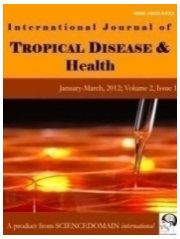

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# The Antibiotic Resisting Profile of *Salmonella* spp Isolated from the Sewage of the Campus of the University of Cocody, Abidjan, Côte d'Ivoire

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author CKJ have made the stereotyping and antibiotic sensibility test of the strains. Author CKJ also write the article, prepared the media and identified strains. Author GAAG write the protocol and has took samples in the sewers before made the culture. Author GAAG identify salmonella with the author CKJ. Authors KK and KKS rewrite and correct the article in English Author YOB designed the study and corrected the protocol. Author DM signed the protocol, gave the material and supervised all the work with the author YOB. All authors read and approved the final manuscript*

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## ABSTRACT

**Background:** Recent studies have shown that wastewater is contaminated by *salmonella* sp., pathogenic antibiotics-resisting bacteria. Using wastewater in periurban agriculture in Abidjan is likely to be the source of food-borne diseases such as salmonellosis. However, what we know about these resistant *salmonella* spp. in wastewater is limited in the country.
**Aims:** This study aims to establish the susceptibility profile of *Salmonella* spp., isolated from wastewater to antibiotics and to antimetabolite commonly used by medical

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practitioners.
**Study Design:** Spatio-temporal variation was taken into account.
**Place and Duration of Study:** The study took place from August 2008 to January 2009 at the main campus of the university of Cocody in Abidjan.
**Methodology:** Sampling was done on a weekly basis. Wastewater samples were collected at four different sewers in the campus area. *Salmonella* sp was isolated by a standard method of laboratory. The resistance of these isolated species to antibiotics was determined according to the disk diffusion method of Kirby-Baeur. The serotypes of *salmonella* were identified with the Kauffman-White table
**Results:** Five serotypes of eleven strains, which consist of 4 Hato, 3 Farmsen, 2 Derby, 1 Essen and 1 Ovonmouth, were isolated and tested in order to determine their resistance to antibiotics. Amongst the various classes of antibiotics, high resistance was found to sulfonamid (100%), followed by cefotaxime (46.67%) and tetracycline (9.1%). Ampicillin, amoxicillin and clavulanic acid, gentamicin, kanamycin, amikacin, ciprofloxacine, nalidixic acid and chloramphenicol had a high potentiality: their efficacity in the elimination of the *Salmonella* sp was proved at a level of 100%. Although the majority of strains tested (85.94%) were eliminated by the antibiotics, the serotypes Derby, Hato and Farmsen showed resistance.
**Conclusion:** The Wastewater in the area of the main campus of the University of Cocody contains the antibiotic-resisting strains of *salmonella* sp. In spite of the fact that the efficacity of some antibiotics in the elimination of *Salmonella* sp. is proved, the resistance of these strains to third generation of cephalosporin and sulfamid is worrisome. Further studies should be carried out to determine the effects of this antibiotic-resisting *salmonella* species on humain health..

*Keywords: Wastewater; Salmonella spp; resistance; sensibility; antibiotics; urban environment.*

## 1. INTRODUCTION

Developing countries are facing serious problems in wastewater management due to demographic explosion and a poor urban planning. This lack of good waste management system has negative influences on the environment and public health [1]. Abidjan, the Ivorian economic capital, and the most populous city of the West African French-speaking countries is not spared from this ordeal. Wastewater which is used by people as a resource in these cities also constitutes a great threat [2]. Directly poured into the sewerage network and in the nature [3], without being treated before [4,5], wastewater is used to irrigate crops, even though this is risky for health [6], of poor people for whom this practice is certainly a source of making money [7]. The composition of contaminants in wastewater dependeds on households' drinking water source and domestic water-use; Using these waters can bring a quasi-infinite number of polluants essentialy the organic matters (urine, faeces) in sewers [8]. Re-using water in agriculture is probably the cause of contamination of plants and crops [9]. However, infiltrating rainwater and cesspool leakage may lead to groundwater contamination [10,11].

Human and animal pathogens, excreted by individuals infected or healthy carriers are also constituents of wastewater in the sewage systems [2]. In Abidjan, it has been reported that cesspool leakages within precarious settlements is responsible for the prevalence of enteric diseases (19%) [3].

