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Evaluation of Performance of the Processing Chain of Surface Water of the River of Tshopo in Kisangani Region (DR Congo)

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Abstract: ***Our study is based on the evaluation of performance of the processing chain of the surface waters of the Tshopo river by the characterization of raw and treated water based on rate of drawdown chemicals and bacteria unwanted fecal origin present in raw waters captured. The results obtained show that very sweet of the Tshopo river and treated waters are overall physicochemical quality and great but raw waters are microbiologically much polluted. Very good drawdown of medians after treatment rates are higher than the standard of the Democratic Republic of Congo (DR Congo) to 80% with medians of most probable numbers (MPN) of fecal coliforms and fecal streptococci (SF) 28/100 ml and FC (0/100 ml) against the standard of DR Congo 0/100 ml. So, the quality of the water of the Tshopo river has evolved enormously these last 2 decades after population growth estimated at 294,37%, the absence of collectors and sewage treatment of wastewater as well as climatic conditions particularly after very heavy frequent rains in the Equatorial area. Hence the need for good management of anthropogenic waste and a good political l sanitation "environment and also adapt, intense rainfall days, changes in parameters of emergency treatment to analyze to improve the quality of water to produce, according to the WHO guidelines and standards, DR Congo.***

Keywords: Characterization, water treatment, Tshopo, Kisangani, rate of drawdown, disinfectant**.**

1. Introduction

The protection of water in an environment becomes too sensitive to news because it is scientifically recognized that polluted water remains the leading cause of disease and mortality [1]

The city of Kisangani in the Democratic Republic of Congo (DR Congo) has a rising population unprecedented with more production of anthropogenic waste particularly upstream waters of plants extraction site operator surface waters of the River of TSHOPO. There is a lack of sewage treatment 1plant and a malfunction of these waste products by the man and his activities in the region. From 1993 to 2015, the estimated population of Kisangani went from 406.249 to 1.602.144 people or a population growth of 294,37% while the installed capacity of the Tshopo factories has not changed since 1980 [2], [3].

Of course, blue gold is a complex environment whose composition depends on the soil and the geological layers she had been through. The chemical composition of natural waters is strongly correlated to the chemical composition of the substratum whatever their origins [4].

Issues on water form a set of pressure that makes it vulnerable. The ethical and sustainable management of water resources requires a change in behavior, the new basic criteria for sustainable use and management of water [5]

Water-related diseases are due to lack of drinking water, floods, usually as a result of the torrential rains or the tidal waves caused by earthquakes or underwater volcanic eruptions leading causes of pollution chemical and microbiological [6]

Water is the source of life and conflicts. It kills more than war.

The delay of Africa and the Democratic Republic of Congo for drinking water supply don't is is not significantly filled after settlement despite the massive investments in the sector. Several systems are taken out of operation because of maintenance problems, problems of war (plunder or sabotage of facilities), excessive population growth,... [7]

One of the major concerns of the caterers of water is to produce and maintain the quality of the water produced during its distribution according to the who guidelines and national or international standards of known potability and in order to preserve public health [8]

The surface waters of the TSHOPO River are 2 types of treatment of treatment:

1) Physical: by screening, sedimentation and filtration

2) Chemical: by coagulation-flocculation, disinfection and the correction of the *p*H by brought of the water treated carbon balance (*p*H 6.5 to 8.5).

In the present study on large plants in the city of Kisangani, one must determine the characteristics of surface water of the TSHOPO River and processed so that evaluate the performance (efficiency) of water treatment stations of factories Tshopo by the rate of drawdown (RD) of 16 parameters including 2 bacteriological, on the one hand. On the other hand, evaluating disinfection of the treated water by the Calcium Hypochlorite according to *p*H and the temperature of the medium to bring so much self bit solutions to do this.

It aims to bring the leadership and political sphere to understand environmental problems related to the management of our Blue Gold resources and strengthen measures of hygiene and sanitation of the city. This contributes to an integrated management of the Tshopo River.

