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Treatment by Slow Filtration on Charcoal, Sand and Gravel of Raw Domestic Wastewater from the City of Conakry, Guinea

Daloba SOUMAH[1*], Demba MAGASSOUBA[2], Ansoumane SAKOUVOGUI[3*], Mamby KEITA[4]

[1] Department of Biology, Faculty of Sciences, Gamal Abdel Nasser University of Conakry, Guinea.
[2] Department of Biology, Faculty of Sciences, Gamal Abdel Nasser University of Conakry, Guinea.
[3] Energy Department, Higher Institute of Technology of Mamou, Guinea.
[4] Department of Physics, Faculty of Sciences, Gamal Abdel Nasser University of Conakry, Guinea.

* Corresponding author email : *dalojsoumah41@gmail.com*

Abstract: *This present study aims to treat raw domestic wastewater from the city of Conakry in the Republic of Guinea by the method of filtration on charcoal, sand and gravel. Wastewater has different compositions and comes from various origins and constitutes a problem for nature when it is discharged without undergoing prior treatment. In order to show the interest of their purification, we carried out the treatment by a trial of domestic wastewater from the five (5) municipalities of Conakry (Kaloum, Matam, Matoto, Ratoma and Dixin). Wastewater of different compositions and origins poses a problem for nature when discharged without undergoing prior treatment. In order to show the interest of their purification, we presented in this work a trial of treatment of domestic wastewater of the city of Conakry by filtration from sand, gravel and coal. After treatment of raw domestic wastewater by slow filtration on charcoal, gravel and sand, bacteriological analyzes of twenty-five (25) wastewater samples still show the presence of faecal coliforms/E.coli (CF) and faecal streptococci (SF) in water samples but with smaller values compared to untreated water. The treatment or abatement rates varied from 99.95% to 99.99% for CFs and from 99.97% to 99.99% for SFs, which shows good efficiency of the filtration treatment device executed. Parasitological analyzes revealed the total absence of parasites (Entaboiba histolytica, Ascaris, Pinworm, Fasciola hepatica and Trichuris). According to standards, treated water can be used in agriculture, on construction sites and can be discharged into the natural environment without danger.*

Keywords: Treatment, slow filtration, coal, sand, gravel, domestic wastewater

1. Introduction

In the Republic of Guinea, water consumption is increasing considerably and the shortage is felt throughout the country, with repercussions on socio-economic development as well as the preservation of the environment. This strong demand is the result of population growth and improved living conditions. Faced with these constraints, Guinea is deploying significant scientific, technical and financial efforts to mobilize its hydraulic potential in order to meet these challenges [1].

In Guinea, nearly 12% of urban households and 49% of rural households do not consume drinking water and are therefore exposed to all water-related diseases. Even if the water quality is good at the point of use, it deteriorates considerably all along the chain from drawing to use. Slightly more than one household in ten (12.7%) treats water before consuming it. The proportion of households that treat water before consuming it is 25.2% in urban areas compared to 7.1% in rural areas. Inadequate water supply combined with inappropriate hygiene behaviors and practices are the cause of waterborne diseases, including diarrhea and cholera [2].

Based on the quality of domestic raw wastewater from the city of Conakry, we define the most appropriate treatment processes to rid the water of the suspended and colloidal matter it contains and the undesirable dissolved substances, to guarantee also a good protection vis-à-vis the parasitic risk which supposes a treatment of clarification and disinfection.

The purification of domestic wastewater uses physico-chemical and biological techniques. Among the latter, treatment by filtration on sand, gravel and carbon remains an appropriate technology for the treatment of water in urban and rural areas of developing countries, by the elimination of pathogenic microorganisms [3]. The safety and quality of drinking water is an important issue that threatens human life. The death of several million people is due to the use of polluted water. It is with this in mind that the World Health Organization (WHO) and national and international regulations have set up standards and recommendations to avoid the presence of microorganisms and undesirable chemical substances in domestic drinking water [4, 5].

