Study of the Physico-Chemical and Microbiological Parameters of Household Wastewater in Brazzaville

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Abstract: - In order to contribute to the improvement of sanitation conditions in order to prevent health and environmental risks related to the discharge of household wastewater, household wastewater samples from four districts of Brazzaville were analysed in their physico-chemical and microbiological quality. The physicochemical parameters were determined according to the methods defined by the AFNOR standards and the Rodier technique. Microbiological quality has been determined by conventional microbiological methods consisting of isolation, identification and enumeration. The isolation of the germ was done using specific and/or selective media. The identification was done by determining the cultural and biochemical parameters. The count was done using the liquid method by dilution and then sowing using the Rodier technique. The results of the physico-chemical analyses showed pH values ranging from 8.12 to 9.34; water temperatures ranged from 22.35 to 23.40 0C ; turbidity from 288.75 to 440.87 NTU, electrical conductivity from 1062.54 to 2370.93 µs/cm, TSS from 264.75 to 1483.25 mg/l, total hydrometric titre from 30.52 to 33 mg/lCaCO3, the complete alkalimetric titre from 114.03 to 156.39 mg/lCaCO3, the alkalimetric titre from 36.57 to 70.49 mg/lCaCO3, bicarbonate ions from 21.16 to 86.79mg/l and oxidability at KMnO4/H+ from 0.065 to 0.14 mg/lO2. Microbiological analyses allowed us to isolate one hundred and two (102) microorganisms, including ninety-nine (99) (97.05%) bacteria and 3 (2.95%) yeast. The isolated bacteria consisted of: 51 Enterobacteria (51.51%), 16 Staphylococcus (16.16%), 16 Bacillus (16.16%), 8 Clostridium (8.08%), 8 Pseudomonas (8.08%).

Key-Words: - Physico-chemical parameters, microbiological parameters, wastewater and households.

1 Introduction

Water is the most common mineral substance on the surface of the globe. It is the fundamental and indispensable constituent of all life forms (Makhoukh et al., 2011). It deserves special attention because life depends on water quality. However, water quality is impaired and seriously threatened by human activities. Indeed, population growth accompanied by rapid urbanization is causing many disruptions to natural environments. Industrialization, the non-rational use of fertilizers and pesticides and the lack of public awareness for environmental protection lead to an imbalance in the ecosystem and generate pollutants that can affect the physico-chemical and biological quality of receiving aquatic environments (Mulliss et al., 1997) and also alter water uses (water catchment, swimming, etc.) (Burton et al., 2001). Many of the diseases that affect the world's population are linked in part to inadequate domestic and industrial wastewater disposal. In the absence of treatment, wastewater constitutes an increasing danger to human health and the natural environment because of its load of toxic chemicals and pathogenic micro-organisms (bacteria, viruses, parasites, etc.). They therefore constitute permanent threats to human and animal health (Ouali et al., 2014, Ait et al., 2002, Talouizte et al., 2007). According to WHO, 80% of the diseases affecting the world's population are linked to water pollution (WHO, 2004). Indeed, most of the microorganisms that are at the origin of major historical waterborne epidemics are normally found in the intestines of humans and some warm-blooded animals. Thus, the control and monitoring of water quality in general and of wastewater quality seems increasingly essential (Ouali et al., 2014).

In Congo, for several years now, the populations of Brazzaville have not had access to individual or collective sanitation services. Data from the Congolese Household Survey (ECOM, 2008) reveal that the coverage rate for individual sanitation (showers, latrines and flush toilets) is only 10.5%.

The remaining 89.5% of the infrastructure consists of non-conventional showers. The absence of wastewater disposal networks forces people, particularly in the districts of Brazzaville, to throw wastewater into the courtyard, street and rainwater pipes (Notten, 2008). Groundwater from captive and surface aquifers is a water resource that is exploited by humans for various uses (Matini et al., 2009). Water quality is an important parameter that affects all aspects of ecosystem and human well-being, such as community health, food production, economic activities, ecosystem health and biodiversity (Pujol, 1999). Water pollution is defined as a disturbance of the natural balance of the environment that compromises its use. Wastewater results from the physical, chemical and microbiological pollution of good quality drinking water due to human activities, whether domestic, industrial or agricultural (Defo, 2012).

In this work, we have set ourselves the general objective of contributing to the improvement of sanitation conditions with a view to preventing health and environmental risks related to the discharge of household wastewater. We first determine the physico - chemical parameters and, secondly, the microbiological parameters of household wastewater.

2 Materials and Methods

2.1 Material

It consisted mainly of wastewater from households in four districts of the city of Brazzaville, which are: Diata and Water Tower (district 1 Makélékélé), Moungali (district 4 Moungali) and Poto-poto (district 3 Poto-poto).

2.1.1 Sampling

Water samples were collected at specific points and at a defined time during the period from August to September 2016, with two samples per site. The different sampling points are recorded in Table I.