2. Material and Methods

2.1. Middle and working material

Kisangani, formerly called Stanleyville, is chief town of the Province of the Tshopo (0°31'N, 25°E, 428 m) [3]. In the Kisangani region, the climate is equatorial of the Afi type (hot, wet and very low thermal amplitude) and rainfall are abundant but irregularly distributed with average maxima of 1915,4 mm (March to May) and September in November and average minimum of 1.417,5 mm (from December to February) and from June to August [9]. Our material is the water of the TSHOPO River captured and treated in the Kisangani region (RD Congo).

2.2 Sampling

In this study it is interested in the study of 2 types of water (before and after treatment) the choice of these waters was motivated by the mismanagement of human waste and the erection of new houses before the capture of raw water 40 years after the construction of the last big factory (Tshopo (II) treatment of the surface waters of the river of Tshopo in Kisangani.
Sampling was conducted throughout the year 2014 and analyzed 16 settings per sample 2 Bacteriological (FC and SF) to characterize our water before and after wastewater treatment process and the effectiveness of the latter.
P1: Taken water BRUTE TSHOPO: capture of raw water in the Tshopo River.
P2: Out factories TSHOPO I & II: output of water treated plant after treatment.

2.3 Analysis

2.3.1 Physicochemical analysis

To determine the physicochemical quality of the analyzed waters the following parameters were measured in the laboratory according to the procedures described by HACH, REGIDESO (DR Congo water board), health of the Brazil National Foundation and RODIER (2009): color, turbidity, total iron, ions nitrite NO_2^- , ion nitrate $No._3^-$(nitrate ion), the oxidizable materials (OM), the quantity of suspended solids (my) per liter of water, the temperature (in ° C), the title alkalimetric simple (TA), the full alkalimetric title (TAC), the carbon dioxide free (CO_2- free), the total water title or hardness total (TH_t) and the free chlorine (Cl_2- free) [10], [11] [12], [13]

2.3.2 Microbiological analyses

Determining the bacteriological quality is to the fecal coliform count CF (on broth lactose at 44 ° c), and fecal streptococci SF (on Sherman milk at 37 ° c) by fermentation to multiple tubes (FTM) after 24 h of incubation. The law of fish allowed to estimate statistically the NPP of CF and SF supposed distributed in water at random and this based on 3 test of each series tubes seeding successive dilutions (1, 1/10 and 1/100) of liquid culture medium in the water to be analyzed. [14], [15]

3. Results and Discussions

In table 1, have grouped settings descriptors of quality in 2 groups (physicochemical and bacteriological) to interpret our test results in table 1 according to the standards of the republics of Congo (DR Congo).

Considering that our samples were taken in circumstances and different conditions we used the average ($\bar{X}$) and median (Me) distribution of the experimental results as statistical functions to interpret our data on the characterization of the analyzed waters. The rate of drawdown (RD) medians of results allowed us to evaluate the performance of the treatment process of surface waters of the Tshopo River.

The average of the results is: $\bar{X}=\frac{\sum_{i=1}^{n} x_i}{n}$ where $\sum_{i=1}^{n} x_1$: sum of the results (data) x and n: number of samples.

For organoleptic and physicochemical analyses: n = 10 and n = 2 m; m = 10/2 = 5. Otherwise, the median is the average of 2 numbers in the middle.
$M_e = \frac{X_5 + X_6}{2}$ with $X_{m+1} = X_6$ and $X_m = X_5$

For bacteriological analyses: n = 3 and n = 2 m + 1 with m = 2/2 = 1. Here, the median is the middle value.
$M_e = X_{m+1} = X_2$ [16]

The rate of drawdown: $RD = \frac{X_1 - X_2}{X_2} x\ 100$.

- X_1 : variable to the output of factories,
- x_2: variable to the tap of usage [17]

Table 1: Average rate of drawdown (RD) of various indicators of potability medians and treated water

Indicators of potability			Average / treated water			Median		
		Standard DRCongo	Min	Max	Moy		TW	RD (%)

