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EFFECTS OF SLAUGHTERHOUSE EFFLUENTS IN SABALIBOUGOU A DISTRICT OF BAMAKO ON THE NIGER RIVER.

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Abstract:

The general objective of this study, was evaluated the impact of discharges from the Sabalibougou slaughterhouse on the bacteriological and physic-chemical waters quality of the Niger River. This study a carried during three weeks from December 30, 2019 to February 5, 2020. The effluents they taken from the basins different: treatment basin (BT); flocculation basin (BF); filtration basin (Bfi); exit point (PS), and at the level of the Niger River: discharge point (PR).

The results obtained show the effluent of discharges from the slaughterhouse of Sabalibougou have high levels of bacteriological pollution in the effluents above the Malian discharge standards (CF: 1.56×10^6 CFU/ml; CT: 3.14×10^6 CFU/ml and SS: 90.6×10^6 CFU/ml). The presence of pollution indicators in the receiving environment having a negative impact on the Niger River course. The physicochemical characterization of the raw wastewater revealed that this liquid discharge is very loaded with organic matter terms of COD (Avg. = 451.611 mg/L), BOD5 (Avg. = 233.66 mg/L) and mineral matter in Electrical conductivity (Avg. = 652.83 µS/cm).

The average nitrate contents; orthophosphates; Nitrites and ammonium respectively are of the order of 2.382 mg/L; 52.67 mg/L; 1.875mg/L and 0.050mg/L. Although this wastewater has a high organic load (BOD5/COD ratios = 0.75; for a standard DBO5/DCO > 0.4), it exhibits satisfactory biodegradability. Examination of the COD/BOD5 ratio = 1.64 clearly underlines the biodegradable nature of the wastewater from the Sabalibougou slaughterhouse, for which biological treatment seems entirely suitable. The study shows that at the point of discharge of these effluents into the river, there is an evolution a state eutrophication state that results, an abundant development of algae (Enteromorpha intestinally a Physic-chemical analyzes d Ulva lactuca) and a high bacterial contamination of the river water at the slaughterhouse level.

Keywords: Impact; slaughterhouse; effluent; River.

Introduction

Wastewater discharges is a fundamental element in pollution, and constitute a threat to flora and fauna. However, industrial and artisanal discharges represent a danger for the physicochemical and bacteriological qualities but also for the environment that they contaminate (Benyagoub et *al.*, 2018). Wastewater discharges are therefore a fundamental element of pollution because it is the location of many chemical reactions and proliferation of many disease vectors. Besides addition, the water transports heavy metals and inserts them into the food chain (fish, etc.). Although these are most often present in trace amounts in industrial and artisanal waste, they are nevertheless very dangerous since their toxicity develops through bioaccumulation in the body (Fahssi and Chafi, 2015). Therefore, many studies highlight the negative consequences a bad sanitation, in terms of health, environment and economics. Chevalier (2002) mentions that hundreds of millions of people around the world suffer from schistosomiasis, cholera, typhoid fever, worms responsible for various health problems and other infectious diseases. In addition, 3.5 million children die each year from diarrhea, due to poor sanitary conditions. According to (Morel, 2002) 51% of African countries experience severe environmental pollution, which risks damaging water resources.

However, the slaughterhouse reject was characterized of high alkalinity, high chemical oxygen demand, high volatile matter content well as high ammonium and phosphorus content. This effluent contains a fraction of soluble COD, which is markedly lower than the total COD. This difference is mainly due to the high content of suspended organic matter, essentially comprising fat. These lipids represent 40% of the total COD of the effluent from the slaughter of cattle. These constituents represent less than 1% of the soluble COD but more than 67% of the insoluble COD of the slaughterhouse reject. The insoluble fraction represents between 30% and 75% of the overall pollutant load of the slaughterhouse discharge. In addition, this confirms the moderate biodegradability of the total organic load that was characterized by a BOD5/COD ratio of around 0.49 (Belghyti et *al.*, 2009). Besides the water, becoming an increasingly scarce commodity and the health of thousands of depends people. Therefore, the European Community Directive assess the quality of water for the nitrate quantity as nitrogen in wastewater content. The human consumption intended came into effect in August 1985 with a limit of 11 mg/l N03-N (nitrate as nitrogen) as the maximum admissible level for nitrate (Briggs, 1987). Therefore, the Meteorological events and pollution are a few of the external factors, which affect physic-chemical parameters such as temperature; pH and dissolved oxygen (DO) of the water.

