Physico-chemical and Bacteriological Quality of an Abattoir Wastewater Discharged into Water Bodies in Ibadan, Nigeria and drug resistant profile of isolated *Salmonella* species

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ABSTRACT

The discharge of untreated abattoir wastewater constitutes public health concern because diseases are transmitted through contaminated water bodies. Contaminated water supply systems used for drinking and other purposes have been implicated in the transmission of antibiotic resistant pathogens. This study was carried out to determine the physico-chemical, bacteriological qualities of abattoir wastewater in Ibadan and antibiotics resistance patterns of *Salmonella* species from the wastewater. Wastewater samples were collected from the slaughter slab and drainage. Physico-chemical parameters, total bacteria counts (TBC) and total coliform counts (TCC) were determined using standard procedures. *Salmonella* species were isolated from the samples using pour plate techniques and identified using biochemical tests, while susceptibility test of the isolates against 10 antibiotics was determined using disc diffusion technique. The physico-chemical parameters of the wastewater showed total dissolved solids of 4,150 mg/l and 2300 mg/l for slaughter slab and drainage respectively while biochemical oxygen demand was 867.2 mg/l and 698.5 mg/l. Dissolved oxygen was between 0.01 mg/l and 0.02 mg/l; the mean value of TBC and TCC ranged between 4.24x10⁷- 4.78x10⁷ cfu/ml and 3.03x10⁷-3.51x10⁷cfu/ml respectively. *Salmonella* species isolated were 48 and were all resistant to ampicillin and ceftriazone. The strains of *S. enterica* subspecies enterica exhibited resistance to eight antibiotics combination (AMP-TET-OFX-AMC-CLX-CRO-STR-SXT, AMP-TET-AMC-CLX-CRO-CHL-STR-SXT) while two of the isolates were pan-resistant. The abattoir wastewater must be properly treated before being discharged into the environment as it is evident that it harbours multiple antibiotic resistant pathogens.

Key words: *Salmonella*, multi-drug resistance, abattoir, environment

INTRODUCTION

As the world population increases, there is also a drive to increase meat production but this is not without the attendant environmental pollution problems [1]. In abattoirs, animals are slaughtered for meat production and they are generally located near flowing rivers, especially in developing countries because of water demand for washing of meat and cleaning of abattoir environment, hence abattoir effluents are discharged directly into rivers [2]. The abattoir wastewater can be harmful to humans and environment as it enters natural bodies of water due to natural drainage pattern and sequence [3]. The use of water for different purposes such as drinking, household, industrial, agricultural (irrigation), swimming and other recreational purposes makes it possible for the spread of diseases such as typhoid and dysentery in human population [4]. It has been reported that waterborne zoonosis can be a serious problem especially in the developing countries that lacks adequate water treatment facilities and hence make use of untreated wastewater [5]. Typhoid fever caused by the bacterium *Salmonella* accounts for several cases of morbidities and mortalities in Nigeria [6]. Salmonellosis is one of
the most important zoonotic diseases because of its fecal-oral route transmission associated with water contamination [7]. Some cases of salmonellosis are severe and require antimicrobial therapy for its treatment, thus, resistance to antimicrobial drugs is a great concern [8].

Increase in *Salmonella* species developing resistance to antibiotics has been reported with treatment difficulty of severe infections. Multidrug resistant *Salmonella* especially *Salmonella enterica* remains a formidable and major public health concern with reports of increase in its incidence [9]. The true incidence of Salmonella-associated diseases is difficult to evaluate in Nigeria due to lack of epidemiological surveillance systems. As a result of this, many cases were neither documented, diagnosed nor reported [10]. However, in Lagos, out of 85,187 confirmed cases of Salmonella-associated diseases, between 1999 and 2008, 880 deaths were reported with a case-fatality rate of 1.03% [11]. In the livestock sector, different types of farm animals are associated with the transmission of zoonotic pathogens and most of the animals brought for slaughtering in urban area often comes from villages where pathogen control regimens are very weak, un-coordinated and often not available. Lack of veterinary services in these livestock rearing areas poses a substantial risk of widespread occurrence of diseases in the livestock population and concurrent human exposure to these zoonotic disease agents [12].