Physico-chemical	Color	0-15 Hazen	0	18	3	112	1	99,107
	Turbidity	0-4 NTU	0	5	1.1	20.5	0.5	97,561
	OM	0-2.2 mgO2/l	0.6	2.5	1.12	6.2	1	83,871
	QSS	0-25 mg/l	0.25	0.96	0,421	24,15	0.365	98,488
	T ° (° C)	20-25 ° C	22	**27**	23.8	24	24	0.0
	*P*h	6.5 - 8.5	6.6	6.9	6.78	6.9	6.75	2.17
	CL_2- free	0.1-2 mgCl2/l	0.9	1.9	1.46		1.45	-
	CO_2- free		12.3	20.1	14,17	24.95	13.20	47,094
	TAS	0-50 ° F	0	0	0	0	0	0.0
	FAT	0-50 ° F	1.2	1.9	1.48	1.4	1.4	0.0
	THt	0-15 ° F	0.9	1.4	1.08	1.05	1.05	0.0
	$No._2^-$	0-0.1 mgNO_2^- /l	0	0.009	0.024	0,008	0.0015	8.125
	$No._3^-$	0-50 mgNO_3^- /l	0.03	0.15	0.09	0.16	0.09	43,750
	Fe-total	0-0.3 mgFe^+3/l	0.01	0.1	0.034	1.6	0.03	98,125
Bacteriological	FC	0 - 10/100 ml	0	0	0	1.100	0	100.00
	SF	0/100 ml	0	28	476	1,400	28	98.0

The results of our study on the physico-chemical aspect shows that with the exception of samples taken days of strong rain that gave high values of color, turbidity and oxidizable material (MO) with maximum 18; 5 and 2.5; all results of treated water are in the standards either for the average for the median of all the analyzed parameters.

However taken the same day and under the same conditions, on the bacteriological all FC fecal coliforms have been eliminated after Calcium hypochlorite disinfection while fecal streptococci SF have given most probable numbers(MPN) outsized particularly heavy rain days.

For color, the directive who is from 0 to 15 Hazen as the standard RD Congolese. Wastewater treated at Kisangani (RD Congo) are not colored, so they lack metal ions that can be complex and very little of the MB to give coloring to these waters and contribute to the excessive consumption of disinfectant (RD (Fe) = 98,125%, RD (MO) = (93,871% and RD (color) = 99,107%), iron spent a median of 1.6 mg/l to 0.03 mg/l after treatment).

For turbidity, the average is 1.1 NTU and the median is 0.5 NTU standard DR Congo. Turbidity is an important parameter to assess effectiveness or performance of the steps of the clarification and filtration as well as degradation of quality especially during the period of intense rainfall, 5 NTU turbidity obtained as maximum the day of heavy rain requires traders to apply special treatment by reducing the speed of crossing water in decanters for a TR more than 97,561%.

For the OM, 1.12 mg O_2/l average and the median of 1.0 mg O2/l are in standard DR Congo 0 to 2.2 mg O_2/l. The OM are not high, so do not give a cause of microbial origin. These OM come from microbial degradation of cellulose and organic debris. The fluviques acids have a mass small as humic acids in our waters. The oxidizability of surface water varying between 3 and 8 mgO_2l, the waters of the Tshopo River of median 6.2 also.

For the my trained settleable material separable by gravity or coagulation with a directive who from 0 to 25 mg/l as the standard RD Congo, average of 0,421 mg/l and the median of 0,365 mg/l obtained for water treated with a 98,488% drawdown.

The CF with an average and median equal to 0 / 100 ml (RD (FC) = 100%) and the SF with an average of 476/100 ml and a median of 28 (RD (SF) = 98%) proves that the disinfection is good. However the maximum of 1,400/100 ml obtained the day of heavy rain and the median of 28/100 ml pushes us to realize that the day of rain where the waters are too loaded, water-disinfectant contact time must be improved by a post-chloration for pass 1 to 6 contact hours. In default, it is necessary to decrease the speed to cross water purified and filtered to improve outcomes because it is estimated that the SF are more resistant to the HClO them FC [13]

Rates (RD) drawdown of medians of color, turbidity, OM, QSS, total iron (Fe-total), FC and SF recorded in table 1 above are in standards of DR Congo that is higher than 80%, the other parameters (T ° (° C), *p*H, Cl_2- free, CO_2- free, TAS, FAT, NO_3^- and NO_2^-) depending on the chemical treatment non-existent water and Cl_2- free in raw to treat water not been taken into account.