2.2 Material

2.2.1 Physico-Chemical Study

The various parameters were determined according to the techniques described in the standards NF EN ISO (2004), NF EN ISO 19458 (2006), AFNOR (1997), the following parameters were determined: pH, suspended matter temperature, colorimetry, conductivity, turbidity, total hydrometric title, alkali title, carbonate content and oxidability.

- **pH and temperature**
  pH and temperature were measured using the built-in HANNA Hi 991001 pH thermometer.
- **Suspension matter and colorimetry**
  Suspension matter was measured by colorimetry using a HACH Be Right 48471-94 DR/890 colorimeter.
- **Conductivity and turbidity**
  Conductivity was measured using the WTW, Cond. 340i HACH and the ELAMOTTE 2020e turbidimeter was used to determine turbidity.
- **Complexometry**
  The complexometry was used to determine the total hydrometric titre (water hardness) using a precision burette and reagents (K10 buffer, NET indicator and EDTA). (Rodier. 2009).
- **Titrimetry (Rodier, 2009)**
  The titrimetry was used to determine the alkalimetric titre (TA); the complete alkalimetric titre (TAC) and the oxidability to potassium permanganate using 0.035 M sulphuric acid, the coloured indicator and 10M sulphuric acid respectively, and 0.01M potassium permanganate solution.

2.2.2 Microbiological Study

2.2.2.1 Isolation and Identification of Microorganisms

Isolation was performed on different selective culture media. The following culture media were used:

- Chapman agar medium (Mannitol Salt) for the isolation of *Staphylococcus* bacteria
- Mossel agar for the isolation of *Bacillus* bacteria
- Methylene Blue Eosin Agar (EMB) for the isolation of enterobacteria;
- SS agar for the isolation of the genera *Salmonella* and *Shigella*;
- TSN agar for isolation of *Clostriduim* bacteria
- Sabouraud chloramphenicol for the isolation of yeast, in particular *candida albicans*;
- Cetrimide for the isolation of bacteria of the genus *Pseudomonas*.

The identification of the different isolated germs was made by the cultural characteristics (Case of *Stahylococcus, Pseudomonas, Bacillus, Clostriduim)* and biochemical (case of enterobacteriaceae using the Enterobacter System gallery).

2.2.2.2 Microorganism Enumeration

The enumeration was carried out using the liquid method by cascade dilution (Rodier, 2005).

2.2.2.3 Data processing

Data analysis was performed using Microsoft Excel 2010 software.

3 Results

3.1 Physico-Chemical Parameters

- **pH and temperature**

These results show that the pH varies from 8.12 in Ward 2 to 9.34 in Ward 3. The lowest temperature was observed in the wastewater sampled in Ward 1 (22.35°C) while the highest temperature was found in Ward 4(Poto-poto) (23.4°C); as shown in Figure 1.

- **Electrical conductivity, turbidity and suspension matter**

Figure 2 shows the variation in electrical conductivity, turbidity and suspension matter of wastewater. Conductivity measurement is a good assessment of the degree of mineralization in water where each ion acts by its concentration and specific conductivity.From our study, it appears that the average electrical conductivity ranges from 1062.54 (Ward 2) to 237.93 µs/cm (Ward 3). The average turbidity values range from 206.72 NTU to 440.87 NTU. Suspended solids were more abundant in the wastewater of district 1 with an average value of 1483.25 mg/l compared to district 3 which had an average value of 458.62 mg/l.

- **Total hydrometric titre (THt), complete alkalimetric titre (TAC), alkalimetric titre (TA), bicarbonate ions and oxidability to potassium permanganate**

Figure 3 shows that the mean values of the total hydrometric titre (hardness) range from 33.52 mg / l CaCO3 (Quarter 4) to 33 mg / l$CaCO_3$ (Quarters 1, 2 and 3). The mean total alkalimetric titre values range from 114.03 at quarter 3 to 156.39 mg / l for wastewater collected in the fourth quarter.The levels of hydroxide and carbonate ions range from 36.57 mg / l$CaCO_3$ (District 1) to 70.49 mg / lCaCO3 (District 2). The highest bicarbonate content was observed in Ward 1 (86.79 mg / l). Ward 3 showed the lowest bicarbonate content with an average value of 21.16 mg/l. Household wastewater analyzed during our study is low in dissolved oxygen. Mean values range from 0.065 mg /lO_2 (Ward 1) to 0.14 mg /lO_2 (Ward 2) (Figure 3).

3.2 Microbiological Parameters

3.2.1 Isolation

A total of one hundred and two (102) microorganisms were isolated and distributed as follows: (99) bacteria (97.05%) and 3 yeasts (2.95%). The results are shown in Figure 4.
The isolated bacteria consisted of: 51 Enterobacteria (51.51%), 16 *Staphylococcus* (16.16%), 16 *Bacillus* (16.16%), 8 *Clostridium* (8.08%), 8 *Pseudomonas* (8.08%) (Figure 5).

