Antibiotic Susceptibility Pattern of *Salmonella* and *Pseudomonas* Species Isolated from Meat Market and Ogoja Road Abattoir Effluents in Abakaliki Metropolis


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**Abstract:** This work was aimed at determining the antibiotics susceptibility patterns of *Salmonella* and *Pseudomonas* species isolated from abattoir effluents in Abakaliki Metropolis. A total of thirty (30) abattoir effluent samples (5 from each collection points viz; butchering point, rinsing point and discharging point) were collected and transported to the microbiological laboratory unit of Ebonyi State University for bacteriological analysis. Bacteria isolated were characterized using standard microbiological and biochemical techniques. A total of fifty (50) bacterial isolates (27 from meat market abattoir and 23 from Ogoja road abattoir) were isolated from both meat market and Ogoja road abattoirs. Out of the 50 bacterial isolates, 30 (60 %) were *Salmonella* species while 20 (40 %) were *Pseudomonas* species. A total of 15 *Salmonella* species and 12 *Pseudomonas* species were isolated from meat market abattoir, while a total of 15 *Salmonella* species and 8 *Pseudomonas* species were isolated from Ogoja road abattoir. Antibiotic susceptibility study on the organisms was carried out using Kirby Bauer disc diffusion method according to Clinical Laboratory Standards Institute, (CLSI, 2005). The *Salmonella* species were most sensitive to gentamicin (90 %), followed by meropenem (80 %), ceftriaxone (50 %), ofloxacin (30 %), cefuroxime (20 %) and caftazidime (10 %) while amoxycillin (0.0 %), cefotaxime (0.0 %) and clindamycin (0.0 %) showed the least activity against the bacteria. *Pseudomonas* species were more susceptible to meropenem (80 %), followed by gentamicin; (80 %), ofloxacin (60 %), ceftriaxone (20 %), ciprofloxacin (20 %), cefuroxime (20 %) and amoxyccillin (20 %) while erythromycin (0 %), ceftazidine (0 %) and cefotaxime (0 %) and chindamycin showed the least. The multiple antibiotics resistance (MAR) index of *Salmonella* was 0.73 from the two abattoirs while that of the *Pseudomonas* from meat market abattoir was 0.79 while that from Ogoja road was 0.82. This gave an indirect suggestion of the probable source(s) of the organisms. The presence of these multidrug resistant bacterial strains isolated from abattoir effluents could be a vehicle for the spread of antibiotic resistance gene to other bacteria. Hence, there is need for adequate treatment and safe disposal of abattoir effluent in Ebonyi State and also in Nigeria at large.

**Key words:** Antibiotic susceptibility • *Salmonella* • *Pseudomonas* species and Abakaliki

**INTRODUCTION**

An abattoir is a particular facility accepted and registered by the authoritarian power designed for assessment of animals, clean slaughtering, dispensation as well as efficient conservation and storage of meat yield meant for individual utilization. [1]. In addition, suitable services to make certain secure discarding of abattoir wastes in an approach that will not compose a probable risk to community wellbeing, mammal wellbeing, as well as the surroundings is measured extremely vital. The majority of abattoirs within Nigeria contain no amenities meant for trash management; trashes are moreover discarded into close by flow, thus leading to an environmental hazard [2]. Some pathogenic bacteria like *Salmonella* and *Pseudomonas* are most often isolated from waste water in unkept abattoir.

*Salmonella* is most extensively spread organism that can lead to food toxicity plus it is conveyed commonly via infected cuisines and water [3].

*Pseudomonas* species are ubiquitous organisms there within several different ecological setting, moreover they can be secluded from diverse existing sources, together with plant life, animals, as well as humans. Their
capacity to live on smallest dietary necessities in addition to stand a range of physical circumstances have permitted the organisms to persevere mutually in society as well as hospital settings.

*Pseudomonas* is extremely everywhere within water systems and has inherent antimicrobial resistance owing to small surface covering permeability and an extrinsic efflux force structure.

Pathogens can spread from animal to man by several different ways, for example via direct contact, consumption of food or water that is contaminated, indirect contact via objects that are contaminated and transmission by vectors and by aerosols [4]. A study by [5] suggests that wild animals can transfer pathogens to humans and other animals from abattoir waste by feeding on the same. Water contaminated with pathogens can also cause infection in animals and humans drinking the water or eating crops or foods contaminated by the water [6]. Waste matter in the false intelligence is in common measured to be water contamination, as well as the outpouring from an abattoir. Waste matter sump push, for example, pushes waste water from abattoir into a nearest water body. In the perspective of waste water management, waste matter that has been treated is occasionally called secondary effluent, or treated effluent. The sludge sinks to the base, parting the peak segment of water plain, open to be pumped back into the river or be reused in the procedure once more [7].