Drug resistant bacteria may therefore be transmitted to humans who come in contact with abattoir wastewater. This study was thus designed to determine the physicochemical and bacteriological quality of the abattoir wastewater as well as the antibiotic resistance pattern of *Salmonella* species isolated from the wastewater.

MATERIALS AND METHODS

Study site and sample collection:
The study was carried out in Akinyele abattoir, Ibadan, Nigeria. A total of 12 wastewater samples were collected twice a week between May and June, 2015 into sterile plastic bottles using standard method from both the slaughter slab and drainage system during slaughtering process, and transported to the Environmental Microbiology and Biotechnology Laboratory of the Department of Microbiology, University of Ibadan for analyses.

Physico-chemical analysis of the wastewater:

Ten physicochemical parameters: pH, Temperature, Conductivity, Turbidity, Salinity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Dissolved Oxygen (DO) of the wastewater samples were determined using standard analytical methods [13].

Bacteriological analysis of the wastewater:
The total bacteria and coliform counts of the wastewater samples were determined according to the methods described by Fagade *et al.* 2008 [14] using Nutrient Agar and MacConkey Agar respectively.

Isolation and Identification of *Salmonella* species:
The wastewater samples were serially diluted and appropriate dilutions plated on Deoxycholate Citrate Agar (Oxoid, UK) and MacConkey Agar using the standard pour plate method, and incubated at 35°C for 24-48hrs as described by Orji *et al.* 2005 [15]. Colony morphology, Gram’s reaction, biochemical and sugar fermentation tests were used to identify the bacterial isolates.

Antibiotic Susceptibility Testing of the Isolates:
All the *Salmonella* isolates were tested for susceptibility to ten antibiotics namely: Ampicillin (10μg), Chloramphenicol (30μg), Streptomycin (10μg), Cefotaxime (30μg), Amoxicillin/clavulanate (30μg), Ciprofloxacin (5μg), Ofloxacin (5μg), Tetracycline (25μg) and Trimethoprim/sulfamethoxazole (25μg) (Oxoid, UK). The susceptibility test was carried out using the agar diffusion technique described by the Clinical Laboratory Standards Institute (CLSI) [16] on Mueller-Hinton agar. The plates were incubated at 37°C for 18-24 hours. The zones of inhibition were recorded in millimeters (mm) and interpreted based on interpretive criteria of CLSI [16].

RESULTS

Physicochemical properties of the wastewater:
The result of physico-chemical analysis of the wastewater samples is as shown in Table 1. Except for the DO which the mean value was higher for the drainage sample (0.02 mg/l) compared to the slaughter slab sample (0.01 mg/l), all other parameters were higher in the slaughter slab. The result showed that the
conductivity (2,260 Us/cm), turbidity (3,529 mg/l), salinity (2,870 mg/l) and total dissolved solids (4,150 mg/l) in the wastewater samples from the slaughter slab doubled that of the drainage which were 1,220 Us/cm, 1,057 mg/l, 1,580 mg/l and 2,300 mg/l respectively. All the parameters were higher than WHO and FEPA/FMENV except the pH values which conform to the standards.

The total bacteria and coliform count of the wastewater:
The mean total bacteria count of the wastewater samples from the slaughter slab and drainage system were $4.24 \times 10^7$ cfu/ml and $4.78 \times 10^7$ cfu/ml respectively. Meanwhile, the mean total coliform counts were $3.03 \times 10^7$ cfu/ml for slaughter slab and $3.51 \times 10^7$ cfu/ml for drainage (Table 2).