These parameters have major influences on biochemical reactions that occur within the water. These parameters to changes may indicate include events, on river water body and within bacterial and plankton populations (Bezuidenhout et al., 2002). (Ghose et al., 2009) have studied the physic-chemical and microbiological parameters of different fresh water systems (river).

Keeping this in view, was worked they undertaken during the period 2019-2020 to measure some physic-chemical and microbiological (total, fecal coliform counts and Salmonella) parameters of wastewater from the slaughterhouse and the river in Sabalibougou. However, the studies carried out on discharges from the slaughterhouse aimed to assess its environmental and social impacts with a view to ensuring its sustainability.

Materiel and methods

Sampling sites:

Sampling points have been identified, located within the enclosure of the Sabalibougou slaughterhouse and in the Niger River at the level of the slaughterhouse. The geographic coordinates of the site were taken using a Garmin brand GPS (Global Positioning System), and thus mentioned (figure 1).

Sampling

Three water samples were collected from the slaughterhouse enclosure, including: (i) one from the water basin treated with sodium hypochlorite (NaClO); (ii) the second in the flocculation basin and (iii) the third sample in the filtration basin. In fact, three other samples at the slaughterhouse effluent exit point and at the end, the last three samples discharge point into the river. These water samples we taken using the sterile bottles once a week for three weeks from

December 30, 2019 to February 5, 2020. The sample bottles were labeled as follows: treatment basin (BT); flocculation basin (BF); filtration basin (Bfi); point of exit (PS) and point of discharge (PR) with date and source of withdrawal. The samples were put in a cooler and transported to the laboratory for bacteriological analyzes and physicochemical parameters (figure 2).

Methods:

Bacteriological analyzes:

The bacterial flora was determined on each sample containing 500 ml of water from the Niger River and wastewater from the slaughterhouse. Briefly, decimal dilutions was carried out, 2 replicate of 0.02 ml droplets from up to six dilutions were plated; on the surface of an agar medium sectored at most into four sectors per petri dish containing the different culture media (Bah et *al.,* 2019; O'Kane et *al.,* 2017). The fecal and total coliforms were isolated on Eosin Methylene Blue Agar (EMB) incubated at 37 to 44°C for 24 h, and *Salmonella* / *Shigella* we counted on hektoen agar incubated at 37°C for 24 h. After incubation, the colony count a done on all sectors containing 30 or less colonies per drop.

Identification by API 20E Gallery:

The purees cultures of different strains were used to identification by API 20E. Briefly, the bacterial suspension were putted in the tubes in wells of the tests. The anaerobiosis was created for ADH, LCD, ODC, URE, H2S tests and by filling their well with the candle. The gallery an incubated at 37°C for 24 hours protocol describe by (Devenish and Barnum, 1982).

Physicochemical analyses

The temperature was determined using calibrated mercury in glass thermometer (0-1000 C) to the nearest 0.050C. The pH was performed for each samples waters; by using pH-meter with inoLab WTW SERIES pH 730. The biochemical oxygen demand (BOD5) were determined by the Winkler's method. The ammonium ions, Orthophosphates and Nitrate also Nitrites were determined using calorimeter. Chemical oxygen demand (COD) was determined by titration method, using ferrous ammonia, sulphate and Ferron as indicator. The turbidity was measured on site using a microprocessor turbid meter (Igboanugo et *al.,* 2013).

Statistical analyses:

Statistical analysis of all bacterial strains isolated in the effluent from the slaughterhouse and the Niger River; was performed on the transformed data in logarithmic form using the OriginPro

9-64bit software. ANOVA models were used to examine the significance level of the number of colonies (CFU/mL) of the slaughterhouse wastewater in Sabalibougou (Kar et *al.*, 2010).

