Indicator organisms in surface runoff and borehole water samples.

Isolates	Location*							
	BTL		ADL		UGL		BSL	
	Main Site	300m DS**	Main Site	300m DS	Main Site	300m DS	Main site	300m DS
Enterobacter spp.	+	+	+	+	+	-	+	-
Bacillus spp.	+	+	+	+	+	+	+	+
Micrococcus spp.	+	-	+	+	+	-	+	-
Klebsiella spp.	-	-	+	-	-	-	-	-
Serratia spp.	-	-	-	-	+	-	+	-
Pseudomonas spp.	+	-	-	-	-	-	-	-

*BTL-Benin Technical Road Lairage; ADL-Aduwawa Lairage; UGL-Ugbolokposa Lairage; BSL-Benin Sepele Road Lairage RW-Runoff Water, +present, -absent; **DS Down slope from Main Liarage.

Table 5: Microbial species isolated from runoff water of some selected liarages in Edo and Delta states.

this is particularly relevant for garden vegetables that are usually consumed raw without cooking-as it may result in food poisoning [20-22]. The microbial contamination of fresh vegetables via manure has been documented in the United States [23] and elsewhere hence liarage locations need to be carefully selected particularly in major urban agglomerations such as Nigeria as it is a major source of land/soil pollution. Furthermore, manure and other animal waste management technologies must be put in place to contain pathogens in order to prevent or minimize human and animal exposures to them and thus the associated health risks [3,24-26]. In fact, manures in most liarages should be routinely scraped and sold to landscapers and farmers as organic fertilizers [27]. By so doing, it would reduce the eyesore nature of the manure piles in these liarages in urban agglomerations as well as the chemical pollutants that can potentially contaminate surface and ground water systems [28-30].

Conclusion

In conclusion, this study shows that liarages in major urban agglomerations are an additional source of pollution of all environmental media-land/soil, water and air (chemically and, microbiologically) and thus must be regulated by city and urban planners. Furthermore, their presence could lower property values in the locations where sited. Of great significance however is the possibility of contamination of groundwater sources by manure-based endocrine distruptors and pathogenic organisms such as *Enterobacter spp, Bacillus spp* and *Micrococcus spp* that were the most frequently isolated microbial species identified in all the runoff water samples from this study. Engineered liarages with septic systems that are routinely maintained and manures sold to farmer are plausible suggested alternatives for liarages in Nigeria's urban agglomerations in order to minimize pollution and related public health risks.

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