*Salmonella* spp. is responsible for ailments such as typhoid-fever infections or diarrhea in human and animals [12,2].Several studies have linked the occurrence of *Salmonella* infection to the using of contaminated waters by human or animal faeces [8,10,13]. Berge et al, reported that the abundance of *salmonella* in sewages, if untreated before re-using is a great health risk, especially with the emergence of strains of *salmonella* sp resistant to antibiotics [13]. Therefore, wastewater is an effective transport medium in the spread of *Salmonella* sp in the environment and amongst humans. Studies have shown that strains of *Salmonella* sp. referred to as wild-type are characterized by their sensitivity to all antimicrobials active against enterobacteria [14,15]. However, there are concerns about progressive increase in the natural environment of the resistant *salmonella* strains and also due in the presence of resistant clinical strains. The abuse of antibiotics by humans and in animal husbandry could be responsible [16].

The main objective of this study is to establish the antimicrobial susceptibility profile of *Salmonella* spp. isolated from wastewater sewage of the campus of the University of Cocody in Abidjan (Côte d'Ivoire) to antimicrobials commonly used in medicine to antimicrobials commonly used in human medicine.

## 2. MATERIALS AND METHODS

### 2.1 Study Location

The campus of the University of Cocody is situated in the commune of Cocody. 8,000 inhabitants and thousands of visitors are estimated to access the campus area daily. The campus is surrounded by neighboring precarious settlements such as WASSA, CHU village and CHU Baghdad from which households' wastes and wastewater are directly poured into the Ebrié lagoon Fig. 1.

Sampling was conducted from August 2008 to January 2009.

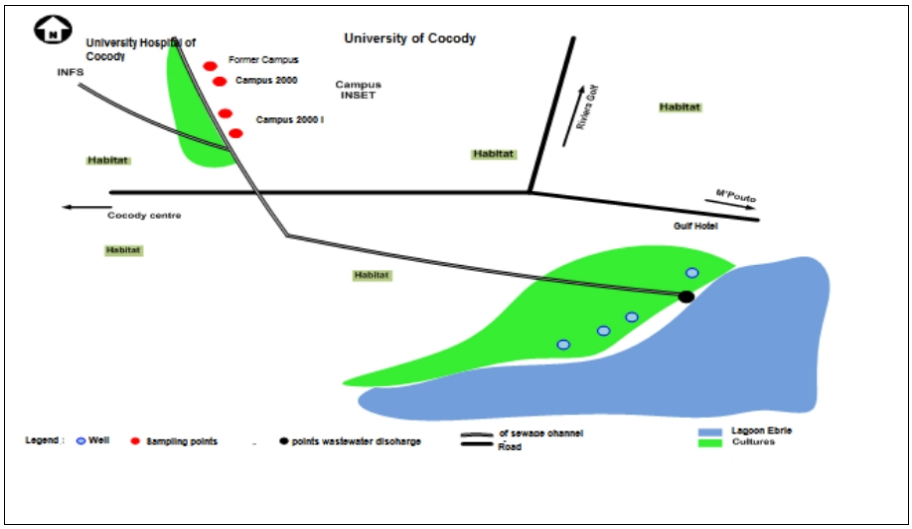


**Fig. 1. Map depicting the Cocody's communal area, the discharge channel of wastewater into the lagoon and the sampling sites of the study (Source: André GADJI, 2009)**

## 2.2 Sampling Methodology

Sampling was carried out in four sewers. The choice of the site was based on the following criteria: sewers' draining capacity, accessibility, and their physical condition. Wastewater samples were collected onto a sterile jar and packaged in 0.5 Liter sterile polystyrene bottles. Collection was done between 7 am and 8 am, once a week for a period of ten weeks.

Samples were labeled (date and time of sampling, location, batch number), transported to the laboratory in an ice-packed cooler and immediately analyzed. A total of 40 samples were collected from four (4) different sewers. 4 sub samples (2 L of wastewater) per sewer.

## 2.3 Detection of *Salmonella* in Sewage Wastewater

The detection of *Salmonella* spp. was according to the conventional method of Edel and Kampelmacher [17] and retain by the international standards [18]. This involves 4 steps: non-selective pre-enrichment, enrichment in selective media, the solid selective medium isolation and biochemical and serological identification.

### 2.3.1 Pre-enrichment in liquid media

10 mL sample was diluted by 90 ml of buffered peptone solution. The resulting mixture is left to stand for about 3 min. A control (containing only peptone solution) was also run simultaneously. They were subsequently incubated in an oven at 37ºC for at least 16 hours in sterile plastics.

### 2.3.2 Enrichment in selective liquid media

0.1mL subsample is then collected and poured onto sterile tubes of 10mL of Rappaport Vassiliadis media (RV10) and incubated at 42-44ºC for 20 hours.