Results

Bacteriological parameters:

All the basins except the treatment basins, presented total means of total coliforms of 12.57 $\times 10^6$ UFC/mL and fecal of 6.45×10^6 UFC/ Ml. According to the basins based on the average *Salmonella* counted was different and the total to 3.62×10^8 UFC/mL, as the appearance has been demonstrated (figure 3). Suspected colonies of being *Salmonella* were confirmed on TSI agar. After the strains purification, the cultures pure showed different macroscopic aspects. Thus, the biochemical characters results of Enterobacteriaceae showing that, all in the slaughterhouse effluents they revealed the dominance of *E. coli*. Nevertheless, the coliforms presence in the effluents as well as for the river water indicates pollution in the aquatic environment. Besides namely sugars: dextrose, sucrose, lactose, maltose and mannitol were fermented of all isolates with production of acid and gas. Acid production an indicated by the color change from reddish to yellow and gas production we observed by the appearance of gas bubbles in inverted Durham tubes. All isolates of *E. coli* were catalase, indole positive and oxidase test negative. The strains identification, previously isolated and characterized on EMB culture media was followed by API 20E tests by referring to the identification catalogs. Indeed, the bacteriological analysis show the pathogenic bacteria without in the treatment basin. However, we observe the pathogenic bacteria abundant in the other basins, which exceeds the rejection threshold according to the Malian standard show in the table 1.

Salmonella sp. counted in the wastewater average between 0.84×10^6 UFC/ mL to 347.35×10^6 UFC/ mL that does not comply with the Malian standards for the discharge of wastewater into a receiving environment. To exit points to discharge point the *Salmonella* sp. /*Shigella* sp. count were decreased in the effluent into the river. *Salmonella* sp. pathogenic bacteria responsible for typhoid fever, were detected during this study in all wastewater with a relatively high rate compared to the point of discharge. The total mean of coliforms was to 2.05×10^6 UFC/ mL at the level of the flocculation basin, which increases to a very important threshold compared to the filtration basin and the point of discharge, as well as the point of exit of the Niger River. Moreover the Statistical analysis of the transformed data in logarithmic using ANOVA revealed a significant difference at 0.05 level of significance and highly significant for repeats of total fecal coliforms; *Salmonella-Shigella*; counted at the level of the flocculation basins. The variation in the density of the strains and of the repeats showing in (Table 2). The filtration basin level, the mean strains counted not significantly different, but a very highly significant variation in the repeats. Therefore, on the exit point and discharge point the logarithmic means of bacteria counted was not significantly different for the two-parameters (the time and repetition) showing in figure 3. The assessment of the pollution of raw wastewater was do according to the determination of a certain number of physicochemical parameters characterizing this wastewater (suspended solids, COD, BOD5, ammoniums, turbidity, conductivity, nitrates, nitrites and ortho-phosphates) (table 3). For the sake of comparison, we have used the Malian standard project for wastewater discharge. The temperature of wastewater from the Sabalibougou slaughterhouse is between 24.4 and 26.3°C for an average of 24.9°C. As for the water in the Niger River, the temperature was to 29.1 at the level of the slaughterhouse, 26.4°C upstream from the discharge point and 29.9°C downstream from this point. The pH of the slaughterhouse wastewater was respectively between 7.65 and 6.75 at the outlet of the sewer draining this wastewater to the river, generally the wastewater from the slaughterhouse and that of the river at the slaughterhouse have a relatively neutral pH. For electrical conductivity, the average values recorded are between 43.75 µS/cm and 1833 µS/cm with 826.56 µS/cm as the average value of the slaughterhouse wastewater. The recorded values of the conductivity of the waters of the river vary between 46 µS/cm and 502 µS/cm. Nitrates, like other nitrogenous forms, evolve very quickly in the natural environment according to the nitrogen cycle. The nitrate contents of the slaughterhouse effluents vary between 0.044 mg/L and 4.632 mg/L with an average concentration of 2.382 mg/L. The nitrate content obtained in the waters of the river varies between 0.044 mg/L and 2.687 mg/L. On the other hand, the nitrite values recorded in the slaughterhouse discharge vary between 0.020 mg/L and 6.704 mg/L with an average value of around 1.875 mg/L. The nitrite content in the waters of the river varies between 0.02mg/L and 0.7164mg/L with an average value of 0.280 mg/L. The recorded levels of ortho phosphates in the slaughterhouse effluents vary between 0.0145 mg/L to 175.03 mg/L with an average value of 52.67 mg/L, and those obtained in the waters of the river are respectively between 0.0145 mg/L and 4.1 mg/L with an average of 1.38 mg/L. The organic pollution values expressed in BOD5 recorded vary respectively between 96 mg/L to 833 mg/L in slaughterhouse effluents and those recorded in river waters are between 96 mg/L and 257 mg/L with an average of 175mg/L. The values of the chemical oxygen demand of the slaughterhouse wastewater vary between 206.4 mg/L and 636.36 mg/L with an average of

451.611 mg/L and those recorded in the river at the level of the slaughterhouse are respectively between 206.4 mg/L to 421.41 mg/L with an average of 332.53 mg/L (table 5). The flow rate of the slaughterhouse effluent is approximately 78 m3/d. On this basis, the average chemical pollution flow was estimated at 18,225,480 g of BOD5/d. COD values are between 96 mg/L (minimum) and 421.41 mg/L (maximum) with an average value of 332.53 mg/L. The further we move away from the discharge point, the greater the dilution effect becomes with a COD of 369.8 mg/L. According to the dilution curve, the maximum values of the nitrate contents; nitrites; ammonium and ortho phosphate are recorded at the point of release but they decrease when one moves away from showing in (figure 5).