An Abattoir is defined as a ground permitted plus registered with the scheming power for clean slaughtering in addition to examination of animals, possessing as well as efficient conservation with storage of meat yield for human use [8]. Within Nigeria, the abattoir manufacturing center is an essential part of the farm animal production providing household meat supply to above 150 million populace and job opportunities for teaming populace [8]. In Nigeria, adequate abattoir waste management is lacking in all public abattoirs such that huge solid wastes along with unprocessed effluents are general sites [2] unlike in urbanized countries where these amenities are sufficiently provided [3]. These abattoir wastes could be a source of embarrassment since conventional methods of waste supervision is ignored [6]. Adding to this, there could as well be the company of pathogenic microorganisms, the same as *Enterobacter aerogenes*, *Hafniaalvei*, *Erwiniamallotivora*, *Edwardsielliaclatulai*, *Enterobacter amnigenus*, *Proteus miriabilis*, *Staphylococcus* spp. rotaviruses, hepatitis E virus, *Pseudomonas aeruginosa*, *Enterobacter intermedium*, *Yersinia aleksiciao", *Serratiaodorifer",* *Enterobacter cloacae*, *Escherichia coli* (including serotype 0157:H7), *Shigella*, *Giardia lamblia* parasite eggs, amoebic cysts, *Aspergillus*, *Mucor*, *Saccharomyces* and *Penicillium* species which are of public health importance [9]. These pathogens may make threats to the community wellbeing by transferring inside earth water or outside water; wind or else vectors like animals, birds and arthropods can transmit diseases from these microorganisms [8]. Enteric bacteria from animal feces can be gotten from surface waters; the fecal bacteria are brought into marine environments mostly through unprocessed wastewater discharge, plane runoffs and earth leakage [10].

**Salmonella**: This is a diverse organism. It is rod-shaped, Gram-negative, facultative anaerobe, non-spore forming and is mostly motile by way of peritrichous flagella, excluding *S. Pullorum* and *S. Gallinarum*, with no flagella.

**Classification of Salmonella**: The Genus *Salmonella* is among the Domain Bacteria, Phylum Proteobacteria, Class Gamma Proteobacteria, Order Enterobacteriales, Family: Enterobacteriaceae and Genus *Salmonella*. There are two species under *Salmonella* namely, *Salmonella enterica* and *Salmonella bongori* [11]. The subspecies are further divided into serotypes. Within *Salmonella enterica*, more than 2000 serotypes have been identified; and these account for about 99% of all the serotypes of *Salmonella*.

**Current Nomenclature**: Current *Salmonella* classification scheme is based on biochemical character, DNA homology and enzyme electrophoresis [12]. The taxonomy of the genus *Salmonella* developed from the first one serotype-one species theory anticipated by Kauffmann on the base of the serologic classification of somatic (O), flagellar (H) and capsular (Vi) antigens [13].

**Identification of Salmonella**: Since the importance of *Salmonella* as a human pathogen a lot attempt has been committed to the growth and development of diverse discovery methods in diverse matrices along with medical, environmental, food and feed samples [14].

**2 Molecular Detection Methods**: Numerous molecular methods are now projected for revealing *Salmonella* within foods as well as feeds. Choice of a particular process depends on attributes like reliability of the method in detecting small amounts of *Salmonella*, cost, promptness, effortlessness of handling, likelihood of ease mechanization, lack of false-negative as well as
false-positive results and international acceptability [15]. Nevertheless, molecular methods used for recognition of Salmonella categorised as immunological and nucleic acid-based techniques [16]. These methods include enzyme-linked immunosorbent Assays (ELISA), enzyme-linked fluorescent assays (ELFA), immunomagnetic separation (IMS), dip-stick and antibody microarray [17]. Whereas, Nucleic Acid-Based techniques used for recognition of Salmonella, are based on specific binding of flagellar antigens of the target organism to monoclonal antibodies. PCR, DNA hybridization and DNA microarray are examples of nucleic acid based methods used for recognition of Salmonella [14].

Antimicrobial Resistance of Salmonella: In addition to its pathogenicity, there has been concern about antimicrobial resistance in Salmonella, which has led to failure of treatment of Salmonellosis and other bacterial infectious diseases [17]. Since the discovery of antibiotic-resistant bacteria in the 1940s, efforts are being made to develop new antibiotics though at a very steady rate. In the present day, the unnecessary utilization of antibiotics and the lack of fresh effective chemotherapeutic agents on the sell have increased the trouble of antibiotic resistance more than ever into a fast rising universal health disaster. The control of communicable diseases is critically susceptible by the fixed increase in the number of microorganisms that are resistant to antimicrobial agents. Infections by resistant pathogens badly influence death, cure costs, disease spread and length of sickness [18]. Drug resistance in bacterial pathogens like Salmonella is mainly due to intensive utilization of antimicrobial drugs in food-manufacturing animals and humans [19].