3.2.2 Identification

After identification, the microbial flora was distributed as follows:
The 51 Enterobacteria included: 8 *Escherichia coli* (15.68%), 8 *Salmonella spp* (15.68%), 8 *Shigella spp* (15.68%), 8 *Klebsiella spp* (15.68%), 5 *Enterobacter aerogenes* (9.80%), 8 *Enterobacter cloacae* (15.68%), 3 *Arizona spp* (5.90%), 3 *Proteus spp*(5.90%).
The 16 *Staphylococcus* consisted of 8 *Staphylococcus aureus* (50%) and 8 *coagulase-negative Staphylococcus* (50%)
Of the 16 isolated *Bacillus* isolates, 8 *Bacillus cereus* (50%) and 8 *Bacillus spp* (50%) were identified. *Clostridium* represented a single species which is *Clostridium perfringens* (100%) as well as *Pseudomonas* which were composed of the species Pseudomonas aeruginosa (100%). All yeasts were of the *Candida albicans* species (100%).
These results show a predominance of Enterobacteria; among which the most representative are *Escherichia coli, Salmonella spp, Shigella spp, Klebsiella spp, Enterobactercloacae*. Figure 6 shows the distribution of identified enterobacteria.

3.2.3 Counting

The following genera were isolated from all the districts selected in our study: *Staphylococcus, Bacillus, Salmonella, Shigella, Echerichia, Enterobacter, Klebsiella Pseudomonas, Clostridium*. *Proteus spp* were absent in districts 1 and 2, *Arizona spp* were isolated only in districts 1 and 3. The *Candida* were not isolated in the samples from Ward 4. Of all isolated genera, the highest microbial load was observed in *Staphylococcus*, particularly in *coagulase-negative Staphylococcus* with a respective load of 93.3510^6 CFU/200ml in Ward 1 (Figure 7).

4 Discussion

4.1 Physico-Chemical Parameters

- **pH**

Our pH results differ from those found by Makhoukh et al. in Eastern Morocco (pH=7.04 to 7.89); Abouelouafa et al. in Morocco (pH= 5.4 to 8.05); Guamri et al. in Morocco (pH= 7.2); Belghyti et al. in Rabat (pH = 7.5); Nola et al, (pH=7.24), Madjioutede (pH between 6.4 and 7.02) and by Pkia et al. (pH= 7.71) and quite similar in some respects to those found by Ouali et al., Parihar et al, in Morocco; Srivastava et al. in India and by Mukhopadhyay et al. whose respective averages range from 6.2 to 9.2; from 7.5 to 8.7; 7.6 to 8.6 and 7.62 to 8.79". According to Order No. 6199 of the Moroccan standard established by the Ministry of the Environment in 2002, these pH values are between 5.5 and 9.5. These results can probably be related to the nature of the detergents used, the degradation of organic matter by microorganisms and some landfills.

- **Temperature**

In our study, pH values disagree with those found by Makhoukh et al. in eastern Morocco in the dry season surface water study, by Guamri et al., Belghyti et al. in Rabat, Madjioutede, Parihar et al, whose respective averages are 29°C; 20.8°C; 21.5°C; 25.7-25.8°C; 28-31°C and are comparative, at some sampling points, to those found by Abouelouafa et al. in Morocco and (Ouali et al.,2010) and Pkia et al., whose respective temperatures range from 17-29°C; 20-30°C and 21.11-22.95°C. Our measured temperature values do not represent a risk of thermal pollution for the receiving environment, but do not support an acceleration of biological wastewater and sludge treatment processes, as they do not contribute to an increase in the degradation kinetics of organic matter. Our average temperature values are lower than the one prohibited by the Moroccan standard according to the official bulletin N°6199 established in August 2013 (temperature =300C). This can be explained by the season during which we carried out our work and by the different sampling times.

- **Electrical conductivity**

Our results differ from those found by (Amghar, 2002) in Ghana (EC = 4520 µs/cm), Nola et al in 2006 (EC = 6320 µs/cm). They are close for some sites to those found by Parihar et al (2012) in India, Abouelouafa et al, 2002 in Morocco where the respective averages range from 1510 to 3660 µs/cm ; 2630 to 2740 µs/cm and fairly close to those found by Guamri et al. ; Belghyti et al. ; Rabat, Srivastava et al. ; Mukhopadhyay et al, Pkia et al., Madjioutede; Ouali et al. in Morocco whose averages are: 1658 µs/cm ; 1360 µs/cm ; 1460 µs/cm ;1230 to 1466.68 µs/cm ; 2615 to 3380µs/cm ; 910 to 1017 µs/cm ; 1360.5 µs/cm and 2600 µs/cm. In comparison to the USAID standard, these waters must be used with caution because the electrical conductivity is less than 3000 mg/l. The average values recorded do not exceed the Moroccan surface water standard (2700µs/cm). Our results could be explained on the one hand by the presence of several dissolved solids (high mineralization) and on the other hand by a continuous supply of household waste.