This fact should therefore stimulate and encourage the improvement of pollution control techniques and the development of new processes to satisfy and comply with increasingly restrictive international standards. Different techniques have been used for the elimination of certain soluble pollutants in industrial or domestic effluents. They are different from each other and are among others adsorption, electrolysis, flotation, precipitation, ion exchange, extraction, membrane filtration, etc. Of all these possibilities, filtration by the use of certain local materials (coal, sand and gravel) can constitute a simple, selective and economically acceptable alternative for the treatment of wastewater in developing countries [6].

Filtration is the process of removing suspended particles by passing water through several types of filter media, such as sand, gravel, coal in grains and various fabric, fiber and ceramic filters [7]. Filtration is one of the oldest techniques and by far the most applied in water treatment operations, whether for industrial or domestic use. It was in 1804 that Scotsman John Gibb first designed and built an experimental sand filter for his Daisley series laundry. The carbon filter is also used as a catalyst, it eliminates residual chlorine and chloramines [8].

Raw water, whether underground or surface, does not always meet the required criteria in terms of microbiological and chemical quality, which requires adequate treatment before consumption [7].

Numerous studies have shown that sand, gravel and carbon filters are very effective and reliable in removing suspended solids, turbidity and bacteria. The simultaneous use of this set of filters made of local materials for the treatment of wastewater is the only process which, in a single operation without the addition of chemical products, achieves an improvement in the physical, chemical, biological and microbiological qualities of water [9, 10]. Thus, the objective pursued in this present work is to carry out a trial of treatment of domestic wastewater from the city of Conakry by the technique of filtration from three materials local (coal, gravel and sand).

2. Material and methods

2.1 Material

2.1.1 Sampling and analysis equipment

This study is a follow-up to the work of determining the bacteriological and parasitological loads of raw domestic wastewater from the city of Conakry [11]. Sampling and analysis equipment includes: cooler, Sanyo MLS-3750 autoclave, AVX 34/60 vertical liquid autoclave, Jouan MR22i refrigerated centrifuge, PSM MSC Advantage 1.8 - EN12469 laminar flow hood, Pura 14 water bath – Julabo, Jouan EB 170 bacteriological oven, Jenway model 550 portable pH-meter/thermometer, Stomacher type grinder, Astor 20 colony counter, EW-N/EG-N precision balance, Pasteur pipette, Genlb and Liebert type refrigerators, Bath Marie JULABO, NALGENE filtration cup, JOUAN distilled water distiller, VWR 100 µl micropipette, MOTIC binocular optical microscope, Pyrex bottles, DURAN graduated cylinder and RODACK petri dish and MILIPORE filtration membrane

2.1.2 Experimental devices

The experimental devices for processing wastewater samples from the five municipalities of the city of Conakry are: polystyrene buckets with a capacity of 20 liters, cylindrical in shape with a drain tap for recovering the treated water . Filtration materials are: coarse and fine grain gravel, coal and fine sand. The wastewater samples were taken from twenty-five (25) sites in the five communes of the city of Conakry, i.e. five (5) samples per commune.

2.2 Methods

2.2.1 Realization of the treatment device

Five (5) devices were made, each of which consists of a 20-litre bucket that contains the waste water and another 4-litre container to collect the treated water. The main characteristics of the filter medium are: the effective diameter, the coefficient of uniformity, the relative density, the dry unit mass and the porosity. There are other characteristics that are much more difficult to measure, such as grain shape and specific surface area. The effective diameter corresponds to the size of the meshes of the sieve which allow 10% of the mass of the sample to pass [12]. The filtration materials used are arranged as follows (figure 1) :

- Coarse gravel at the bottom of the bucket and occupies a height of 4 cm from the bucket. It allows the rapid reception and evacuation of treated water.
- The small grain gravel is placed in second position and occupies a height of 6 cm.
- Coal occupies the third position with a height of 8 cm.
- The Sand is fine occupies the fourth position on a height of 10 cm.
- The height of the overflow (free space) has a height of 15 cm with a radius of 13 cm, i.e. a volume of (8 liters) which is occupied by the water to be treated.