Pseudomonas: Pseudomonas is a genus of Gram-negative, aerobic gamma proteo -bacteria, the family of Pseudomonadaceae that contains 191 validly described species. The members of the genus show a big deal of metabolic variety and therefore are capable of colonizing a large range of niches. Their simplicity of culture in vitro and accessibility of a rising number of Pseudomonas strain genome sequences has made the genus an outstanding focal point for scientific research; the top studied species consist of P. aeruginosa in its function as an opportunistic human pathogen, the plant pathogen P. syringae, the soil bacterium P. putida and the plant growth-promoting P. fluorescens. Since their prevalent rate in water and plant seeds such as dicots, the pseudomonads were observed early in the times past of microbiology [20].

Transmission of Pathogens in the Abattoir Environment: Pathogens can spread from animal to man by several different ways, for example via direct contact, consumption of food or water that is contaminated, indirect contact via objects that are contaminated and transmission by vectors and by aerosols [5]. A study by [6] suggested that wild animals can transfer pathogens to humans and other animals from abattoir waste by feeding on the same. Water contaminated with pathogens can also cause infection in animals and humans drinking the water or eating crops or foods contaminated by the water [2]. An example of the latter was shown by [21], where they connected a multistate outbreak of disease caused by EHEC O157:H7 to seeds of alfalfa sprouts contaminated with the pathogen.

Transmission by Birds: Birds feeding from sewage outfalls, rubbish tips or shellfish that’s been contaminated can pick up bacteria and then the bacteria can be distributed to other places by the birds [22]. In a survey of faecal samples from birds (mostly gulls) in 1997 the results showed that a small percentage of the birds included were carriers of Escherichia coli O157 [22]. In 2006 [23], found, when investigating the source of infection for an outbreak of disease caused by Escherichia coli O157 in three humans, that isolates from the humans were identical to an isolate found in a sample from wild rooks’ faeces. Their results indicated that indirect contact with faeces from wild birds can result in infection with Escherichia coli O157 and that the infection thereafter can carry on by person to person transmission. It was suggested that the birds had picked up the pathogen from faeces from livestock [23]. Several studies have shown that Salmonella spp. can be found in several different species of wild birds and that they therefore can act as carriers of the bacteria [24]; [25]; [26]; [27]. [24] found that the Salmonella spp. that was most frequently isolated from humans with diarrheal disease was found in wild crows in the same area. A study by [28] showed that contamination with Salmonella spp. and Escherichia coli in a water supply reservoir could be connected to wild birds (gulls) roosting on the water.

The Marabou stork, Leptoptilus crumeniferus, is one of the largest and most common storks in Africa. It weighs approximately five to six kilograms and has a wingspan up to four meters. Marabous are known scavengers and are reported to be omnipresent at abattoirs in some parts of Africa [29].

According to [30] Marabou storks often are in close contact with humans for example at abattoirs. In the study by [30] Marabou storks were euthanized and samples of
faeces investigated for presence of *Salmonella*, however no isolates were found to contain *Salmonella*. In a more recent study by [27], the presence of pathogenic bacteria in droppings from Marabou storks was investigated and it was found that 13 % of the droppings contained *Salmonella*, 14 % *Escherichia coli* and 9 % contained *Shigella*. The study showed that Marabou storks can carry isolates of *Salmonella*, *Escherichia coli* and *Shigella*. It was suggested that the bacteria originated from the storks’ food and water sources [27]. The authors concluded that faeces from the Marabou stork can be a potential hazard to people’s health.

**Earthworms:** Earthworms have according to [31] been suspected to transmit animal and human pathogens. They are known sources of infection of parasites to poultry and wild birds [32]. Microorganisms that are present in the environment of the worm are also often present in the worm [31]. [33] found that *Escherichia coli* O157:H7 can be found on and inside the earthworm *Dendrobaena veneta* after feeding in an environment contaminated with *Escherichia coli* O157:H7. In a study by [34], earthworms (*Lampitomauritii*) were placed in an environment with material from several sewage treatment facilities that were contaminated with *Salmonella*. *Salmonella* were found in the gut of the worms living in the contaminated sewage waste up to 70 days after the start of the study, though the study also showed that the levels of *Salmonella* in the gut of the worms decreased over time. It also showed that *Salmonella* couldn’t be found in worms living in an environment with sewage sludge mixed with cattle faeces and rice straw after 70 days and the decrease of *Salmonella* levels in worms from this group was also faster [34]. That the levels of *Salmonella* decreases when in presence of earthworms have previously been shown in other studies, using another earthworm named *Eisenia fetida* [35].