Discussions

Bacteriological parameters:

According to the analysis of our results, there is a high abundance of bacteriological indicators (CT, CF, SS) when passing through the flocculation basin to the point of discharge. Indeed, the total average of total coliforms of all the basins including the river water with the exception of the treatment basin was 12.57210^{6} higher than the total average of fecal coliforms with the result of (Elmund et *al.*, 1999). This result of the values of total and fecal coliforms in the effluents of the Sabalibougou slaughterhouse is lower than the value found (Gannoun et *al.*, 2009); during the microbiological analysis of raw wastewater from the slaughterhouse in Tunisia. If we consider the fact that the effluents from the slaughterhouses mainly contain a mixture of blood, contents of the stomach and residues of the soil of the slaughterhouse, we understand the richness of this environment in germs that are witnesses of fecal contamination. Such media in fact represent culture media par excellence for these germs, which are indicators of fecal contamination (Manji et *al.*, 2012). Moreover, this richness in bacteria could have consequences on the health of local populations. A high proportion of samples of slaughterhouse effluent and Niger River water analyzed in this study were positive for total and fecal coliforms. These results corroborate those (Middleton et al., 2013); thus, the presence of coliforms in a high proportion of water samples is a good indicator of water contamination. On the other hand, *E. coli* was abundant in the samples of flocculation and filtration basin as well of the exit point and rejection; clearly, show that the effluents of the slaughterhouse have a very negative influence on these environments (figure 3) is similar to the study of Galès and Baleux (1992).

The treatment basin, the pathogenic bacteria was observed absent during this study; this is due to treatment with sodium hypochlorite. The treatment reduces the bacterial load; this is in conformity with the work (Alonso et al., 1999), during their study on the isolation of triclosan-tolerant fecal coliforms from surface water near the outlets of the treatment plant.

The presence of high levels of pathogenic bacteria such as coliforms and Salmonella / Shigella in the various basins and at the point of exit as well as exit from 2.20×10^6 to 3.78×10^6. This number of total, fecal and *Salmonella*/*Shigella* coliforms is high at the level of the flocculation basin and decreases by half at the outlet of the filtration basin. Their proportion gradually decreases to the point of rejection. This number exceeds the rejection standards (Table 4). This value is higher, considered to exceed the limit standard for direct discharge of effluents into the receiving environment; this result was comparable to those of Moussa Moumouni Djermakoye Hamsatou (2005).

We note that the total logarithmic average of the number of pathogenic bacteria decreases in the effluents corresponding to an average of 6.31 log CFU/ml in the filtration basin and at the point of exit 6.13 log CFU/ml (figure 4). This gradual decrease in the bacterial population in was linked to that of the organic matter. These results are in agreement with the data recorded by other studies on the purification performance of natural purification systems show a great reduction in fecal contamination germs > 98% (. Saizonou et al., 2010). Despite these coliforms were abundant in the different basins and the effluents show a rhythm similar to that described by (De Villers et al., 2005). ANOVA data of thermotolerant coliform counts showed significant differences ($P=0.01$), reported by (Chennaoui et al., 2002). According to the statistical analyzes within the flocculation basin, there is a strong significant variation in the concentration of the different strains, of total and fecal coliforms, of Salmonella/Shigella ($p < 0.05$). In addition, significant variations were observed in the repetitions of the flocculation and filtration basin ($p < 0.05$). This difference seems reasonable because a fluctuation in the number of bacteria would result in the abattoir effluent water sample being contaminated with fresh fecal.

The discharge of water thus loaded with bacteria into nature without any treatment inevitably leads to the contamination of the receiving environment and the spread of waterborne diseases, especially diarrhea, which is the cause of high infant mortality in Africa.