Occurrence of Salmonella species in the abattoir wastewater:
A total of 48 Salmonella species were isolated from the wastewater. The frequency of occurrence of the Salmonella isolates in the slaughter slab and drainage were similar (50%). However, the relative occurrence of the Salmonella enterica subspecies enterica and Salmonella species were 54.2% and 45.8%. Though S. enterica subspecies enterica and Salmonella species occurrence in the drainage was 25% each, it was 29.2% and 20.8% for the slaughter slab respectively (Table 3).

Antibiotic susceptibility pattern of the Salmonella isolates:
The result of the susceptibility test of the Salmonella isolates showed that the isolates were completely resistant to both ampicillin and ceftriazone. While 61.6% of S. enterica subspecies enterica were resistant to streptomycin, resistance to cotrimoxazole and tetracycline was 65.4% each. In addition, the resistance of S. enterica subspecies enterica and Salmonella species to cloxacillin and chloramphenicol were 42.3% and 41% respectively. However, resistance of S. enterica subspecies enterica to ciprofloxacin (7.7%) and ofloxacin (15.4%) was quite low (Table 4).

Table 1: Physicochemical parameter of the abattoir wastewater samples

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>SAMPLES</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slaughter slab</td>
<td>Drainage</td>
</tr>
<tr>
<td>pH</td>
<td>7.1</td>
<td>6.9</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>30.9</td>
<td>28.8</td>
</tr>
<tr>
<td>Conductivity (Us/cm)</td>
<td>2260</td>
<td>1220</td>
</tr>
<tr>
<td>Turbidity (mg/l)</td>
<td>3529</td>
<td>1057</td>
</tr>
<tr>
<td>Salinity (mg/l)</td>
<td>2870</td>
<td>1580</td>
</tr>
<tr>
<td>Total Dissolved Solids, TDS (mg/l)</td>
<td>4150</td>
<td>2300</td>
</tr>
<tr>
<td>Total Suspended Solids, TSS (mg/l)</td>
<td>9.2</td>
<td>6.5</td>
</tr>
<tr>
<td>Biochemical Oxygen Demands, BOD (mg/l)</td>
<td>867</td>
<td>699</td>
</tr>
<tr>
<td>Chemical Oxygen Demands, COD (mg/l)</td>
<td>1463</td>
<td>1198</td>
</tr>
<tr>
<td>Dissolved Oxygen, DO (mg/l)</td>
<td>0.01</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Table 2: The total bacteria and total coliform count of abattoir wastewater samples from Akineyele, Ibadan

<table>
<thead>
<tr>
<th>SAMPLE CODE</th>
<th>TOTAL BACTERIA COUNT 10^6 cfu/ml</th>
<th>TOTAL COLIFORM COUNT 10^5 cfu/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slaughter slab (A)</td>
<td>Drainage (B)</td>
</tr>
<tr>
<td>1</td>
<td>33</td>
<td>47</td>
</tr>
<tr>
<td>2</td>
<td>55</td>
<td>61</td>
</tr>
<tr>
<td>3</td>
<td>52</td>
<td>54</td>
</tr>
<tr>
<td>4</td>
<td>45</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>48</td>
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<td>6</td>
<td>36</td>
<td>35</td>
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<tr>
<td>7</td>
<td>35</td>
<td>34</td>
</tr>
<tr>
<td>8</td>
<td>28</td>
<td>51</td>
</tr>
<tr>
<td>9</td>
<td>21</td>
<td>42</td>
</tr>
<tr>
<td>10</td>
<td>49</td>
<td>36</td>
</tr>
<tr>
<td>11</td>
<td>56</td>
<td>62</td>
</tr>
<tr>
<td>12</td>
<td>51</td>
<td>68</td>
</tr>
<tr>
<td>MEAN</td>
<td>42.4</td>
<td>47.8</td>
</tr>
</tbody>
</table>
Table 3: Number and percentage occurrence of isolated organisms from the abattoir wastewater sample in Akinyele, Ibadan

<table>
<thead>
<tr>
<th>Source</th>
<th>Slaughter slab (%)</th>
<th>Drainage (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella enterica sub enterica</td>
<td>14 (29.2)</td>
<td>12 (25)</td>
<td>26 (54.2)</td>
</tr>
<tr>
<td>Salmonella spp.</td>
<td>10 (20.8)</td>
<td>12 (25)</td>
<td>22 (45.8)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>24 (50)</td>
<td>24 (50)</td>
<td>48 (100)</td>
</tr>
</tbody>
</table>

Table 4: Antibiotic susceptibility pattern of Salmonella isolates.