**Antibiotic Resistance in Abattoir Environments:** Antibiotic resistance measures that bacteria can refuse to accept the result of more than one antibiotic [36]. Antibiotic resistance also leads to higher medical costs and endangers the success of certain treatments [37]. It is well known that animals can harbor antibiotic resistant and zoonotic pathogens [4, 8, 38]. Multiple drug resistance has been suggested to be defined as when a bacterium has acquired resistance to one or more antibiotics in at least three antimicrobial categories [39]. Pathogens that are resistant to antibiotics can be passed on from animals to humans and vice versa [36]. As well *Escherichia coli* resistant to several antibiotics have previously been found in faeces from animals taken for slaughter at abattoirs in Kampala [40]. Resistant *Escherichia coli* and *Enterococcus* spp. have previously been isolated from wild birds and have been suggested as a danger to human health if spread to humans via faecal contaminated water [41].

**Aim:** This work is aimed at determining the antibiotics susceptibility patterns of *Salmonella* and *Pseudomonas* species isolated from abattoir effluents in Abakaliki Metropolis.

**Specific Objectives:**
- To isolate and characterize *Salmonella* and *Pseudomonas* species isolates from abattoir effluent in Abakaliki metropolis.
- To establish the prevalence of *Salmonella* and *Pseudomonas* species in abattoir effluents.
- To determine the susceptibility pattern of *Salmonella* and *Pseudomonas* species to commonly used antibiotics.
- To determine the Multi-Drug Resistance Index of *Salmonella* and *Pseudomonas* species.

**MATERIALS AND METHODS**

**Materials:** The following materials used for this study were;

**Equipment/ Glassware:** Sterile bijou bottle, sterile Universal container, Sterile Petri-Dishes, Sterile test tubes, Beaker, Measuring cylinder, Clean grease free slide, Wire loop, Marker, Masking tape, Cotton wool, Aluminum foil, Conical flask (BEMA SCIENTIFIC & CHEMICAL NIG.Ltd).

The following instruments were used, Refrigerator, Microscope, Autoclave, Weighing balance, Bunsen burner, forceps, Incubator, Hot, air oven (GULFEX MEDICAL &SCIENTIFIC ENGLAND).

**Reagent/Chemicals:** The following reagents were used; 'distilled water, normal saline, sodium chloride, peptone water, iodine, acetone, ethanol, safranin, Kovacs Reagent.

**Culture Media:** The following culture media were used, Nutrient agar, Nutrient broth, Mueller-Hinton agar, *Salmonella shigella agar*, Triple Sugar and Iron (TSI) agar, Xylose lysine deoxycholate (XLD),(OXOID)
**Antibiotics:** The following antibiotics were used State mostly populated and inhabited by indigenes and also people from other parts of Nigeria. Ebonyi State is surrounded in the east via cross River state, in the North via Benue State, in the West via Enugu State as well as in the South via Abia State. The climate is characterized by a hot dry period, which stretches from November-April, while the rainy season is from May-October. The maximum temperature during the dry season is 37.6°C while the minimum temperature is 27.1°C.

**Method**

**Research Region:** This research was done in Abakaliki Ebonyi State. Abakaliki town is a capital city of Ebonyi State. The climate is characterized by a hot dry period, which stretches from November-April, while the rainy season is from May-October. The maximum temperature during the dry season is 37.6°C while the minimum temperature is 27.1°C.

**Sterilization of Glassware:** The glasswares were sterilized using dry heat in a hot air oven at 160 degrees Celsius for 1 hour.

**Preparation of Culture Media:** Every media used were prepared according to the producer’s instructions thus; For nutrient agar, 2.8g was dissolved is 500ml of distilled water, for Salmonella- shigella agar, 63g was dissolved in 1000ml of water, for Xylose lysine deoxycholate agar, 5.3g was dissolved in 100ml of water and Mueller Hinton agar, 3.8g was liquefied properly inside 500ml water and then uncontaminated by autoclaving at 121°C for 15 minutes in well corked conical flasks. The sterilized media were allowed to cool to 45°C before being dispensed aseptically into sterile Petri-dishes in 20ml volumes and then allowed to gel. For agar slants, the well dissolved media were dispensed in 10ml volumes into Bijou bottles and sterilized. They were then placed in a slanting
position and allowed to cool and gel. For nutrient broth, 1.3g was dissolved in 250ml of distilled water. This was aseptically dispensed in 5ml volumes into test tubes, corked and sterilized in an autoclaves at 121°C for 15 minutes and allowed to cool.