The fine sand helps retain the eggs of parasites and certain bacteria. Charcoal eliminates bad smells. The gravel allows the rapid reception and evacuation of the treated water. All these materials have been washed and sterilized before being loaded into the container. After loading, a large volume of drinking water was poured for 5 days to finally wash the device completely and make the materials very compact. Figure 1 show steps in this experimental study.

2.2.2 Analysis of treated water samples

a) Bacteriological analysis

The bacteriological analysis focused on the search for Salmonella, streptococci and faecal coliforms. The search for Salmonella was carried out according to the ISO 6579 standard, the broth used is SFB (Segmented Filamentous Bacteria) [13]. A pre-enrichment of

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a 1/10th dilution of the waste water with buffered peptone water was incubated at 37°C for 16h to 24h. The method of research and enumeration of faecal Streptococci (FS) used is similar to that of colimetry in liquid media. The count results for faecal streptococci are expressed like those for Escherichia coli and coliform as the number of germs per 100 ml [14]. For the search for Faecal Coliforms (F.C.), the MacKenzie test is applied. In the most probable count (MPN) method (NF T 90-413, 1985), from each positive tube on lactose broth with BCPL at double or single concentration, a tube of Schubert medium fitted with a bell is inoculated. from Durham and incubate at 44°C for 48 hours [15].

b) Parasitological analysis

This parasitological analysis is done qualitatively and quantitatively. Macroscopic analysis was carried out systematically before any microscopic examination of wastewater. It consisted of evaluating the quality of the sample and looking for the presence of parasitic elements with the naked eye. The parasitological analysis by the method of Mac Master of wastewater was carried out according to the Bailenger technique recommended by the WHO [16, 17].

The results of the parasitological analysis are expressed using the formula proposed by the WHO (1997): (N = A.X / P.V) with, A: number of eggs counted on the Mac Master slide or average of the numbers found on 2 or 3 slides ; X: volume of the final product (ml); P: capacity of the slide of Mac Master (0.3 ml); V: Volume of the initial wastewater sample to be analyzed [11].

Picture 1: Gravel Photo

Picture 2: Charcoal

Picture 3: Sand

Picture 4: Preparation of the device

Picture 5: Device made

Picture 6: Wastewater treatment by filtration

Picture 7: Treated wastewater

Picture 8: Samples of treated water for analysis

Photo 9: Counting of streptococcal colonies

Figure 1: Stages in the production of treatment devices

3. RESULTS AND DISCUSSIONS

3.1 RESULTS

The results obtained are given in Tables 1, 2 and 3; then are represented by the diagrams of FIGS. 2, 3 and 4 for their analysis and interpretation.

3.1.1 Bacteriological analyzes

The results of the bacteriological analyzes of the treated wastewater samples are recorded in Table 1.

Table 1: Bacteriological loads of treated wastewater samples

Locality	Sample	C.F/E.coli ufc/100ml (ISO 9308-1)	S.F ufc/100ml (ISO 7899)	Salmonella/100ml (ISO6579)
Kaloum	Boulbinet Mosquée	20	10	Absence (S. spp)
	Temenètaye	Absence	Absence	Absence (S. typhi)
	Sanfil	50	40	
	Gouvernorat	Absence	Absence	Absence (S. spp)
	Ministère de la pêche	Absence	Absence	Absence (S. typhi)
Matam	Coleah A/Egypte	30	20	
	Madina Sigue	60	Absence	
	Matam Lido corniche	Absence	Absence	
	Bonfi Mosquée	Absence	Absence	Absence (S. spp)
	Dabondy	200	80	Absence (S. typhi)
Matota	Aeroport Camp carrefour	40	20	
	Yimbayah marché	Absence	Absence	
	Tanerie Bas-fond	Absence	Absence	Absence (S. spp)
	Tanerie sept étage	Absence	Absence	Absence (S. typhi)
	Cosa rail	Absence	20	
Ratoma	Coloma1 château rail	40	10	
	Nongo	50	30	
	Kaporo port	Absence	Absence	
	Kakinbo	90	70	
	Minière GT	Absence	Absence	
Dixinn	Dixinn port 3	20	Absence	

	Millenium	Absence	Absence	
	Camp Camayenne	Absence	Absence /100ml	
	Université Gamal	20	30	Absence (S. typhi)
	Clinique Ambroise	Absence	Absence	Absence (S. spp)

The results of the treatment rate and the reduction are given in Table 2.