### 2.3.3 Culture on selective isolation media

Hektoen Agar in Petri dishes was seeded using a sterile Pasteur pipette by streaks of exhaustion from the two selective liquid media of a same parent suspension. The plates were then incubated at 37ºC for 24 hours. After 24 hours of incubation, 3 to 5 typical colonies by Petri dish were selected for the next stage of morphological and biochemical identification.

All typical colonies of *Salmonella* have been submitted to the tests of slide agglutination using agglutinating serums Kauffmann-White scheme and completed by Le Minor identification process [19]. This step has allowed to clarify the antigenic structure of each colony and to confirm biochemical identification.

Serotyped strains were assessed for their antibiotic resistance's pattern.

## 2.4 Evaluation of the Antibioresistance [20]

The agar diffusion method according to Kirby-Bauer was used for this study. Eleven (11) antimicrobial chosen among five (5) different families were tested namely ampicillin,

amoxicillin + clavulanic acid, cefotaxime, gentamicin, kanamycin, amikacin, ciprofloxacin, nalidixic acid, chloramphenicol and sulfamide which is an antimetabolite.

### 2.4.1 Inoculum preparation

Using Pasteur pipette one to two colonies were taken from a 24 hours' culture on regular agar and transferred in a 2 mL saline suspension (0.9% Nacl) in a bottle. The solution was homogenized with a VORTEX. Solution density was measured with a DENSIMAT to read the turbidity. An amount of 100 µL of the solution is diluted into 10 mL of saline water to adjust to McFarland 0.5 standard (~ $10^8$ cfu/ml).

### 2.4.2 Seeding

A small amount of the inoculums was flooded on to a Mueller-Hinton agar previously casted in a 90 mm diameter plate. The surplus of the inoculums was removed and antibiotic disks are then placed on the surface of the agar with pliers or an automatic applicator. Boxes were allowed to rest for 3 to 5 min to allow the dissemination of antibiotics into the agar before incubation in an oven at 37ºC for 18-24 hours.

### 2.4.3 Reading

The Diameter of inhibition zones after 24 hours incubation at 37ºC is measured using a foot slide for each disk and the values interpreted as (sensitive (S), resistant (R) or intermediate (I) according to the CA-SFM instructions.

## 3. RESULTS

### 3.1 The Distribution of *Salmonella* sp in the Water Samples

42.5% of the analyzed samples contained the *salmonella* sp. Fig. 2 .36.36% *salmonella* Hato, 27.27% Farmsen, 18.18% Derby and 9.09% each of Essen and Ovonmouth, in order of decreasing abundance Fig. 3. This show the poor quality of these domestic effluents directly discharged into the lagoon environments without any form of treatment.