- **Turbidity**

It is used to characterize optical purity. It is related to the measurements of suspended matter and gives a first indication of the content of colloidal matter of mineral or organic origin (clays, silts, microorganisms...). The turbidity results obtained from our work differ from those found by Srivastava et al; Mukhopadhyay et al., whose averages range from 1.5 to 3.5 NTU; from 0.3 to 1 NTU. Our results are close to those found by Attab, whose average ranges from 161 to 453 NTU. The turbidity values can be explained by the high content of colloidal material of mineral or organic origin (sand, microorganisms,...).

- **Suspension matter**

These are very fine suspended particles (sand, clay, organic products, pollutant particles, micro-organisms,...) that give a cloudy appearance to the water (turbidity) and prevent the penetration of light necessary for aquatic life.Our results on suspended solids differ from those found by Madjioutede; by Niang et al.; at the level of wastewater in Dakar and also differ at some sampling points from those of Abouelouafa et al.; Makhoukh et al.; whose values range from 33 to 651 mg/l; 123 mg/l (S1) and 2730 mg/l (S2) and are comparative to those found by Guamri et al, and by Belghyti et al; in Rabat, whose averages are 513 mg/l and 482 mg/l. According to USAID, this wastewater is severely restricted because the suspended solids are >100 mg/l. These can lead to physical or biological clogging, thus reducing soil aeration of anaerobic conditions. Excessive quantities cause obstruction of localized irrigation systems (USAID). Apart from point 1 of the castle, all the averages obtained exceed the limit value of the Moroccan waste water standard of decree n°5448 of 2006 set at 250 mg/l. These results can be explained by the presence of poorly biodegradable materials and/or by a continuous supply of household waste (Fathallah et al., 2014).

- **Total Hydrometric Title**

The Total Hydrometric Title expresses the overall concentration of water in alkaline earth ions (Ca^{2+} and Mg^{2+}); i.e. calcium and magnesium salts present in the water (Guamri et al., 2007). Our results disagree with those found by Parihar et al. in India; Srivastava et al. and Mukhopadhyay et al. whose respective averages range from 152 to 332 mg/l $CaCO_3$; 229 to 560 mg/L and 240 to 340 mg/L. These results could be explained by a low concentration of Calcium and Magnesium salts.

- **Alkalimetric title**

Our results differ from those found by Guamri et al.; Ouali et al. in Morocco; Belghyti et al.; Srivastava et al. and Mukhopadhyay et al. whose respective averages are 191.1 mg/l$CaCO_3$; 100 to 260 mg/l$CaCO_3$; 201 mg/l$CaCO_3$; 350 to 620 mg/l $CaCO_3$ and 180 to 300 mg/l CaCO3. Variations in the alkalinity of wastewater give an indication of the degree of oxidation of organic compounds. Our results may be related to the nature of the soil.

- **Complete alkalimetric title**

The concentration of carbonates (CO3 $^{2-}$) and bicarbonates (HCO^{3-}) in water is a function of the CO2 content because CO2 is highly soluble in water (200 times more than oxygen) and its solubility depends on temperature and atmospheric pressure. The slightly high CAT concentrations in the samples analysed could be due to the fact that these wastewater are less loaded with fermentable organic matter that can be oxidized and that results in high CO_2 production (Belghyti et al., 2009).

- **Bicarbonate ions**

These results differ from those found by Abouelouafa et al. These results can be explained by the presence of $CaCO_3$ with low water solubility and by the presence of CO_2, which gives water a much higher dissolution strength by transforming calcium carbonate into calcium bicarbonate, which is more soluble in water in the presence of carbon dioxide.

- **Oxidability with potassium permanganate**

These results differ from those found by Ounoki et al. in Algeria, by Belghyti et al. in Rabat, Ouali et al. in Rabat, Parihar et al. in Srivastava et al. in Mukhopadhyay et al. and Attab whose respective averages are: 0.5 to 4 mg/lO_2; 1.8 mg/lO_2; 1.37 mg/lO_2; 7.4 mg/lO_2; 3.1 to 4.7 mg/lO_2; 5.16 to 6.86 mg/lO_2 and 0.6 to 1.68 mg/lO_2. Our results can be explained by the presence of several strict and aerobic microorganisms that consume dissolved oxygen and by the absence of photosynthetic organisms.

4.2 Microbiological Parameters

The microbiological study of the wastewater revealed significant bacterial contamination of human and/or animal origin (Figure 7). The results obtained can be explained on the one hand by the fact that wastewater is rich in carbonaceous or nitrogenous elements, which promotes bacterial growth and by the absence of a disinfection treatment used to destroy pathogens and on the other hand by very significant neighbouring human activity. In addition, wastewater is considered the optimal medium for microbial growth. The results on *Salmonella spp*. differ from those found by Ouali et al. in the studies carried out in Morocco at two stations, Dokkarate and Pont Narjiss. These resultsindicate that these waters do not comply with WHO guidelines (1994). Abdelmalek et al. and Aboulkacem et al. found no positive samples for *Salmonella spp.*