Table 2: Average rate of eliminating unwanted substances after wastewater treatment

Turbidity, color, my, cod, BOD, Al, Cu, Cd, Pb, Hg, Phenol, viruses, bacteria			
	F, Zn, algae, Pesticides	MN, Ba, surfactants	$No._3^-$, NH_4^* , $no._2^-$, N_2, CN^-
⍰60%	20-60%	0 to 20%	0%

[17]

Overall, the RD of the medians of parameters of primary emergency same ones analyzed heavy rain days (table 1) are all higher than 80% and referring to table 2 above, the channels of the Tshopo river wastewater treatment are effective. Is a need to improve the process of disinfection to treat to totally eliminate also the SF finally to get a water RD

Congo from the physical-chemical point of view that bacteriological standard.

The overall surface of the Tshopo river water quality was evaluated according to median (table 1) and indices in the grid of table 3 of T°(en °C), *p*H, my, no.$_3^-$ and turbidity.

Table 3: Grid for assessment of the overall quality of surface waters [18]

Alteration No.	Quality classes		Excellent	Good	Average	Bad	Very bad
	Indices		100 80	80 60	60 40	40 20	20 0
1	**Temperature**						
	Temperature	° C	0-20	20 - 25	25 - 30	30 - 35	35 - 40
2	**Acidification**						
	P H		6.5 - 8.5		8.5 - 9.2	3 - 6.5 and 9.2 to 10	
3	**Organic and oxidizable materials (MO)**						
	O_2 dissolved	mgO2/l	7 - 10	5 – 7	3 - 5	1 - 3	0-1
	DBO_5	mgO2/l	0.5-3	3 – 5	5-10	10 - 25	25 - 1,000
	COD	mgO2/l	1.5-30	30 - 35	35 - 40	40 - 80	80 - 2,000
	NH_4^+	mg NH_4^+/l	0-0.1	0.1-0.5	0.5-2	2 - 8	8 - 50
4	**Material phosphorus**						
	PO_4^{-3}	mgPO_4^{-3}/ l	0-0.2	0.2-0.5	0.5-1	1 - 5	5 - 20
5	**Nitrates**						
	No.$_3^-$	mgNo.$_3^-$/ l	< 10	10 - 25	25 - 50	> 50	
6	**Mineralization**						
	TO 20 ° C	µS/cm	100 - 750	750 – 1300	1.300-2.700	2,700 - 3,000	3,000 - 7,000
7	**Materials in suspension (MIS)**						
	MY	mg/l	<50	50 - 200	200 - 1,000	1,000 - 2,000	2000 - 10000
	Turbidity	NTU	<15	15 - 35	35 - 70	70 - 100	> 100

According to tables 1 and 3 above, the surface waters of the Tshopo River are generally excellent except the temperature which is good**.** Medians of 1,400 SF/100 ml and 1,100 CF / 100 ml confirms that the surface waters of the Tshopo River are of bad quality from the microbiological point of view. The lack of collectors and sewage treatment plant especially the mismanagement of human waste (livestock, septic built without shelter or isolation,...), the intense construction of houses in the northeast of the region which is upstream of the abstraction of water to be treated of the Tshopo river since more or less a decade may make very bad quality of the surface waters of the Tshopo river. Therefore if we don't take some useful provisions at the level of the Public power, the company dealing with the supply of drinking water as well as the inhabitants of the region of Kisangani for integrated and sustainable management accompanied by a policy rigorous environmental sanitation, the Kisangani region could in the future victim of microbial diseases related to water. In light of our results, it appears clear that lack of domestic wastewater collectors and of same sanitation water wells you / or appointed sources or not are also exposed to microbiological pollution as the surface waters of the Tshopo river. Tables 6 and 7 below helped to assess the process of disinfection of the treated water

Table 5: Evaluation of the disinfection according to the *p*H and the temperature of the water

Parameter	Sample	Hard Water			Water Treated		
		E1	E2	E3	E1	E2	E3
T ° (° C)	20-25 ° C	**24**	**23**	**23**	**24**	**24**	**24**
p H	6.5 - 8.5	**6.9**	**6.9**	**6.8**	**6.6**	**6.7**	**6.9**
CL_2- free	0.1-2 mgCl2/l				**0.9**	**1.8**	**1.4**
CF	0 - 10/100 ml	**1,400**	**11**	**1.100**	**0**	**0**	**0**
SF	0/100 ml	**120**	**1,400**	**1,400**	**28**	**1,400**	**0**

Table 6: Distribution of 2 forms of free chlorine in water based on the pH at 25 ^{0} C [13].