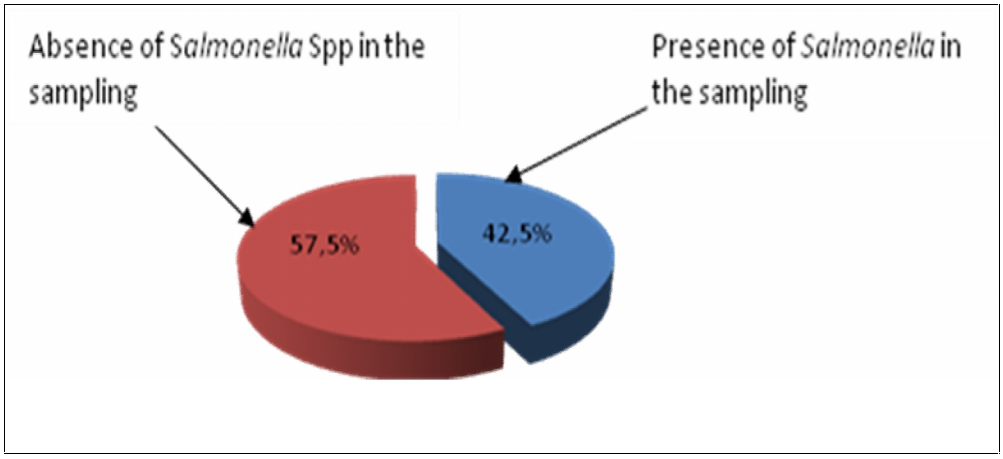


**Fig. 2. *Salmonella* isolates rate in the sewage wastewater**

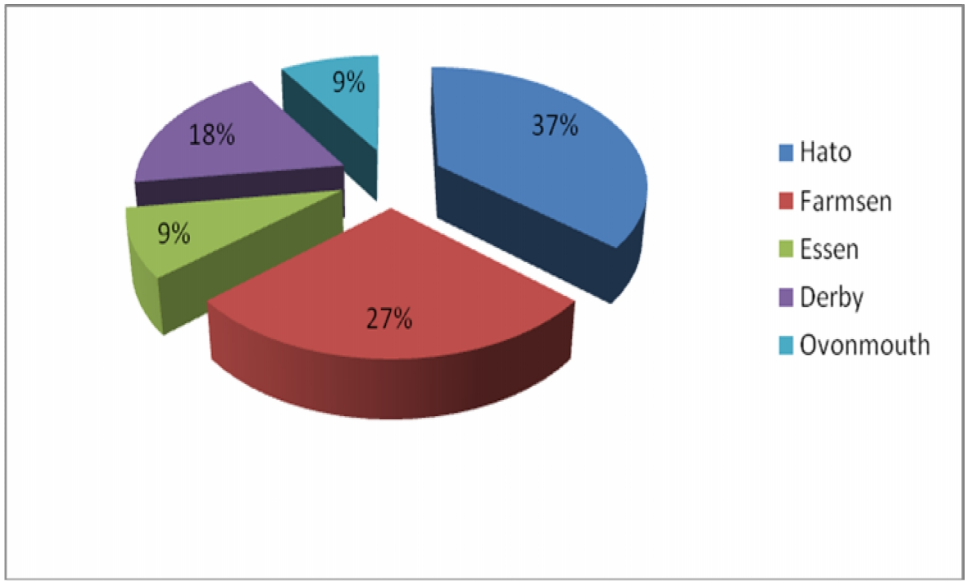


**Fig. 3. *Salmonella* Strains' identified in the sampling**

### 3.2 The Reaction of *Salmonella* Strains to Antibiotics and Antimetabolite

The resistance and sensitivity to antibiotics by 11 serovars of *Salmonella* sp was assessed. These are 4 *Salmonella* Hato, 3 *Salmonella* Farmsen, 2 *Salmonella* Derby, 1 Essen, 1 Ovonmonth. All bacteria strains showed resistance to sulfamide (antimetabolite).

Two of them showed strong resistance to cefotaxime, three showed mild resistance to this antibiotic and a single strain was resistant to tetracycline. In general, 85.54% of tested strains were sensitive to antibiotics drug, 11.58% were resistant and 2.48% showed only mild resistance Table 1.

Amongst the *salmonella* strains, *Salmonella* Derby showed a 50% resistant to cefotaxime and tetracycline Table 2. The overall resistance to antibiotics is estimated at 18.18%. This is followed by *Salmonella* Hato which showed a 25% resistance to cefotaxime and 11.36% resistance to antibiotics drugs. *Salmonella* Farmsen and Ovonmouth showed the same level of resistance but different sensibility (87.88% and 81.82% respectively). All serovars showed resistance to sulfamide the only antimetabolite used in human medicine.

### 3.3 The Effectiveness of Antibiotics and Antimetabolite in the Elimination of the *Salmonella* Strains

Result reveals that several antibiotics and antimetabolite were ineffective against some strains of *Salmonella* such Derby and Hato. Cefotaxime a third generation beta lactam Cephalosporin was the least effective (50%) in their elimination. Secondly, Tetracycline with 91% efficiency was resisted by some strains. Other antibiotics such as ampicillin, amoxicillin and clavulanic acid, gentamicin, kanamycin, amikacin, ciprofloxacin, nalidixic acid and chloramphenical were effective against *Salmonella* strain after 24 hours of incubation at 37ºC. However, the least effective antibiotics (cefotaxime) as proven in this study, had a significantly higher efficacy in the elimination of the *Salmonella* bacteria than the metabolite.

**Table 1. Distribution of Sensitive, intermediaries and resistant strains per antimicrobial drugs**

| Antibiotics/antimetabolite | Sensitive N=11 | Intermediary N=11 | Resistants N=11 |
|---|---|---|---|
| AM | 11 | 00 | 00 |
| AMC | 11 | 00 | 00 |
| CTX | 06 | 03 | 02 |
| NA | 11 | 00 | 00 |
| GM | 11 | 00 | 00 |
| K | 11 | 00 | 00 |
| AN | 11 | 00 | 00 |
| CIP | 11 | 00 | 00 |
| C | 11 | 00 | 00 |
| TET | 10 | 00 | 01 |
| **Antimétabolite** | | | |
| SSS | 00 | 00 | 11 |
| Percent (%) | 85.94 | 02.48 | 11.58 |

*β lactam : ampicillin (AM), amoxicillin + clavulanic acid (AMC) & céfotaxim (CTX) ;Aminosid : amikacin (NA), gentamicin (GM) et kanamycin (K) ;Quinolones : Nalidixic acid (AN) et ciprofloxaxin (CIP) ; phenicol : chloramphenicol (C) ; cycline : tetracycline (TET) ;sulfamides (antimetabolite) (SSS)*