These results disagree with those found by Parihar et al., Who worked on groundwater found that isolated *E. coli* and Enterococcus had microbial loads that ranged from 2 to 2400 CFU / ml.Our results on *Escherichia coli*, *Salmonella spp*, *Pseudomonas aeruginosa, Clostridium perfringen*s, *Staphylococcus aureus* and *Enterococcus* differ from those found by (Popova et al, 2014) whose respective loads are 1.0710^4 CFU/100 ml; $2.27.10^4$ CFU/100 ml; $1.25.10^5$ CFU/100 ml; 4.8010^3 CFU/100 ml; 4.2710^4 CFU/100 ml and 6.8410^4 CFU/100 ml and are fairly close to the results found by the National Institute of Statistics (INS, 2012) of Cameroon during the work carried out on surface and groundwater whose work has proven that *E. coli* was the most represented faecal indicator with an average of more than 100,000 CFU/100 ml and that total coliform concentrations are 10 times higher than those of *E. coli*. Microbial loads of *E. coli*, fecal coliforms obtained by Nitiema et al; Pkia et al. and Attab with respective averages ranging from 1056 to 3042 CFU/100 ml; from 1345 to 8827 CFU/100 ml and from 1.8210^5 germs/100 ml for *E. coli* to 1.1810^6 germs/100 ml fecal coliforms different from those we found. *Fecal Streptococci* were also isolated and counted by Nitiema et al, and Pkia et al, with averages ranging from 713 to 2160 CFU/100 ml and 38 to 4.0410^6 CFU/100ml.

Our results on faecal coliforms(10.3910^7 CFU/200 ml or 51.9610^5 CFU/100ml) differ from those found by Srivastava et al., (Ouali et al., 2010) in Morocco, Nola et al., Cameroon, Aboulkacem et al. in Morocco, Pkia et al., Tallon et al. and by Georges et al, whose respective loads range from 0 CFU/100 ml to 84 CFU/100 ml; $2.5.10^4$ and 6.10^5 CFU/100 ml; 33.10^6 CFU/250 ml; 10^4 to 10^5 CFU/100 ml; 7.2

to 2.24 10^6 CFU/100 ml; 17.210^6 CFU/100 ml and 22.10^6 CF/100 ml and are similar to those found by Abdelmalek et al. in Algeria whose averages range from 10^6 to 10^7 CFU/100 ml.

The loads on *Pseudomonas aeruginosa* and *E. coli* found by Brousseau et al. in Quebec (50 CFU and greater than or equal to 1 CFU/100 ml), by Nola et al. for *Pseudomonas spp* and *Bacillus* (33.10^6 CFU/250 ml) differ from those we found. Aboulkacem et al. in Morocco have found *reducing Clostridium sulfito* whose charges range from 10^4 to 10^5 CFU/100 ml.

Our results on *Staphylococcus* differ from those found by Madjioutede during work on Brazzaville muddy pipeline waters, whose respective values range from $1.625.10^6$ CFU/100 ml to 16.10^7 CFU/100 ml and are close to those of *Salmonella spp* (115.10^3 CFU/100 ml), *Shigella spp* (105.10^3 to 11.10^4 CFU/100 ml), and *E. coli* (105.10^3 to 15.10^4 CFU/100 ml).Our results on *E. coli*, *Proteus spp*, *Bacillus cereus*, *Klebsiella spp*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* are close to those found by Efuntoye et al. whose respective loads per 100 ml of wastewater are: 35.10^3;5.10^3;2.10^3;25.10^3; 7.10^3 and 14.10^3UFC.According to the Moroccan surface water classification, the high concentrations of total coliforms as well as the faecal coliforms found (>50000 CFU/100 ml) and (>20000 CFU/100 ml) allow these waters to be classified as of poor bacteriological quality (Ouali et al., 2010).

5 Conclusion

Nowadays wastewater is frequently reused for the irrigation of fodder or vegetable crops, in industry: cooling circuit, construction, paper mills, textile industries, etc. They are also used in urban areas: fight against the fire, car and road washing, watering parks. They can also be used for the production of drinking water and for recharging the water table. At the end of this study, we have indeed been able to show that wastewater in Brazzaville neighborhoods is characterized by organic and inorganic pollution and that the microbial load is very high. These wastewaters, which provide different elements, modify the composition and equilibrium of certain ecosystems. Therefore, they should never be spilled in the raw state into the environment, let alone be reused for irrigation crops in the city. These represent on the one hand a serious threat to the health of the populations in the case where well water, streams, river, river are used for the various human activities and on the other hand threaten the flora and the aquatic fauna. Wastewater deteriorates at some points the quality of the water distributed to the population by the authorized companies due to the aging of the transport network, which represents a health risk.