<table>
<thead>
<tr>
<th>Antibiotics</th>
<th>S.enterica n=24</th>
<th>S. spp n=24</th>
<th>Senteric</th>
<th>S. spp.</th>
<th>Senteric</th>
<th>S. spp.</th>
<th>TR n=48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin (10ug)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>26 (100)</td>
<td>22 (100)</td>
<td>48 (100)</td>
<td></td>
</tr>
<tr>
<td>Amoxicillin/Clavulanate (30ug)</td>
<td>10 (38.5)</td>
<td>8 (36.4)</td>
<td>17 (77.3)</td>
<td>5 (19.2)</td>
<td>2 (9.1)</td>
<td>5 (10.4)</td>
<td></td>
</tr>
<tr>
<td>Ceftriaxone (30ug)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Giproxacin (5ug)</td>
<td>19 (73.1)</td>
<td>18 (81.8)</td>
<td>3 (13.5)</td>
<td>2 (9.1)</td>
<td>4 (15.4)</td>
<td>2 (9.1)</td>
<td></td>
</tr>
<tr>
<td>Cloxacinil (5ug)</td>
<td>14 (53.8)</td>
<td>12 (54.5)</td>
<td>1 (3.8)</td>
<td>1 (4.5)</td>
<td>11 (42.3)</td>
<td>9 (41)</td>
<td></td>
</tr>
<tr>
<td>Chloramphenicol (30ug)</td>
<td>14 (53.8)</td>
<td>12 (54.5)</td>
<td>1 (3.8)</td>
<td>1 (4.5)</td>
<td>11 (42.3)</td>
<td>9 (41)</td>
<td></td>
</tr>
<tr>
<td>Tetracycline (30ug)</td>
<td>9 (34.6)</td>
<td>6 (27.3)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>17 (65.4)</td>
<td>16 (72.7)</td>
<td>33 (68.8)</td>
</tr>
<tr>
<td>Trimethoprim/sulfamethaxazole (25ug)</td>
<td>8 (30.8)</td>
<td>9 (41)</td>
<td>1 (3.8)</td>
<td>1 (4.5)</td>
<td>17 (65.4)</td>
<td>13 (59)</td>
<td>30 (62.5)</td>
</tr>
<tr>
<td>Streptomycin (10ug)</td>
<td>10 (38.5)</td>
<td>10 (45.5)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>16 (61.6)</td>
<td>12 (54.5)</td>
<td>28 (58.3)</td>
</tr>
</tbody>
</table>

Table 5: Antibiotypes of Salmonella species isolated from the abattoir wastewater.