Table 2: Abatement or treatment rate

Commune	**Before treatment**		**After treatment**		**Abatement**	
	C.F/100ml.	S.F/00ml	C.F/100ml.	S.F/00ml	(C.F/100ml.)	S.F/100ml)
Kaloum	480000	360000	70	50	99,99	99,99
Matam	580000	480000	290	100	99,95	99,98
Matoto	460000	420000	40	40	99,99	99,99
Ratoma	500000	400000	180	110	99,96	99,97
Dixinn	500000	400000	40	30	99,99	99,99

3.1.2 Parasitological analyzes of treated water samples

The results of the parasitological analyzes of the treated water samples are given in Table 3.

Table 3: Parasitological loads of samples

Locality	Entaboiba histolytica (Direct Fresh State)	Ascaris (sedimentation)	Oxyure (sedimentation)	Fasciola hepatica (sedimentation)	Trichuris (sedimentation)
Kaloum	-	-	-	-	-
Matam	-	-	-	-	-
Matoto	-	-	-	-	-
Ratoma	-	-	-	-	-
Dixinn	-	-	-	-	-

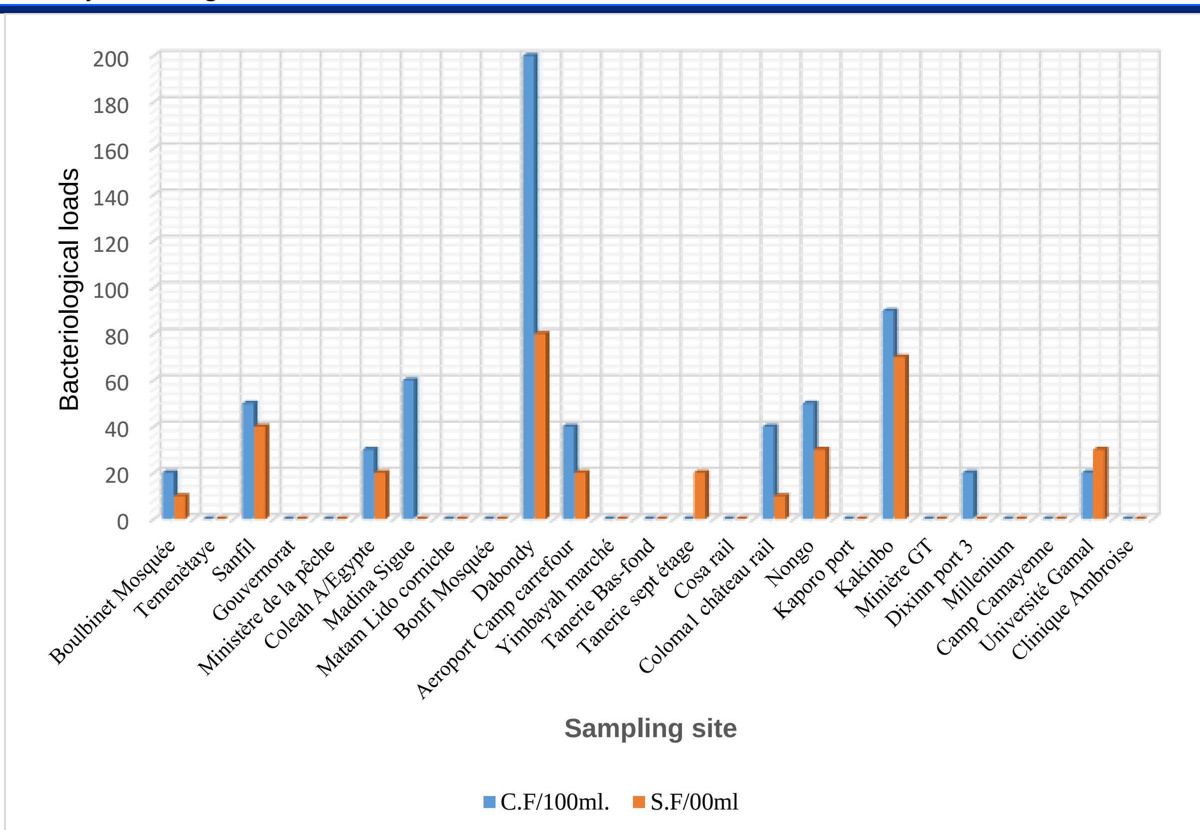

Figure 2: Bacteriological loads of treated water sample

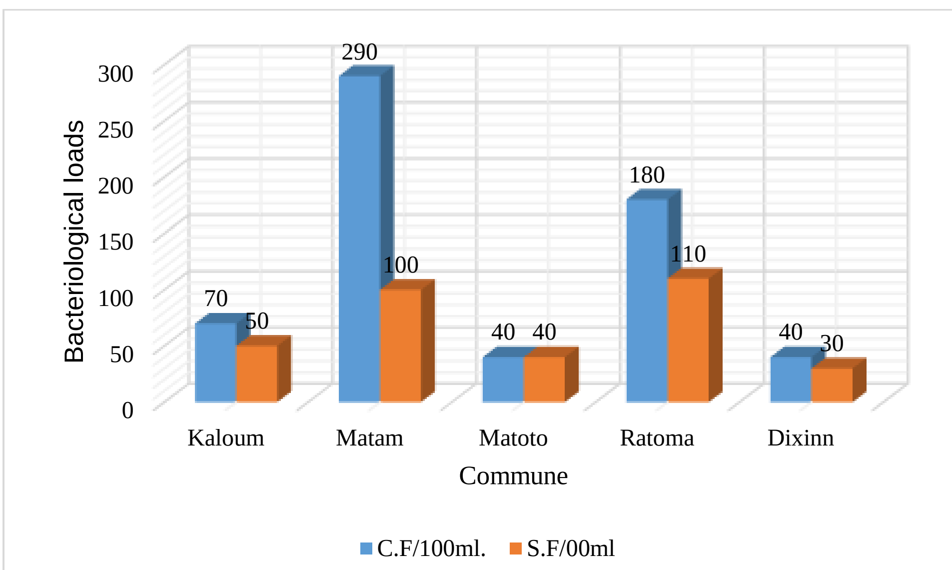

Figure 3 : Bacteriological loads of treated water samples by municipality

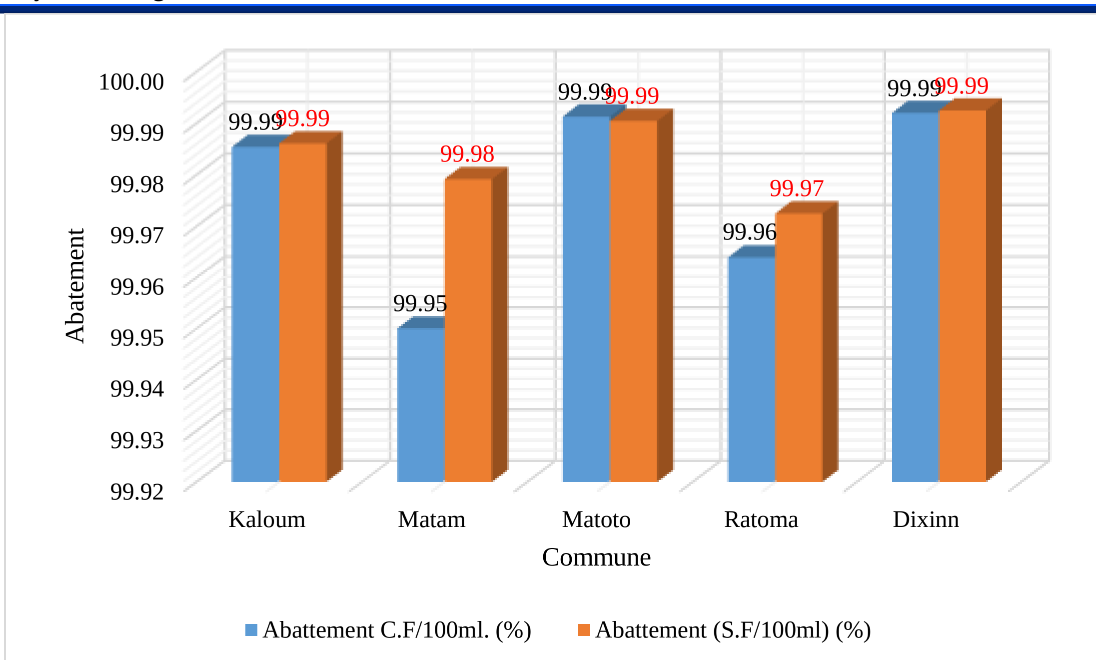

Figure 4: Abatement or treatment rate

3.2 Discussions

After treatment of raw domestic wastewater by slow filtration on charcoal, gravel and sand, bacteriological analyzes of the twenty-five (25) still show the presence of faecal coliforms/E.coli (CF) and faecal streptococci (SF) in the water samples but with lower values compared to untreated water (Figure 3). Parasitological analyzes revealed the total absence of parasites (Entaboiba histolytica, Ascaris, Pinworm, Fasciola hepatica and Trichuris). The average bacteriological loads of samples from different municipalities before and after treatment varied as follows: Kaloum CF from 4.8×105/100ml to 70/100ml and S.F from 3.6×105/100ml to 50/100ml; Matam the CF from 5.8×105/100ml to 290/100ml and the S.F from 4.8×105/100ml to 100/100ml; Matoto the CF from 4.6×105/100ml to 40/100ml and the S.F from 4.2×105/100ml to 40/100ml; Ratoma the CF from 5×105/100ml to 180/100ml and the S.F from 4×105/100ml to 110/100ml; Dixinn the CF from 5×105/100ml to 40/100ml and the S.F from 4×105/100ml to 30/100ml. The treatment or abatement rates varied from 99.95% to 99.99% for CFs and from 99.97% to 99.99% for SFs, which shows the good efficiency of the filtration treatment device produced [16]. According to the standards, this treated water can be used in agriculture, on construction sites and can be discharged into the natural environment without danger [17, 18].

4. Conclusion

This study contributes to the treatment of raw domestic wastewater by slow filtration systems on sand, gravel and charcoal. The results obtained during the present study show that the bacteriological analyzes of the twenty-five (25) wastewater samples still show faecal coliforms/E.coli (CF) and faecal streptococci (SF), but with lower loads. compared to untreated water. These loads vary between 40/100ml in Matoto and 290/100ml in Matam for the CFs and between 40/100ml in Matoto and 100/100ml in Matam for the SFs, which shows that Matam's wastewater is still the most polluted. Parasitological analyzes revealed the total absence of parasites (Entaboiba histolytica, Ascaris, Pinworm, Fasciola hepatica and Trichuris) after treatment. The treatment rates varied from 99.95% to 99.99% for the CFs and from 99.97% to 99.99% for the SFs, which shows good efficiency of the filtration treatment device produced. According to certain standards, treated water can be used in agriculture, on construction sites and can be discharged into the natural environment without danger.

Indeed, the technique of treating raw domestic wastewater by slow filtration using local materials (coal, sand and gravel) could be adopted as a means of treating domestic wastewater in developing and low-income countries. This research is to be continued in order to evaluate the physicochemical parameters of these samples of domestic wastewater from the city of Conakry and other cities in the country.

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