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Table 1: Different sampling points

	Sampling points	Addresses
Ward1(Diata)	Point 1	Fraternitystreet No.17
	Point 2	Kimbenzastreet No. 52
Ward 2 (Château d'eau)	Point 1	Massamba Bernard street No. 10
	Point 2	Saint Paul street No. 13
Ward 3 (Moungali)	Point 1	Djambala Street No. 10
	Point 2	Makotipoko street No. 21
Ward 4 (Poto-poto)	Point 1	Zandé street No.16
	Point 2	Bakukouyas street No. 14

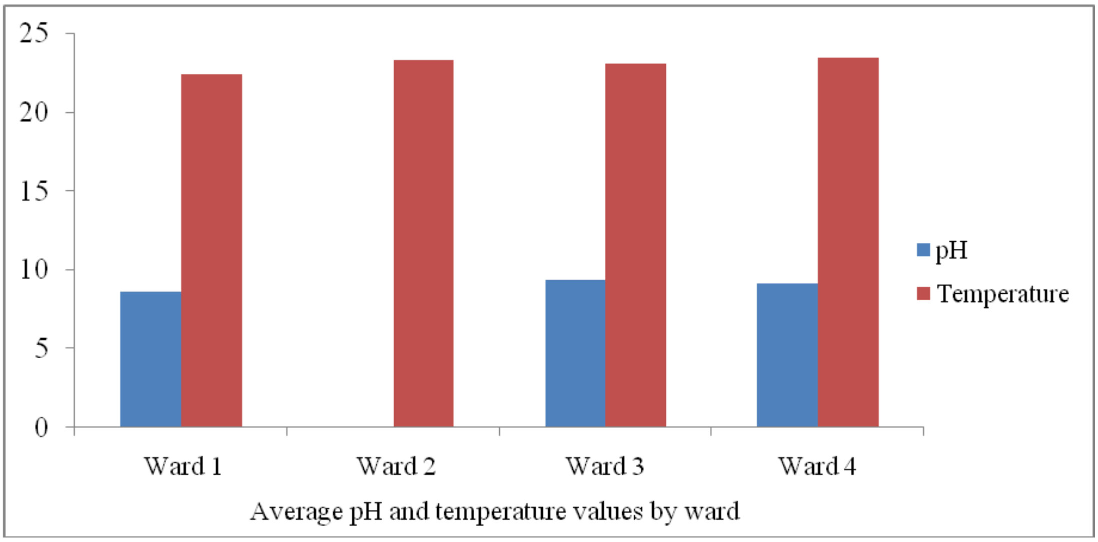

Fig.1: Variation in average pH and average wastewater temperature by ward

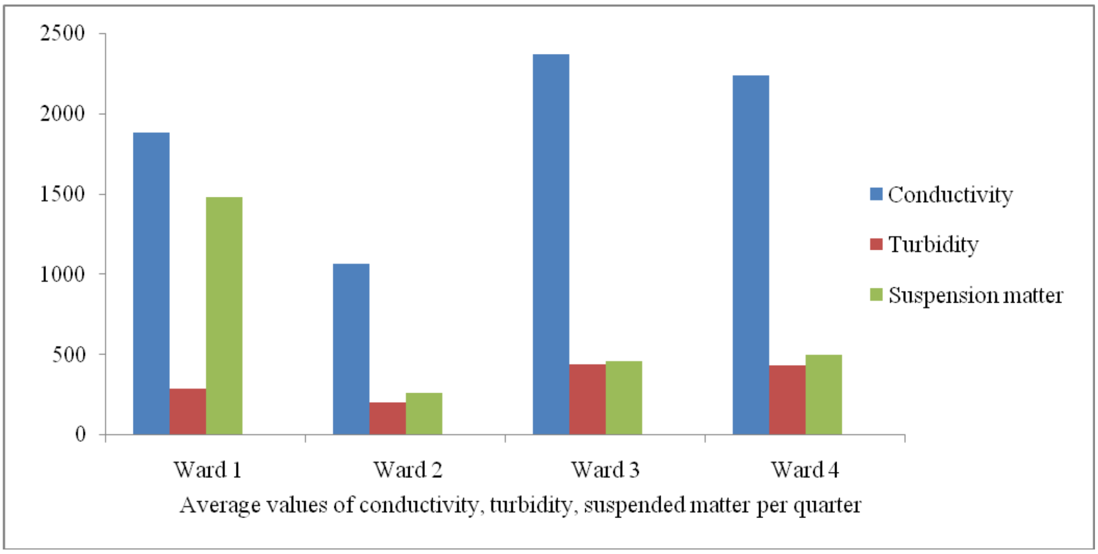

Fig.2: Variation in conductivity, turbidity and average suspended solids of wastewater by neighbourhood.