**Table 2. *Salmonella* strains' antibioresistance profile**

| | S. Hato | | | S. Farmsen | | | S. Derby | | | S. Essen | | | S. Ovonmouth | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Antibiotiques** | **% S** | **% I** | **% R** | **%S** | **%I** | **%R** | **%S** | **%I** | **%R** | **%S** | **%I** | **%R** | **%S** | **%I** | **%R** |
| AM | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| AMC | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| CTX | 50 | 25 | 25 | 66,67 | 33,33 | 0 | 50 | 0 | 50 | 100 | 0 | 0 | 0 | 100 | 0 |
| NA | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| GM | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| K | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| AN | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| CIP | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| C | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| TET | 100 | 0 | 0 | 100 | 0 | 0 | 50 | 0 | 50 | 100 | 0 | 0 | 100 | 0 | 0 |
| **Antimétabolite** | | | | | | | | | | | | | | | |
| SSS | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 |
| Global resistance | 86,36 | 2,27 | 11,36 | 87,88 | 3,03 | 9,09 | 81,82 | 0 | 18,18 | 90,9 | 0 | 9,1 | 81,82 | 9,09 | 9,09 |

*S: sensitive; I: intermediate; R: resistant*

## 4. DISCUSSION

The high abundance of *Salmonella* (42.5%) in domestic source wastewater implies a high exposure risk and environmental pollution. Their abundance in the campus area is due to the density of the population and also to the prevalence of unhygienic and poor sanitary conditions.

The occurrence of *Salmonella* sp in wastewater is common issue in many cities. In Europe, it is formal at wastewater treatment and discharge points [21,10,13,2]

*Salmonella* sp is usually of intestinal origin and found in human excreta. Its occurrence in the environment leads to great health risks. In Côte d'Ivoire, Dongo et al. [3] reported on the uncontrolled discharge of domestic effluents on the streets and in open sewers. The risk linked to these irrational behaviours comes from their using or re-using in peri-urban area agriculture [22] and their possible infiltration into the subsurface waters under hydrogeological condition [11].

The already identified 2400 *Salmonella* serovars worldwide are considered pathogenic. Studies in Abidjan have shown the occurrence of *Salmonella* sp in vegetables [23] and in water used for irrigation [24]. Fresh vegetables collected from three different markets within the commune of Port-Bouet, Koumassi and Cocody has also shown the presence of *Salmonella*. According to Lorougnon [25], this is worrisome since 44% of households in the city don't disinfect vegetables before consomation.

The greatest part of *Salmonella* present in the environment (soil, water, plant) comes from animal and human excreta [26]. It is therefore necessary that domestic effluents have to be treated before discharging them into the environment. The uncontrolled disposal of effluents is responsible for the prevalence of diarrhea (19%) within the precarious settlements in Abidjan [3]. This encouraged the growth of *Salmonella*.

*Salmonella* sp. is at the origin of approximately 48% of food-borne diseases in Côte d'Ivoire [27] both in human and in animals. It is prouved that *salmonella* of human origin and *salmonella* of animal origin are the same. Therefore, the presence of *Salmonella* strains responsible for human infection in wastewater is worrisome. In fact, the serotypes Essen and Farsem identified in this study have already been cited in human pathology in Côte d'Ivoire while the Essen and Derby serotypes have been cited in veterinary medicine. So it can be concluded that in Côte d'Ivoire, the Essen serotype can be found in humans, animals and wastewater, without excluding the other serotypes.

It is proved that wild serotype is characterized by its sensitivity to all active antibiotics on enterobacteria [15], but resistant strains are definitely emerging.

This study shows that the tested serovars are sensitive to all antibiotic drugs commonly used in human medicine. These drugs include cyclin, phenicoles, quinolone, aminoglycosides and β-lactam; except the 3rd generation of cephalosporin. In fact, the study of Pilet et al. [14] showed that *Salmonella* spp. is sensitive to most of the broad-spectrum antibiotics. Nevertheless, it has been observed that there was a resistance to cyclin particularily tetracycline and alsothe 3rd generation cephalosporin, the resistance pattern of which ranged between 9.1% and 18.2% respectively. Generally, there was about 14.16% of *salmonella* bacteria that have shown a resistance to all the antibiotic drugs tested; 11.58% were strongly resistant while, 2.48% had an intermediary resistance. This degree of

resistance is similar to the findings of Al-Bahry et al. in Oman [28] but, lower than that of Melloul et al. [21] in Morocco; who isolated 36.5% resisting strains of *salmonella* in wastewater. All the tested *salmonella* strains were resistant to sulfonamide (100%). Previous studies [29] and those realised by Bonny in Côte d'Ivoire [30] have obviously demonstrated the resistance of non-typhoid *salmonella* strains to sulfonamide and tetracycline. The percentage of resistance to sulfonamide ranged between 11.59% and 93.75% while, the resistance to tetracycline ranged between 4.35% and 56.25%.