<table>
<thead>
<tr>
<th>Antibiotypes</th>
<th>S. enterica sub enterica</th>
<th>S. spp</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMP-CRO</td>
<td>6 (23.1)</td>
<td>2 (9.0)</td>
<td>8 (16.7)</td>
</tr>
<tr>
<td>AMP-CRO-CLX</td>
<td>1 (3.8)</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-AMC-CRO</td>
<td>1 (3.8)</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-CRO-STR</td>
<td>0 (0)</td>
<td>2 (9.0)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>AMP-TET-CRO-STR</td>
<td>1 (3.8)</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-TET-CRO-CLX</td>
<td>0 (0)</td>
<td>1 (4.5)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-TET-CRO-CHL</td>
<td>0 (0)</td>
<td>1 (4.5)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-CRO-CLX-CHL</td>
<td>0 (0)</td>
<td>1 (4.5)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-AMC-CRO-STR-SXT</td>
<td>1 (3.8)</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>CIP-AMP-AMC-CRO-STR</td>
<td>0 (0)</td>
<td>1 (4.5)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-FAM-CRO-STR</td>
<td>1 (3.8)</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-TET-CRO-CHL-SXT</td>
<td>1 (3.8)</td>
<td>1 (4.5)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>AMP-TET-AMC-CHL-SXT</td>
<td>0 (0)</td>
<td>3 (13.6)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>AMP-TET-CRO-CHL-SAX-STR</td>
<td>1 (3.8)</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-TET-AMC-CRO-STR</td>
<td>3 (11.5)</td>
<td>2 (9.0)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>AMP-TET-AMC-CRO-CLX-SXT</td>
<td>1 (3.8)</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>AMP-TET-AMC-CRO-CHL-STR</td>
<td>0 (0)</td>
<td>2 (9.0)</td>
<td>2 (4.2)</td>
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<tr>
<td>AMP-TET-CLOX-CHL-STR-AX-STR</td>
<td>3 (11.5)</td>
<td>1 (4.5)</td>
<td>4 (8.3)</td>
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<tr>
<td>CIP-AMP-TET-AMC-CRO-CLX-SXT</td>
<td>3 (11.5)</td>
<td>1 (4.5)</td>
<td>4 (8.3)</td>
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<tr>
<td>AMP-TET-OFX-AMC-CRO-CLAX-SXT</td>
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<td>2 (9.0)</td>
<td>2 (4.2)</td>
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<tr>
<td>AMP-TET-OFX-AMC-CRO-CHL-SAX</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
<td></td>
</tr>
<tr>
<td>AMP-TET-CRO-CLX-CLX-STR-AX-STR</td>
<td>0 (0)</td>
<td>1 (2.1)</td>
<td></td>
</tr>
<tr>
<td>CIP-AMP-TET-OFX-AMC-CRO-CLX-CHL-SXT</td>
<td>1 (3.8)</td>
<td>1 (4.5)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>Total</td>
<td>26 (54.2%)</td>
<td>22 (45.8%)</td>
<td>48 (100%)</td>
</tr>
</tbody>
</table>

Antibiotypes of the Salmonella species isolated from the wastewater samples

The result of antibiotypes of the Salmonella species in table 5 showed that the isolates exhibited resistance to combination of several antibiotics. Two (0.2) of the isolates were resistant to the entire drug tested while four (0.4) of the isolates were resistant to combination of seven antibiotics that include AMP-TET-CRO-CLX-CHL-STR-SXT and eight antibiotics combination AMP-TET-AMC-CRO-CLX-CLX-STR-SXT. The result also showed that 16.7% and 10.4% of the isolates were respectively resistant to the antibiotic combinations namely AMP-CRO and AMP-TET-AMC-CRO-STR-SXT. S. enterica subsp. enterica (11.5%) were resistant to another seven antibiotic combination AMP-TET-CRO-CLX-CHL-STR-SXT.

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DISCUSSION

The pH range (6.9-7.1) observed in this study is within the WHO permissible limit of pH range of 6.0-9.0 of effluents for discharge into the environment and is also similar and comparable with the mean value (7.2) previously reported in a study conducted in Benin City, Nigeria [20]. The low dissolved oxygen, high BOD and turbidity characteristics of the wastewater samples in this study are indicators of potential danger to the receiving surface water. Low concentrations of dissolved oxygen, when combined with the presence of toxic substances, may lead to stress responses in aquatic ecosystems because the toxicity of certain elements is increased by low concentrations of dissolved oxygen [21]. The lower DO and higher BOD value could be due to biological respiration induced by decomposition processes [22]. Meanwhile, the result of BOD from the slaughter slab (867 mg/l) and drainage (699 mg/l) obtained in this study is not in agreement with the BOD (450 mg/l) earlier reported [23] in a study carried out in Otamiri River in Egbu, Owerri, South-eastern part of Nigeria. Although, both studies were conducted on abattoir wastewater, the reason for the difference may be as a result of sampling point. While the later samples were collected about 60m away from the abattoir slaughter slab, the samples for this study were collected from the abattoir slaughter slab and drainage that is very close (15 metres) to the abattoir. However, TDS value (4,150 mg/l) obtained in this study is similar and comparable to the TDS value (4,356 mg/l) reported in a study conducted on Ebangaie abattoir in Niger State, in the northern part of the country [24]. Furthermore, it has been reported that each of the physicochemical parameters analyzed has synergetic effects on the others with great impact on water quality [25, 26].