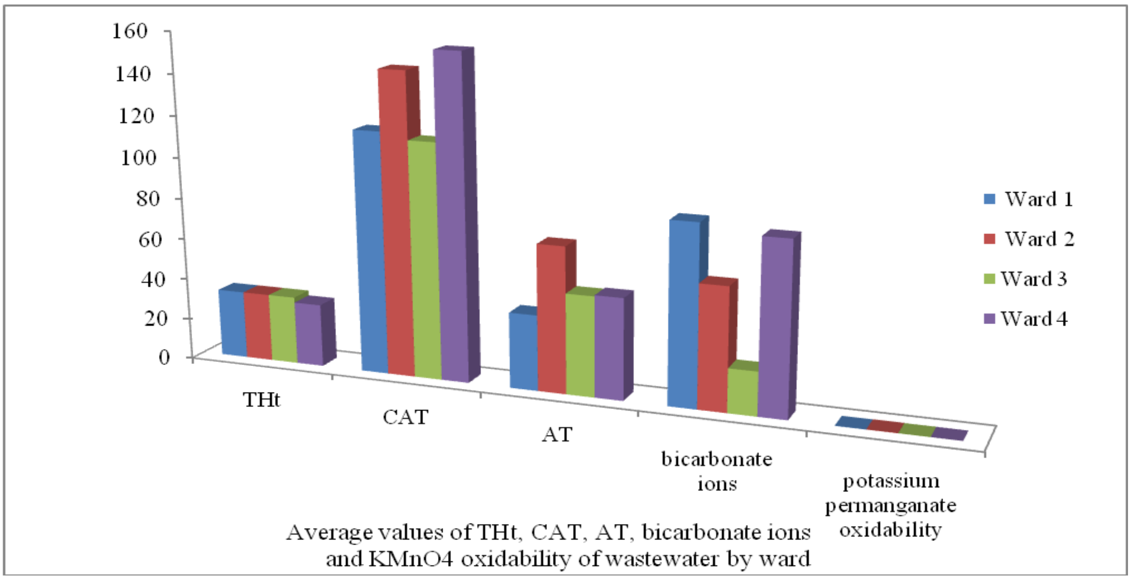

Fig.3: Mean change in total hydrometric titre (THt), total alkalinity titre (TAC), alkalinity titre (TA), bicarbonate ions and mean potassium permanganate oxidability of wastewater from different sampling points.