The presence of antibiotic-resisting strains of *salmonella* spp. in wastewater in Côte d'Ivoire is disturbing because of the increasing rate of salmonellosis observed in clinics and by veterinaries. According to Coulibaly et al, the percentage of resistance of *salmonella* sp to Fluoroquinolone increased from 0% in 1980 to 10.52% and to 31.57% to the third generation cephalosporin (C3G) in 2009 in humans. [27].

The bacterial strains of animal origin were resistant to tetracycline (approximately 100%) and also resistant to the third generation cephalosporin (6.82%) in 2009 in poultry.

Therefore, the *Salmonella* strains isolated from wastewater seems to resist to the third generation cephalosporin stronger than those observed in humans and animals, even if this fact is not statistically proved.

The bacteria strains, found in birds poultry were more resistant to tetracycline than were those observed in this study and in literatures [27]. This might be due to the low number of samples.

The transmission of antibiotic-resisting *Salmonella* strains from humans to animals and vice-versa is established; since they both live in the same environment that they contaminate. [31].

The presence of gene in the *Salmonella* spp, isolated from untreated wastewater, that gives him the capacity to resist to tetracycline was described by Zhang et al [32]. This, confirmed the role that could been played by the wastewaters in the transmission of the resistant genes between the *Salmonella* species and also between the human and animal population [32].

In Côte d'Ivoire, this relatively high percentage of *salmonella* sp. resisting to the third generation of cephalosporin, (C3G) found in humans, animals and in the environment, should be taken in account very carefully, since this antibiotic drug is commonly used in the treatment of infant salmonellosis [13]. In 2009, 8.1% of *salmonella* strains isolated from infants have resisted to the third generation of cephalosporin C3G [33]. World Health Organization, (WHO) reported the alarming increasing of the incidence of antibiotic-resisting *Salmonella*. This might be due wether to the abuse of antibiotic drugs in both human medicine and veterinary medicine [16] or to the presence of resistant *salmonella* strains in wastewater [34]. The genes of resistance to antibiotics are transferable between strains in the environment. That is another worrisome observation [32,35]. Courvalin et al. believed that the antibiotic-resisting bacteria are the result of the modification of the genetic material (DNA). This gives them the capacity to grow in the presence of an antibiotic concentration superior to the quantity that normally inhibits them [36].

From what has been said, It is apparent that there is a progressive increasing of antibiotic-resisting *salmonella* strains from environment, humans and animals [37]. Domestic and industrial effluents sometimes contain antibiotic residus [38]. This contributes strongly to the

keeping, the evolution and also the spreading of the populations of antibiotic-resisting bacteria, initially exhibiting low level resistance [39].

Although, antibiotic-resisting strains were observed, the study showed a high level of sensitivity of all serovars to the eight tested antibiotic drugs across a broad spectrum ranging from phenicoles family (chloramphenicol), aminoglycosides (amikacin, gentamicin and kanamycin), quinolones (nalidixic acid and ciprofloxaxine) and a β-lactam particularly of the Penicillins group has (ampicillin and amoxicillin and clavulanic acid). In case of salmonellosis, any of the above-named drugs can be administered.

This limits of this study are due to the weak quantity of samples used (forty samples) and also to weak quantity of strains (eleven strains). Therefore, it cannot be generalized.

## 5. CONCLUSION

This study revealed, the presence of various *Salmonella* serotypes in wastewater *Salmonella* Derby, *S*. Essen, *S*. Farmsen, *S*. Hato and *S*. Ovonmouth. It also showed out the degree of resistance of these strains to commonly used antibiotic drugs. It also revealed that the strains are resistant to 3rd generation cephalosporins (β-lactam antibiotics (cefotaxime)), cyclin including tetracycline and antimetabolites (sulfonamide). Even though, 11.58% of *Salmonella* strains resisted to antibiotics, *Salmonella* serovars remain totally sensitive to phenicoles, aminoglycosides, quinolones and other β-lactam particularly the penicillins Group A. These phenotypic characters of *Salmonella* allow to understand the challenges related to the treatment of salmonellosis and also to understand the necessity on a rational use of antibiotics.