Physicochemical parameters of slaughterhouse wastewater:

The effluents from the Sabalibougou slaughterhouse have an average temperature (26.76°C) lower than that found in the effluents from the Cotonou slaughterhouse in Benin by Mickael Saizonou et al., 2010 at (30.6°C) but higher than that of Driss Belghyti, (2015) at (21.5°C) in the effluents of the Kenitra slaughterhouse in Morocco and in the waters of the Niger River at the level of the slaughterhouse. The wastewater temperature values recorded are all below 40°C considered as the limit value for direct discharge into the receiving environment.

The pH indicates the alkalinity of wastewater, its role is essential for the growth of microorganisms, which generally have an optimum pH ranging from 6.5 to 7.5. The pH values measured in the effluents remain around 6.98 on average, so these effluents are favorable to the growth of microorganisms. This value obtained is lower than that of Driss Belghyti (7.5) and higher than that of Saizonou et al, 2010. Slaughterhouse wastewater, which generally has a neutral to slightly basic pH.

The electrical conductivity reflects the degree of overall mineralization, it tells us about the salinity rate. The results obtained show a more or less significant variation in the mineralization of slaughterhouse wastewater and that of the river expressed in average conductivity. These results could be explained on the one hand by the discharge of wastewater rich in animal waste; soap for cleaning the slaughter area and bleach to disinfect the water in the highly mineralized slaughterhouse treated water basin. Similarly, these average values are lower than those found by Mickael Saizonou et al (2360 µS/cm) and Driss Belghyti (1360.5 µS/cm); but they are less than 2500 µS/cm, considered as the limit value for direct discharge into the receiving environment in Mali. Nitrogen present in wastewater can have an organic or mineral character. Organic nitrogen is mainly a constituent of proteins, polypeptides, amino acids and urea. Mineral nitrogen which includes Ammonium (NH_4^+), Nitrite (NO_2^-) and Nitrates (NO_3^-) constitutes most of the total nitrogen. For nitrites, which constitute an important step in the metabolization of nitrogen compounds, they are also part of the nitrogen cycle between ammonium and nitrates. Nitrites generally come either from an incomplete degradation of Ammonia or from a reduction of Nitrates, they only represent an intermediate stage and are easily oxidized into nitrates (by chemical or bacterial means). The concentration of nitrite in the wastewater from the Sabalibougou slaughterhouse at the outlet of the sewer is higher than the discharge standard, which leads to a slight variation in the nitrite content in the river, which is higher than the standard in surface waters. The nitrite values in the effluents from the Sabalibougou slaughterhouse are on average (1.875 mg/L) lower than those tested by Mickael Saizonou et al (5.01 mg/L) of the effluents from the Cotonou slaughterhouse and the values found by Reounodji (900 mg/L) in Etoudi slaughterhouse effluents in Cameroon. The average nitrate values (2.382 mg/L) agree with the direct discharge standard; but it is higher than the value found by Driss Belghyti (1.742 mg/L) and lower than the values of Reounodji (79.5 mg/L).

Phosphorus compounds exist in natural waters and wastewater in different forms, namely soluble ortho - phosphates, water-soluble phosphates and organophosphate derivatives the concentration of ortho phosphate in water samples on average (52.67 mg/L) is greater than the standard for discharge into the receiving environment; but they are lower than that found by Reounodji, (2016) to (164.75 mg/L) and higher than the values found by Saizonou (14.29 mg/L). Excessive discharges of phosphorus and nitrogen contribute to the eutrophication of lakes and rivers.

This phenomenon was characterized by the proliferation of algae and the decrease in dissolved oxygen, which impoverishes the fauna and flora of surface waters (rivers, lakes, etc.). Phosphates are involved in the composition of many detergents. They must be degraded and hydrolyzed by bacteria into ortho phosphates to be assimilated by other aquatic organisms. Eutrophication can occur at relatively low phosphate concentrations (50 µg/L) (Chennaoui et *al.,* 2002).

The high BOD5 values could be explained by the abundance of organic matter (rumen debris), and by the concentration of this effluent by the blood from the slaughterhouse discharges. The average of the BOD5 values (233.66 mg/L) of the slaughterhouse effluents is higher than the direct discharge standards and the value found by Driss Belghyti (482 mg/L) but lower than that found by Mickael Saizonou (512mg/L). For the COD, the average values (451.611 mg/L) are higher than 150 mg/L, considered as the direct discharge limit value but they are lower than the value found by Mickael Saizonou (428mg/L) and higher than that of Driss Belgyti (219.52 mg/L). The values of coliforms (total and faecal) and salmonella found in the effluents of the Sabalibougou slaughterhouse comply with the standards for direct discharge but they are lower than that found by Chennaoui et *al.,* (2002) in Morocco and higher than that of Alexandre Reoundodji.