**Collection of Samples:** A total of 30 abattoir effluent samples were collected from two abattoirs, fifteen (15) each from Meat market abattoir and Ogoja road abattoir within Abakaliki metropolis. From the 15 samples (Abattoir effluents) collected from each abattoir, 5 were collected from butchering point, rinsing point and discharging point respectively. The effluents were collected in sterile containers and were transported to Ebonyi State University Microbiology Laboratory complex for bacteriological analysis, within 1hr of collection.

**Cultivation of Abattoir Effluent:** A loop full each of the abattoir effluents were first inoculated into sterile test tubes containing 5ml each of sterilized Nutrient broth also they were kept warm at 37°C up to 24 hours.

**Isolation of Bacteria:** A loop full each from the resulting broths with turbidity be aseptically inoculated by streaking on plates of *Salmonella-Shigella* agar for the seclusion of *Salmonella* specie and *Pseudomonas* Cetrimide selective agar plates used for the isolation of *Pseudomonas*. Inoculated Plates be kept warm at 37°C up to 18-24 hours.

**Identification/ Characterization of the Isolates**

**Gram Staining:** Bacteria colonies were collected using a sterile wire ring and emulsified in a plunge of sterilized condensed water placed on a glass glide to make a slender spread. These were dried up by air and heat fixed by passing the slide above a Bunsen burner flare to prevent the spread from being washed off during staining. Crystal violet stain was used to fix the smear and it was allowed to stand for 60 seconds and it was later washed off with clean water. Lugol's iodine was then poured over the smear and allowed to stand for 60 seconds and was rinsed off with clean water. Acetone-alcohol was used to decolorize the smear and was washed off immediately. Then safranin was used to counter stain the smear and washed off after about 30 seconds. The slide was placed on a draining rack to air dry before being examined under the microscope using X40(to confirm the staining and distribution of materials) and oil immersion XI 00.

**Biochemical Tests:** The following biochemical tests were carried out on the isolates.

**Sulfide, Indole and Motility Medium (SIM):** The center of the medium (which contains thiosulfate and tryptonedwater) was stabbed with a loop full of the test isolate. This was kept warm at 35°C up to 24-48hours and was observed. Blackening of the medium indicated a positive test for H₂S (hydrogen sulphide) production and diffused growth from the line of inoculation spreading outward is indicative of a motile organism. Kovac's reagent measurement of 0.5ml was added and the tube shaken, a brick-red layer on the surface after 10 minutes indicated indole production [42].

**ii. Nitrate Reduction Test:** Nitrate broth in tubes were inoculated with a heavy growth of the test isolates and incubated for 24-48hours at 37°C. Then, one drop each of sulfanilic acid and alpha naphthalamine was added to each broth. Red colouration indicated a positive test for nitrate reduction.

**Sugar Fermentation Test:** Using a sterile straight inoculation needle, a colony of the test isolate was collected and the center of the TS1 agar (made of lactose, sucrose and glucose in ratio of 10:10:1) in a tube was stabbed and also the surface of the agar was streaked. The tube medium remains red this indicated that there was no fermentation. If the slant shows red and butt yellow colour, this indicated that only glucose has been fermented. If the slant and butt turn yellow, this will indicate that all 3 were fermented. And if there is black coloration, H₂S has been produced [42].

**Citrate test:** A loop full of the isolate be inoculated on Simmon’s citrate agar slope. Using wire loop that is sterile, the slope was first streaked with the saline suspension of the test organisms and the butt was then stabbed. They were kept warm at 35°C up to 48 hours. If the shown colour is blue, it indicates positive citrate test but if no color change indicates that the citrate test is negative [42].

**Antibiotics Sensitivity Testing:** Subsequent detection, the isolated microbes were subjected to antibiotic sensitivity testing by disc diffusion technique using commercially available discs according to Clinical Laboratory Standard Institute (CLSI).
Preparation of McFarland Standard Turbidity: Standard turbidity equivalent to 0.5 McFarland were organized by adding 1m of concentrated tetraoxosulphate (vi) acid to 99ml of purified water and dissolve 0.5g of dehydrated barium chloride (BaCl₂H₂O) in 50ml of purified water in a different reaction flask respectively. Barium chloride solution (0.6ml) was added to 99.4ml of the tetraoxosulphate (vi) acid solution in a different test tube and the reaction mixture assorted well to form 0.5 McFarland standard turbidity. Small portions of the turbid solution were transferred into a well capped test tubes related to the tube used initially for preparing the test microorganisms and were stored at room temperature [42]. All the test bacteria were standardize individually before use to 0.5 McFarland standard turbidity [6].