The result of the total bacteria count in the drainage (4.78×10^7 cfu/ml) and slaughter slab (4.24×10^7 cfu/ml) is similar to the 3.3×10^7 cfu/ml and 2.7×10^7 cfu/ml obtained from a previous study carried out in Odo and Agege abattoir respectively in Lagos State [27]. However, the count was higher and not in agreement with the report of the study carried out in a private and government-approved abattoir in Benin, Edo state, a city in the south-south Nigeria [20] where a count of 9.8×10^5 cfu/ml and 4.1×10^5 cfu/ml respectively were obtained. The report of this study also disagrees with the result obtained from another recent abattoir study from Akpino, south east Nigeria where 1.00×10^6-1.77×10^4 was reported [28]. Meanwhile, the drainage total bacterial count was slightly higher than that of the slaughter slab. It was observed that the drainage received wastewater from domestic sources and this may account for the disparity. The total coliform counts obtained from this study for slaughter slab (3.03×10^7 cfu/ml) and drainage (3.51×10^7 cfu/ml) were above the coliform discharge permissible limit (4.2×10^7 and 5.2×10^7 cfu/ml) of the Federal Environmental Protection Agency [17]. However, the total coliform count is in agreement with coliform counts previously reported from studies conducted in abattoirs in the Federal Capital Territory where total coliform counts of 3.2×10^7 cfu/ml, 8.2×10^7 cfu/ml, 4.8×10^7 cfu/ml, 3.2×10^6 cfu/ml and 4.4×10^6 cfu/ml were reported from Deidei, Gwagwalada, Karu, Kubwa and Kuje abattoir respectively [29].

Nonetheless, this observation is not in agreement with the report of a government-approved abattoir study carried out in Benin, a city in the southern part of the country where the total coliform count of 1.8×10^3 cfu/ml was obtained. The high coliform count in this present study is an indication that the level of contamination of the abattoir wastewater is very high as previously reported in some abattoirs in the developing countries [22].

The isolation of Salmonella species from the present study is consistent with the reports of previous studies in abattoir wastewater both in Nigeria and Kenya [28, 30]. This observation is not strange as Salmonella is a pathogen that persists and able to survive and proliferate in different environment [28]. Although, resistance (68.8%) of Salmonella strains in this study to tetracycline is a bit high, it is however lower compared to the 90% and 80% reported in similar studies carried out in Nsukka, South Eastern, Nigeria [31] and Nairobi, Kenya [30] respectively. The reason for the difference may be due to the concentration of the antibiotics used, which was 25µg as against the 30µg used in this study. Resistance of Salmonella species to tetracycline in this study is also lower compared to the 71.4% reported from a study on clinical isolates obtained from the stool samples of diarrheic patients in Ethiopia [32]. The resistance to tetracycline in this study is however higher than the 32.1% and 36.5% recently reported from studies in Ethiopia [33, 34]. While the samples for the present study was raw abattoir wastewater,
Garedew’s study samples was from swabbing of utensils, knives, meat shops and the hand of the meat handlers and Tsegaye’s study samples from exotic chicken eggs; these could have been responsible for the difference. Nonetheless, it has been previously reported that tetracycline resistance genes are present in *Escherichia coli* and *Salmonella* species isolated from an oxytetracycline production wastewater [35]. Furthermore, the findings that 100% of *Salmonella* species were resistant to ampicillin are in agreement with similar studies in Nigeria [37] and elsewhere [32]; this is however higher than 88.7% [33], 60% [30], 58.3% [36] and 55.8% [34] previously reported in some other studies. Tetracycline and ampicillin are widely used in the treatment of animal diseases in Nigeria. The high resistance rate of *Salmonella* to these two drugs in this study may be due to their frequent use in animal husbandry [31].