Conclusion

The waters of all the effluents and of the river at the level of the Sabalibougou slaughterhouse show high levels of the main bacteriological and physicochemical parameters indicators of pollution, which significantly exceed the limit values for direct and indirect discharges into the receiving environment; with values above Malian discharge standards. *Escherichia coli* was the abundant flora in the effluents, especially considered indicator bacteria of water pollution. From a physicochemical point of view, the effluents from the Sabalibougou slaughterhouse contain nitrogenous organic compounds that are pollution indicators at levels that are in accordance with the draft Malian discharge standard with 0.050 mg/L of ammonium ions; 1.875 mg/L of nitrous ions and 2.382 mg/L of nitrate ions. The conductivities of the drained water are high (values between 1833 µS/cm and 46 µS/cm) thus justifying the significant organic and mineral pollution of the discharges. The contents of the physicochemical parameters studied are higher at the level of discharges into the river than upstream. This proves that the discharge of effluents contributes to the degradation of the physicochemical quality of the river water. These alterations undoubtedly constitute a long-term threat if measures are not taken to curb a possible increase in polluting flows. In short, this water discharged into the Niger River constitutes a source of pollution with harmful repercussions on the aquatic flora.

Conflict of Interest

The Authors declare no conflict of interest.

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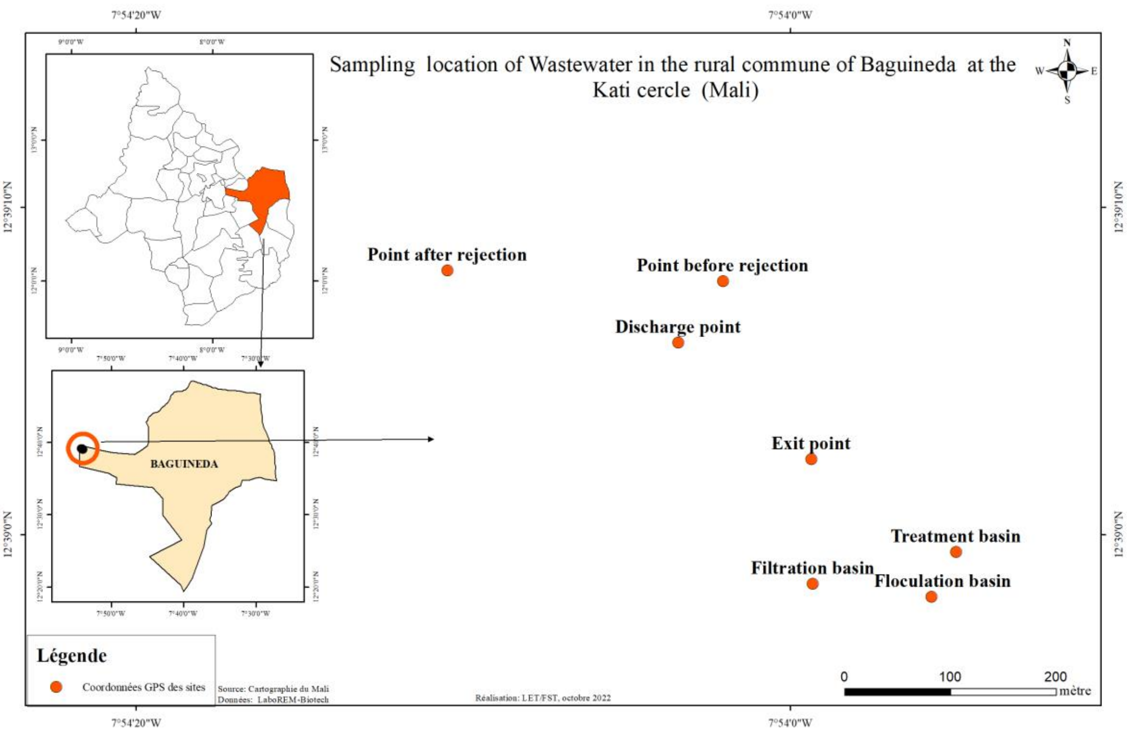

Figure 1. The geographic coordinates of the site were taken using a Garmin brand GPS (Global Positioning System).