Culture: A 0.1ml suspension of each of the bacterial isolates, equivalent to -0.5 McFarland standards was made by diluting the culture with sterile NaCl and this was aseptically swabbed onto Mueller Hinton agar plates and allowed to stand for about 30 minutes to pre-diffuse. Different antibiotics types from the six classes of antibiotics (Macrolide, Quinolone, Tetracycline, Aminoglycoside, Cephalexin, Cotrimoxazole,) were used. The antibiotic paper discs were aseptically placed on the surface of the inoculated Mueller Hinton agar, using sterile forceps and incubated for 24hours at 37°C. Diameters of the zones of inhibition were measured in Millimeter and recorded, after growth/incubation.

RESULTS

Result of Morphological, Microscopic and Biochemical Characteristics of the Bacterial Isolates: Table 1 below represents the result of the cultural tests carried out on the isolates. It gives a summary of the morphological, microscopic and biochemical characteristics of the bacteria isolates from meats market and Ogoja-road abattoirs. According to the different tests carried out organisms isolated were Salmonella spp. and Pseudomonas spp.

<table>
<thead>
<tr>
<th>Colony morphology</th>
<th>Gram morphology</th>
<th>Biochemical tests</th>
<th>Sugar tests</th>
<th>Suspected organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Translucent</td>
<td>Colorless</td>
<td>Catalase</td>
<td>Methyl red</td>
<td>Suspected organisms</td>
</tr>
<tr>
<td>Colony with Black center</td>
<td>Rod</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bluish green pigment</td>
<td>Rod</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Table 2: Distribution of *Salmonella* Species Isolated from Various Parts of the Abattoir at Meat Market

<table>
<thead>
<tr>
<th>Collection point</th>
<th>No of samples collected</th>
<th>No. of isolates</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butchering point</td>
<td>5</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Rinsing point</td>
<td>5</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Discharging point</td>
<td>5</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>15</td>
<td>100</td>
</tr>
</tbody>
</table>

This table shows that there was an equal distribution of *Salmonella* species in each point at meat market abattoir.

Table 3: Distribution of *Pseudomonas* Species Isolated from Various Parts of the Abattoir at Meat Market

<table>
<thead>
<tr>
<th>Collection point</th>
<th>No of samples collected</th>
<th>No. of isolates</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butchering point</td>
<td>5</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>Rinsing point</td>
<td>5</td>
<td>4</td>
<td>33.3</td>
</tr>
<tr>
<td>Discharging point</td>
<td>5</td>
<td>5</td>
<td>41.7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>12</td>
<td>100</td>
</tr>
</tbody>
</table>

This table shows an unequal distribution of *Pseudomonas* species in each point at meat market abattoir.

Table 4: Distribution of *Salmonella* Species Isolated from Various Parts of the Abattoir at Ogoja Road

<table>
<thead>
<tr>
<th>Collection point</th>
<th>No of samples collected</th>
<th>No. of isolates</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butchering point</td>
<td>5</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Rinsing point</td>
<td>5</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Discharging point</td>
<td>5</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>15</td>
<td>100</td>
</tr>
</tbody>
</table>

This table shows that there was an equal distribution of *Salmonella* species in each point at Ogoja road abattoir.

Table 5: Distribution of *Pseudomonas* Species Isolated from Various Parts of the Abattoir at Ogoja Road

<table>
<thead>
<tr>
<th>Collection point</th>
<th>No of Samples Collected</th>
<th>No. of Isolates</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butchering point</td>
<td>5</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Rinsing point</td>
<td>5</td>
<td>3</td>
<td>37.5</td>
</tr>
<tr>
<td>Discharging point</td>
<td>5</td>
<td>3</td>
<td>37.5</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>8</td>
<td>100</td>
</tr>
</tbody>
</table>

This table shows an unequal distribution of *Pseudomonas* species in each point at Ogoja road abattoir.

Into open drainage without any form of treatment. Related study was reported by [48].

Out of the 50 bacterial isolates, 30 (60 %) were *Salmonella* species while 20 (40 %) were *Pseudomonas* species. This high presence of *Salmonella* species in this study is not surprising since *Salmonella* is reported to be an environmentally relentless pathogen competent of existing and proliferating in varied surroundings [49]. Moreover, previous studies reported that *Salmonella* can persevere in the farm surrounding for extensive periods of time owing to movement inside the farm from animals, human and livestock excrement, soil and plants [50]. The 60 % prevalence of *Salmonella* obtained in this study is higher than the 33.3 % prevalence rate by [45]; 19.5 % by, [3] and 13.5 % by [8, 51] got 12.3 % from receiving water bodies with 13.2 % from vegetables irrigated with wastewaters from Gwagwalada abattoir, Nigeria. In agreement with this study, is [48] which reported 64 % prevalence of *Salmonella* from abattoir effluent in Afikpo.