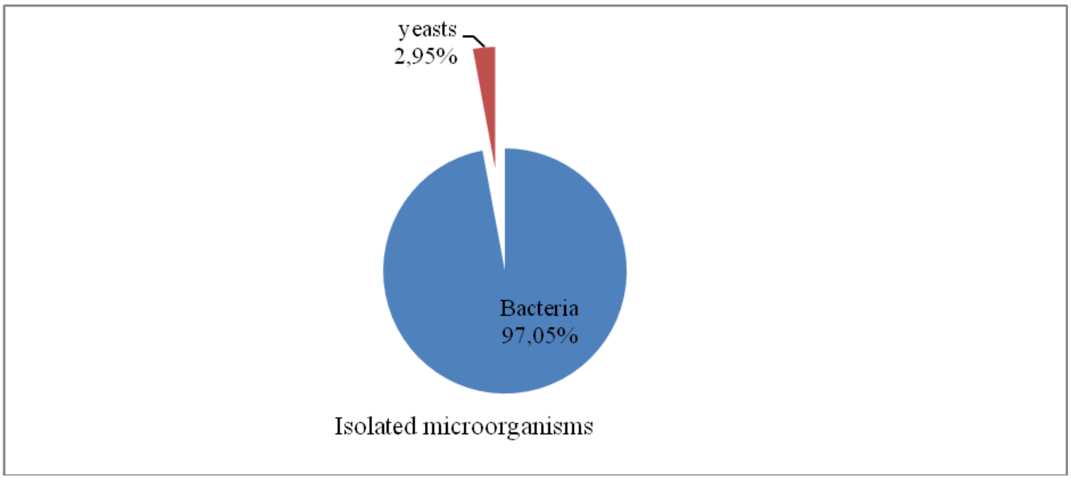

Fig.4: Distribution of microorganisms isolated from household wastewater

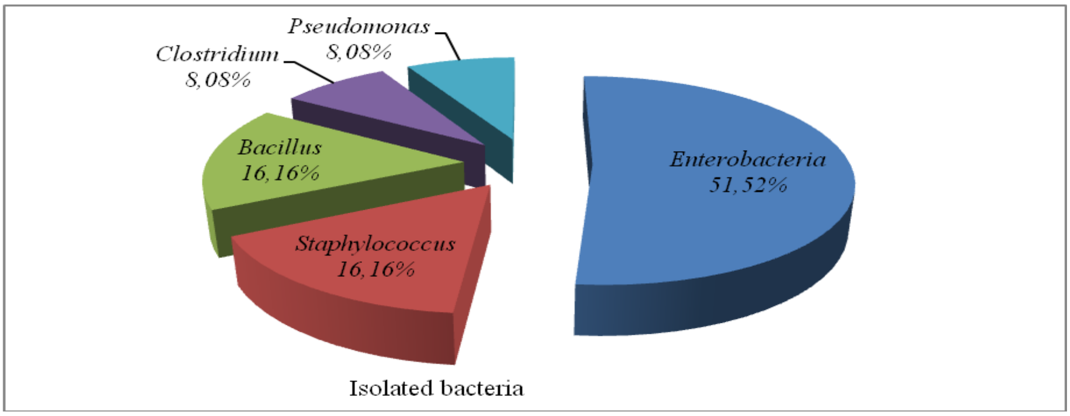

Fig.5: Distribution of bacteria isolated from household wastewater

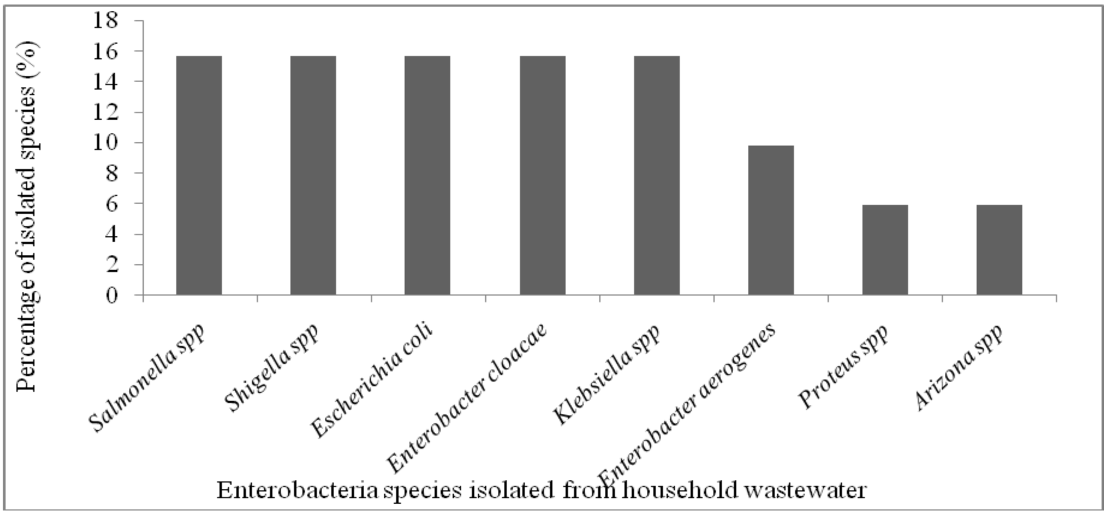

Fig.6: Distribution of identified enterobacteria.

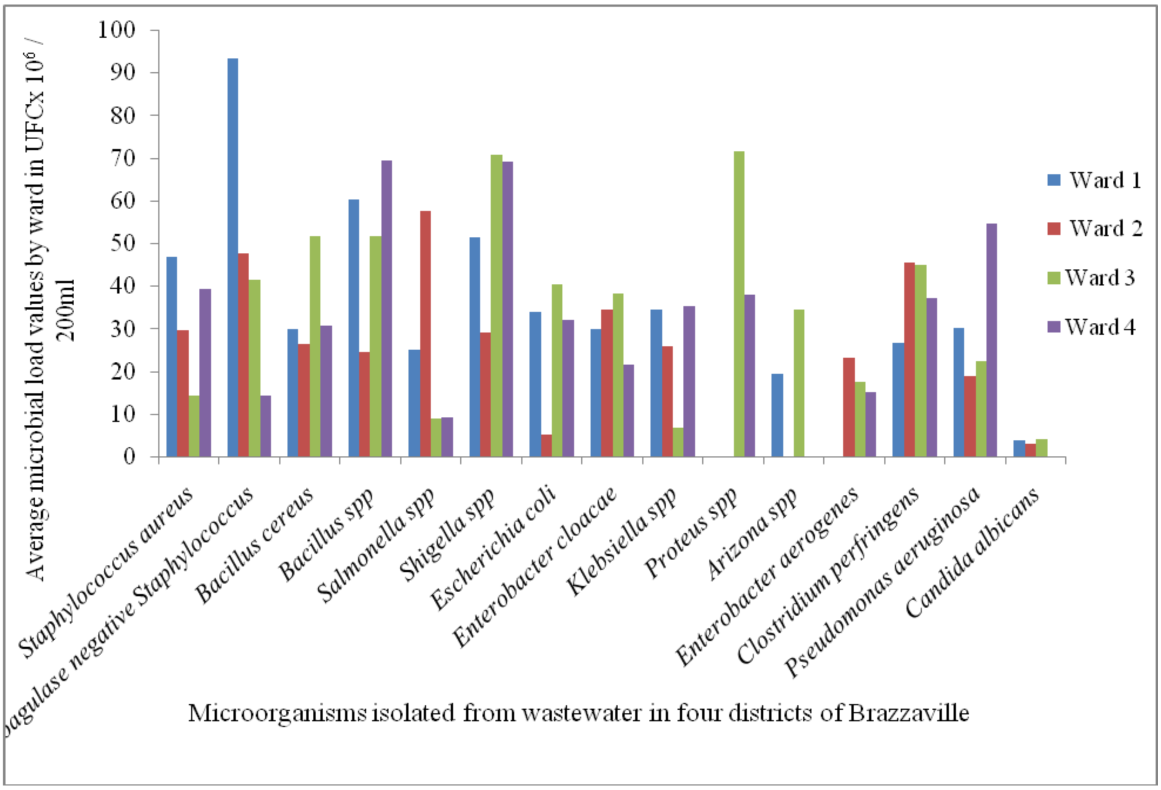

Fig.7: Variation of the average microbial load per district