Figure 2: Water samples.

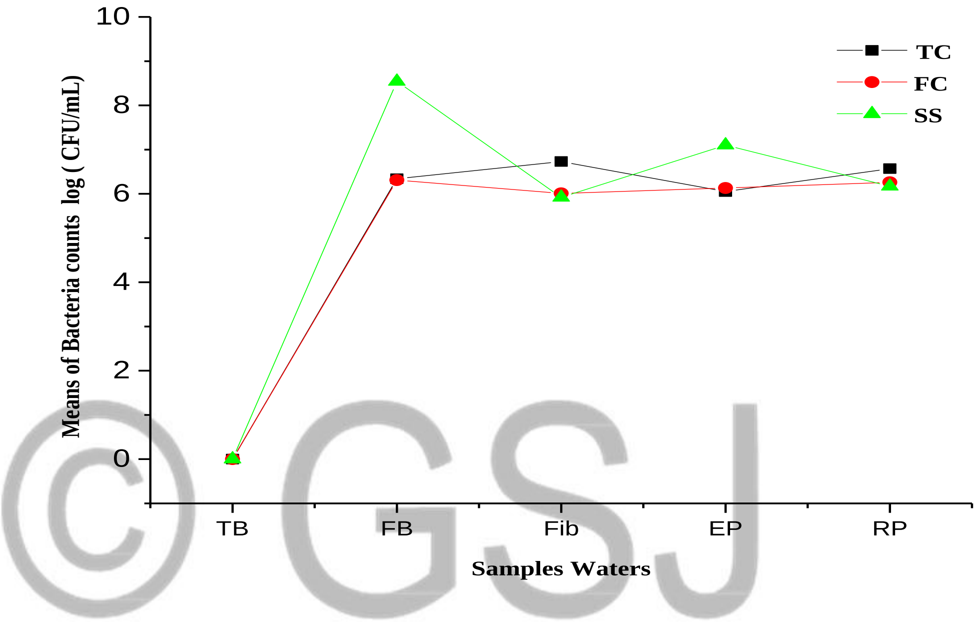

Figure 3. Evolution of the bacteria counts according to the sampling sites.

TC: total coliforms; FC: fecal coliforms; SS: *Salmonella/Shigella*; TB: treatment basin; FB: flocculation basin; Fib: filtration basin; Ep: exit point; Rp: rejection point.

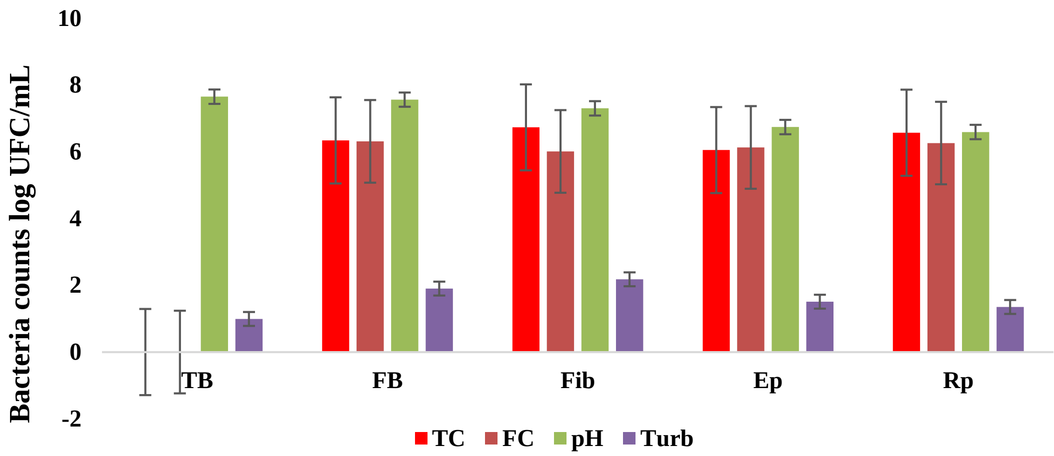

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Figure 4: Evolution of fecal and total coliforms according to turbidity and pH

TB: treatment basin; FB: flocculation basin; Fib: filtration basin; Ep: exit point; Rp: rejection point.