A total of 15 *Salmonella* species (Table 2) and 12 *Pseudomonas* species (Tables 3) were isolated from meat market abattoir, while a total of 15 *Salmonella* species (Table 4) and 8 *Pseudomonas* species (Table 5) were isolated from Ogoja road abattoir. In the three collection points as shown in Table 2, there was an equal distribution of *Salmonella* species which gave a high frequency of *Salmonella* species 15(100 %) while Table 3 shows an unequal distribution of *Pseudomonas* species at the three collection points where the highest occurrence was at the discharging point 15(41.7 %) followed by the rinsing point 4(33.3 %) and the least being butchering point 3(25 %). This is in agreement with [45] who also had an equal distribution of *Salmonella* species at all the collection points and also stated the high prevalence of *Salmonella* species and a low prevalence of *Pseudomonas* species in their study. There was also an equal distribution of *Salmonella* species at the three collection points at Ogoja road which shows a high frequency occurrence (Table 4) while (Table 5) shows an
Fig. 2: Percentage Susceptibility and Resistant Pattern of *Salmonella* spp Isolated from Meat Market

Fig. 3: Percentage Susceptibility and Resistant Pattern of *Pseudomonas* spp Isolated from Meat Market

Fig. 4: Percentage Susceptibility and Resistant Pattern of *Salmonella* spp Isolated from Ogoja road
unequal distribution of *Pseudomonas* species where the discharging point and rinsing point show the highest and equal distribution of 3(37.5 %) with the lowest occurrence at the butchering point 2(25 %). This result does not fully agree with the result of [51] who reported a 13.5 % *Salmonella* prevalence frequency in abattoir effluent samples. The reason for the slight difference may be as a result of the studied samples. The presence of *Salmonella* and *Pseudomonas* spp. in the abattoir effluents is of public health concern. [52] reported that cattle are the reservoir of *Salmonella* that may be spread to humans with resulting illness.

In this study, *Salmonella* isolates were highly susceptible to meropenem (80 %) and gentamicin (65 %), as shown in Fig 2. Also *Salmonella* species isolates in Figure 4 were also susceptible to meropenem (80 %) and gentamicin (90 %). In agreement with this study, is [48] which reported that *Salmonella* isolates were highly sensitive to Ciprofloxacin, Cetraxone, Gentamicin and Ofloxacin. [45] reported that Gentamicin, meropenem and ofloxacin were the most active antibiotics against *Salmonella* isolates. The *Pseudomonas* isolates were susceptible to meropenem (73.3 %) (Fig 3) and also in Fig 5 they were susceptible to meropenem (80 %), ofloxacin (60 %) and gentamicin 80 %. This agrees with [45] who recorded that Gentamycin was the most effective (85.7 %) drug against *Pseudomonas*. Conversely, the antibiotic resistance patterns of *Pseudomonas* species isolates obtained in this work contradicts the study done in university of Pittsburgh hospital in Palermo, Italy, where *Pseudomonas* isolates obtained from the patients in intensive care unit were resistant to Ofloxacin reason being that *Pseudomonas* species isolated were from different environments [53]. In consonance with this study is [6] who recorded that *Pseudomonas* strains exhibited least resistance to imipenem, colistin sulphate, meropenem and aztreonam. Most of all the bacterial isolates obtained in this work were highly susceptible to gentamicin, meropenem and ofloxacin and this shows that these antibiotics are still very effective in treating infections caused by these microorganisms.

*Salmonella* and *Pseudomonas* species isolates obtained in this work were multidrug resistant as their antibiotic resistance profiles showed that they were resistant to at least two classes of antibiotics. This is in agreement with the report of [55] where all the bacterial isolates were multidrug resistant as they exhibited resistance to at least two classes of antibiotics. The result presented in Table 6 shows the multiple antibiotics resistance (MAR) index of *Salmonella* and *Pseudomonas* species isolated from Meat Market. It was revealed that the isolates had an average MARI of 0.78 (*Salmonella*) and 0.79 (*Pseudomonas* species). The result presented in Table 7 shows the multiple antibiotics resistance (MAR) index of *Salmonella* and *Pseudomonas* species isolated from Ogoja Road. It was revealed that the isolates had an average MARI of 0.73 (*Salmonella*) and 0.82 (*Pseudomonas* species). The multiple antibiotic resistance (MAR) indices give an indirect proposal of the possible source(s) of the organism. The MAR indices in this study were greater than 0.20, this verified the statement of [6] that the MAR index greater than 0.20 indicates that the organisms must have begun from an environment where antibiotics are frequently used as also testified by [6, 56].
Table 6: Multiple Antibiotics Resistance (MAR) Index of Salmonella and Pseudomonas species Isolated from Meat Market