Resistance of the *Salmonella* strains to amoxicillin/clavulanic acid (50.0%) is comparable to the findings of [37] and similar to the recently reported 62.3% [33]. The observation is also comparably similar to the 58.3% from a study in Ethiopia on samples from dairy farms, abattoir and humans [36] but lower than the 100% resistance reported [32] and higher than the 19.2% [34]. However, resistance of the isolates to ceftriaxone (100%) is higher than the 62.5% reported [37] in which the disparity could be due to the studied samples. While the later study was on remnant foods and wastewater from restaurants, the present study was on abattoir wastewater. The result of the resistance to ceftriaxone in this study was in total disagreement with other studies that reported 0% resistance [28, 34]. Meanwhile, resistance to ciprofloxacin (10.4%) was low which is similar to recent observations in some other related studies [28, 34] but completely disagreed with the recent report [36] in Ethiopia who reported 100% *Salmonella* resistance in a study that examined samples from dairy farm, abattoir and humans. Furthermore, resistance (4.17%) of the strains of *Salmonella* in this study to chloramphenicol is higher than the 10.0%, 16.7% and 25.0% previously reported [30, 34, 36] but lower compared to the 62.3% reported from studies on clinical isolates [32]. The result of *Salmonella* to streptomycin in this study is higher but comparable to the 50.0% from another study [36] and much higher than 30.0% and 19.2% reported in Kenya and Ethiopia respectively [30, 34].

Multidrug resistance (MDR) observed in this study is similar to that observed by Beyene et al. [36], and also corroborated the report of Adley et al. [38] that *Salmonella* exhibit multidrug resistance patterns. Similarly, the practice of indiscriminate use of antibiotics in animal husbandry can bring about a selection pressure leading to antibiotic resistance. Antibiotics resistant organisms in the environment are of public health importance since human health could be adversely affected and diseases caused by such resistant organisms are more difficult to treat. The MDR isolates in the abattoir wastewater may serve as reservoir of antibiotic resistance genes and the source of dissemination of resistance organism into receiving water bodies, food, human and animals [28]. In the present study, majority (Over 80.0%) of the isolates were multidrug resistant (MDR) out of which 16.7% and 4.2% were resistant to eight (8) and ten (10) drugs respectively; a similar observation was reported recently [36]. Studies have shown that *Salmonella* exhibits MDR patterns [38] and the level of the high MDR observed in this study is an indication that the isolates were obtained from environment where antibiotics are probably misused or often used for treatment of humans as well as livestock’s growth promoters [39]. Antimicrobial resistance genes have been reported to be common in the environment [40] and the presence of MDR in the effluents of the studied abattoir may be due to multitude of biological and ecological factors [28]. The presence of MDR isolates in the abattoir wastewater is an indication that it may harbour plasmids with several resistant genes to a number of antibiotics; these pathogens and their associated resistant genes can be spread to both humans and animals [28].

**CONCLUSION**

This study revealed the poor physico-chemical and bacteriological qualities of Akinyele abattoir wastewater as well as the occurrence of MDR *Salmonella* species in the wastewater. Therefore, there is an urgent need to educate the abattoir workers on good hygiene practices and the need to ensure proper treatment of abattoir effluent before discharge into water bodies. It is recommended that the State and Local Government health authorities should enforce compliance with requirements and regulations governing abattoir operations.
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Authors’ contributions
This work was carried out in collaboration between all authors. Author OIF designed the study and the protocol. Authors OIF and AGR managed literature search, data acquisition and wrote the manuscript. All authors read and approved the final manuscript.

Conflict of interest
The authors declare no conflict of interest.

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