## CONSENT

Not applicable.

## ETHICAL APPROVAL

Not applicable.

## ACKNOWLEDGEMENTS

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Ahoussi KE, Soro N, Soro GB, Lasm T, Oga MS, Zade SP. Groundwater pollution in African Biggest Towns: Case of the town of Abidjan (Cote d'Ivoire). EJSR. 2008;20(2):302-316.
2. World Health Organization (WHO). WHO guidelines for the safe use of wastewater, excreta and greywater French. 2012;254.
3. Dongo K, Kouamé FK, Koné Brama B, Biémi J, Tanner M et Cissé G. Situation analysis of the health environment in disadvantaged neighborhoods in the urban fabric of Yopougon in Abidjan, Côte d'Ivoire, VertigO - electronic journal Environmental Science [Online] French. 2008;8(3). Accessed January 3, 2014.
   Available : http://vertigo.revues.org/6252. DOI: 10.4000/vertigo.6252.
4. Dufour P, Chantraine JM, Durand JR. Impact of man on the Ebrie lagoonal ecosystem. Int. symposium on utilization of coastal ecosystems: Planning, Pollution and Productivity. 1985;467-484
5. Marchand M. et Martin JL. Determination of chemical pollution (hydrocarbons, organochlorine, metals) in the lagoon of Abidjan (CI) by the study of sediments. Océanogr Trop French. 1987;20:23-39.
6. Cissé G. Health impact of the use of polluted water in urban agriculture. Case of gardening. PhD thesis, EPFL / Ecole Polytechnique Fédérale de Lausanne, Lausanne French. 1997;267.
7. Camara A. Strategic Assessment of market gardening in the future cityscape Ouagadougou. Memory research / postgraduate degree in Engineering and Environmental Management / EPFL, Lausanne French. 1997;52.
8. Baumont S. Reuse of treated wastewater: health risks and feasibility in ile de France. ORS, ENSAT France; 2005.
9. Elissalde N, Ganiere JP, L'Hostis M. Pathogens in sewage sludge from urban wastewater treatment plants. Collection agricultural use of sewage, know to act. Guides and French Cahiers Techniques. 1994;87.
10. Jacob B, Korsak N, Grooven B. Flament E, Daube G. Impact of a biological treatment plant on the level of Salmonella contamination in water and sludge ann. Vet Med French. 2002;146:303-310.
11. Navarro A, Carbonel M. Evaluation of groundwater contamination beneath an urban environment: The Besos River basin (Barcelona, Spain). Journal of Environment Management. 2007;85:259-269.
12. OIE (Organisation Internationale des Epizooties). Salmonelloses in: Manuel terrestre de l'OIE. Rapport France. 2005 ;2-10(3):1117-1133.
13. Berge ACB, Dueger EL, Sischo WM. Comparison of *Salmonella* enterica serovar distribution and antibiotic resistance patterns in wastewater at municipal water treatment plants in two California cities. Journal of Applied Microbiology. 2006;101:1309–1316.
14. Pilet C, Bourdon JL, Tomab, Marchal N, Balbastre C. Edited by DOIN Medical Bacteriology and veterinary bacterial systematic. 2eédition. Biology applied French Collection. 1981;437.
15. Collin M. *Salmonella* spp. French Agency for Food Safety. 2002;6. Accessed 05 january 2014.
   Available: http://biotec.ac-dijon.fr/IMG/pdf/*salmonella*spp.pdf
16. OMS. *Salmonella* multiresistantes. Reminder No. 139. Geneva. Food Safety Department; 2005. Accessed in March 2006.
   Available: http://www.who.int/mediacentre/factchests/fs139/fr/