<table>
<thead>
<tr>
<th>Isolate Code</th>
<th>SAL</th>
<th>Ps</th>
<th>MARI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAL 1</td>
<td>0.9</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>SAL 2</td>
<td>0.6</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>SAL 3</td>
<td>0.8</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>SAL 4</td>
<td>0.8</td>
<td>4</td>
<td>0.9</td>
</tr>
<tr>
<td>SAL 5</td>
<td>0.9</td>
<td>5</td>
<td>0.8</td>
</tr>
<tr>
<td>SAL 6</td>
<td>0.9</td>
<td>6</td>
<td>0.7</td>
</tr>
<tr>
<td>SAL 7</td>
<td>0.6</td>
<td>7</td>
<td>0.8</td>
</tr>
<tr>
<td>SAL 8</td>
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<td>8</td>
<td>0.9</td>
</tr>
<tr>
<td>SAL 9</td>
<td>0.8</td>
<td>9</td>
<td>0.9</td>
</tr>
<tr>
<td>SAL 10</td>
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<td>10</td>
<td>0.9</td>
</tr>
<tr>
<td>SAL 11</td>
<td>0.9</td>
<td>11</td>
<td>0.9</td>
</tr>
<tr>
<td>SAL 12</td>
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<td>12</td>
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</tr>
<tr>
<td>SAL 13</td>
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</tr>
<tr>
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</tr>
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<td>15</td>
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</tr>
<tr>
<td>SAL 16</td>
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</tr>
<tr>
<td>SAL 17</td>
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</tr>
<tr>
<td>SAL 18</td>
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</tr>
<tr>
<td>SAL 19</td>
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<td></td>
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</tr>
<tr>
<td>SAL 20</td>
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<td></td>
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</tr>
</tbody>
</table>

Table 7: Multiple Antibiotics Resistance (MAR) Index of Salmonella and Pseudomonas species Isolated from Ogoja Road

<table>
<thead>
<tr>
<th>Isolate Code</th>
<th>SAL</th>
<th>Ps</th>
<th>MARI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAL 1</td>
<td>0.7</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>SAL 2</td>
<td>0.5</td>
<td>2</td>
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</tr>
<tr>
<td>SAL 3</td>
<td>0.9</td>
<td>3</td>
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</tr>
<tr>
<td>SAL 4</td>
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<td>4</td>
<td>0.8</td>
</tr>
<tr>
<td>SAL 5</td>
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<td>5</td>
<td>0.8</td>
</tr>
<tr>
<td>SAL 6</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAL 7</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAL 8</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAL 9</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAL 10</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

KEY: SAL = Salmonella, Ps = Pseudomonas

and [57]. Thus, from the result of the multiple antibiotic resistance indexes in this work it can be stated that these pathogens might have originated where these antibiotics are used.

**CONCLUSION**

In conclusion, the research has described the bacterial profile and multidrug resistance traits of *Salmonella* and *Pseudomonas* species from abattoir effluents in meat market and Ogoja road abattoirs all located in Abakaliki Ebonyi State as a serious public health concern. This study observed that the sanitary conditions of the environments where these two abattoirs are located are very poor. The presence of these multidrug resistant bacteria in abattoir effluents will pose a serious public health problem if not properly treated before being discharged into the environment. The public health consequences could be grave especially when they enter water bodies which are commonly used for domestic purposes. Thus, it is very imperative that abattoir effluents be properly treated before being discharged into the environment. Most of all the bacterial isolates obtained in this work were highly susceptible to gentamicin, meropenem and ofloxacin and this shows that these antibiotics are still very effective in treating infections caused by these microorganisms.

**Recommendations:**
- Abattoir effluents which are channeled into water bodies should be decontaminated before discharging into the waters and the animals examined before slaughtering.
- In order to avoid serious public health problem, the public should be educated on;
  - Proper hygiene.
  - Increase in hand washing techniques.
  - Proper treatment of water obtained from various water bodies before domestic use.
  - Proper washing of vegetables and fruits before consumption.

Therefore, the importance of adopting suitable abattoir wastewater management procedures to prevent the chances of contaminating water bodies and ground water is recommended.

**REFERENCES**