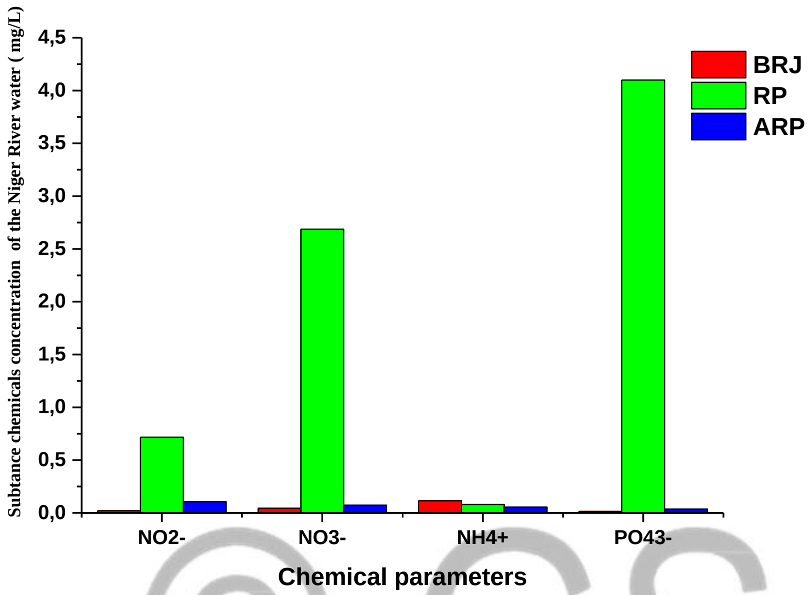

Figure 5. Effets of dilutions

BRJ: Before rejection point; **RP:** rejection point; **ARP:** after rejection point.

Table 1. The quantity of bacteria in the effluents of the slaughterhouse and of the water of the Niger River compared to the Discharge Standard.

Bacteriological parameters UFC/ml	Treatment basin	Floculation basin	Filtration basin	Exit point	Discharge point	Rejection standard
Total Coliforms	0	2.2010 ^{6}	5.4510 ^{6}	1.1410 ^{6}	3.7810 ^{6}	$\leq$ 20000
Fecal Coliforms	0	2.0510 ^{6}	1.0210 ^{6}	1.3510 ^{6}	1.8210 ^{6}	$\leq$ 20000
Salmonella/ Shigella	0	347.3510 ^{6}	0.8410 ^{6}	12.7710 ^{6}	1.4910 ^{6}	None

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Table 2. Variance analysis of bacteriological parameters (log CFU/mL).

	Means of the squares			
Sources of variations	**Fb**	**Fib**	**Ep**	**Dp**
Times	1.79402**	0.00398ns	0.19192ns	0.03384ns
Repetitions	4.76644***	6.23762***	0.07673ns	0.5645ns

Parameters	**Traitement Bassin**	**Floculation Bassin**	**Filtration Bassin**	**Exit point**	**Rejection standard**
T°C	24.4	24.4	24.5	26.3	≤ 40
pH	7.65	7.56	7.30	6.74	6.5 – 9.5
Turbidity (NTU)	9.86	82.21	152.23	32.39	5
CE (µS/cm)	43.75	410	1833	1019.5	≤ 2500
NO_2^-**(mg/L)**	0.4081	6.7049	2.57705	1.1304	≤ 0.6
NO_3^- **(mg/L)**	4.632	3.151	3.138	2.951	≤ 30
NH_4^+**(mg/L)**	0.044	0.047	0.024	0.056	≤ 15
DCO	316.8	613.6	636.36	596.91	≤ 150
DBO5	125	331	216	330	≤ 50
PO_4^{3-}**(mg/L)**	4.11	86.38	175.03	50.38	≤ 10

Fb= Floculation basin ; **Fib=** Filtration basin ***;*** **Ep=** Exit point ; **Dp=** Discharge point.

Tableau 3. Limit values for the different discharges

Parameters	Mean	Max	Min	SD
T°C	26.76	29.9	24.4	2.29
pH	6.98	7.56	6.59	0.39
Turbidité (NTU)	63.73	152.23	12.07	52.59
C E (µS/cm)	652.83	1833	46	674.63
NO_2^- **((mg/L)**	1.875	6.704	0.020	2.5410
NO_3^- **(mg/L)**	2.382	4.632	0.044	1.704
NH_4^+**(mg/L)**	0.050	0.079	0.115	0.28
DCO	451.611	636.36	206.4	167.028
DBO5	233.66	833	96	92.049
PO_4^{3-} **(mg/L)**	52.67	175.03	0.0145	69.29