17. Edel W. et Kampelmacher EH. Isolation of *Salmonella* in nine European laboratories using a standardizeed technique. Bull WLD Org. 1969;41:297-306.
18. Humbert F. Les salmonelles In: SUTRA L, FEDERIGHI M, JOUVE JL. Manual food bacteriology. Polytechnica Paris France; 1998.
19. Bourgeois CM, Mescle JE, Zucca J. Food Microbiology: Microbiological aspect of safety and food quality 2nd edition. Volume 1 Collection Science and Technique Agri French. 1996;62-79.
20. Antibiotics Committee of the French Society of Microbiology. Press 2005. Edition January 2005 Accessed: 05 january 2014.
Available: http://sfm-microbiologie.com/UserFiles/file/CASFM/Casfm_2005.pdf
21. Melloul AA, HASSANI L. Antibiotic resistance of *Salmonella* strains isolated from children living in the wastewater-spreading field of Marrakesh city (Morocco). World Journal of Microbiology and Biotechnologie. 1999;15(1):91-96.
22. Koné Doulaye. Treatment of wastewater stabilization ponds microphyte and macrophytes in West Africa and Central: inventory, purification performance and design criteria. PhD thesis No. 2653, Faculty Architecture, Civil and Environmental Engineering. Ecole Polytechnique Fédérale de Lausanne, Switzerland French; 2002.
23. Aka AG. Detection of Salmonella spp in fresh vegetables: the case of chicory (Cichorium spp.) Master's thesis. UFR-STA, University of Abobo-Adjamé French; 2006.
24. N'Guetta NAM. Evaluation of the risk of contamination of irrigation water and manure used in vegetable cultivation (case of chicory) to Abidjan interest of the isolation of Salmonella spp. Memory of the Diploma of Advanced Studies. UFR-STA, University of Abobo-Adjamé French; 2006.
25. Lorougnon ND. Vegetables consumed in Abidjan: health surveys and quality of production for sale on the market control. PhD in Pharmacy No. 365. Faculty of Pharmacy, University of Cocody, Abidjan (Côte d'Ivoire) French; 1996.
26. Sutra L, Federighi M, Jouve JL. Manual food bacteriology. polytechnicia edition. Paris French. 1998;30.
27. Coulibaly KJ, Bakayoko S, Coulibaly KE, Karou GT, Goualie GB, Akesse L, Gbonon V., Boni-Cisse C, Koffi KS, Ekaza E, N'douba A. et Dosso M. Biodiversity of Salmonella in Abidjan Study isolates from 2003 to 2009 by the reference center of the Pasteur Institute. RASPA French. 2010;8:19-23.
28. Al-Bahry SN, Elshafie AE, Al-Busaidy S., Al-Hinai J, and Al-Shidi I. Antibiotic-resistant *Salmonella* spp. from human and non-human sources in Oman. Eastern Mediterranean Health Journal. 2007;13(1):49-55.
29. Gatti F, Vandepitte J, Van Oye E et Makulu A. Bacteriological and epidemiological study of Salmonella observed at Cliniques Universitaires de Kinshasa (Congo). Ann Soc Belgian Med Too French. 1968;48(2):195-224.
30. Bonny AC. Portage *Salmonella* in chicken gizzard displayed for sale at market Yopougon. Memory of the Diploma of Advanced Studies. UFR-STA, University of Abobo-Adjamé French; 2006.
31. Doublet B, Bousquet-Mélou A, Madec JY. The "One Health" in antibiotic resistance and gene flow concept. Agricultural innovations. 2012;24:79-90.
32. Zhang XX, Zhang T, Fang HH. Antibiotic resistance genes in water environment. Appl Microbiol Biotechnol. 2009;82(3):397-414.

33. Boni-Cissé C, Meité S, Faye-Ketté H, Houedanou C, Timité-Konan M, Kalpi C, Bakayoko S, Nguessend N, Akessé N, Soumahoro K, Dosso M. Serotypes and antibiotypes of *Salmonella* isolated at the University Teaching Hospital of Yopougon, Abidjan, Cote d'Ivoire from 2005 to 2009. Journal of Microbiology and Antimicrobials. 2012;4(2):40-44. Available online at: http://www.academicjournals.org/JMA DOI: 10.5897/JMA11.105. ISSN 2141-2308
34. Levi Y. Concern about the presence of antibiotics and antibiotic-resistant bacteria in the water. Environmental hazards and health French. 2006;5(4):261-65.
35. Alcaide E, Garay E. R-Plasmid Transfer in *Salmonella* spp. Isolated from wastewater and sewage-contaminated surface waters. Applied and Environmental Microbiology. 1984;48(2):435-438.
36. Courvalin P, Goldstein F, A. Philippon et J. Sirot (ed.) L'Antibiogramme. Paris, Bruxelles MPC-Videom. 1985;343.
37. Baquero F. Low-level antibacterial resistance: A gateway to clinical resistance. Drug Resist Updat. 2001;4(2):93-105.
38. Kouadio LD, Traoré SK, Bekro Y-A, Mambo V, Dembélé A, Koné M, Mazellier P, Legube B, Houenou P. Contamination of Surface Water by Pharmaceuticals in Urban Areas of Côte D'ivoire: Case of Abidjan district. European Journal of Scientific Reasearch. 2009;27(1):140-151. ISSN 1450-216X.
39. Berlau J, Aucken H, Houang EPTL. Isolation of *Acinetobacter* spp. including A. baumannii from vegetables: Implications for hospital-acquired infections. J Hosp Infect. 1999;42(3):201-204.



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