*p*H	5	6	7	7.5	8	9	10
% HOCl	**99.8**	**97.8**	**81.3**	50	30.3	4.2	0.4
% Col $^-$	**0.2**	**2.2**	**18.7**	50	69.7	95.8	99.6

According to tables 1, 5 and 6, *p*H of treated water varies between 6.6 to 6.9 and theCl_2- free varies between 0.9-1.8 against the number Plus Probable (MPN) of between 0 to 1,400 CF / 100 ml.

On the one hand we see that this range of *p*H the HClO form for a good disinfection varies between 81.3 to 97.8% of a share. On the other hand, the MPN of CF and SF are null with a content in Cl_2- free equal to 1.4 mg Cl2/l against an equal SF RD 0% to a Cl_2- free content equal to 1.8 mg Cl2/l for a sample taken the day intense rain where the OM, turbidity and color were equal to 2.5 mg O_2/l, 5 NTU and 18 Hazen.

The disinfection or oxidation, used on waters with a heavy load in organic material would have served to break the long carbon chains to small biodegradable strings (elimination of herbicides, pesticides, fungicides, microalgae, some) Protozoa eggs, etc.).

4. Conclusions

In general it is in developing countries as the RD Congo that chemical pollution risks are lower or nonexistent compared to those of known microbiological pollution is more than a century in developed countries. The change in the quality of natural waters requires adaptation of the water treatment processes to produce excellent quality water following the standards and guidelines of the world Organization for health [19] potability.

The assessment of the performance of the chain of water treatment of plants Tshopo in Kisangani region showed that the expansion of the city especially upstream of the point of the Tshopo river raw water extraction and its population growth associated with the absence of the collection of wastewater (sewer) [6, 7, 8] network and stations of processing of applications before their rejection in the TSHOPO River would have a negative impact on the microbiological quality of treated water.

The rate of drawdown medians of first emergency settings (RD) (turbidity, color, OM, QSS, Fe, FC and SF) assessed vary between 83,871 to 100%. According to the DR Congo, the RD standard ≥ 80% and table 2 showing 60% for turbidity, color, my and bacteria as well as 0% for the $No._2$and $no._3^-$ ion^- , the quality of treated water produced by plants Tshopo is good, if considered medians of distribution of our results. On the other hand, according to the who guidelines and standards for potability of the DR Congo, the median of the MPN of SF is a little high (28 instead of 0/100 ml) with a minimum value that is in the standard. This demonstrated that the quality of treated water is not the same every day and intense rainfall days treated water is loaded and sometimes unconventional with the following maximum values (color = 18 Hazen, turbidity = 5 NTU, MO = 2.5 mgO2/l and SF = 0 (0/100ml).

The RD of the *p*H, TAS, FAT and THt medians varies between 0 to 2.17 percent and their median values (6.75; 0; 1.4 and 1.05) standards DR Congo leads US to conclude that the treated water slightly acidic, very sweet and less busy are favorable for a e better disinfection

Compared to the record of the new system of assessment of waters (table 3) and median (table 1), the quality of the surface water of the Tshopo river in the Kisangani region overall is good with microbiological pollution strong days intense rains. Strong anthropic pressure upstream of Capture, with the expansion of the city especially in the North - East of the region of Kisangani, could in the long run alter advantage the microbiological quality of raw and treated water in the absence of the activities industrial on that side, on the one hand. On the other hand, to treat water - disinfectant contact time must be improved by chlorination at the level of the injection of water filtered from the Tshopo I in tanks Tshopo II (*p*H 4.8 to 6.1 of the filtered water) away from the injection of lime water (to *p*H 6.7 to 6.9 of the treated water).

The main disadvantage associated with the pre-chloration is the formation of sub products organochlorines carcinogens [4].
We suggest that we advocate the implementation of a system of collection of water and wastewater treatment plants, a management responsible for anthropogenic waste and a strengthening of measures of hygiene and sanitation in the city of Kisangani. The integrated management of water (IMW) encourages the development and coordinated management of water, land and related resources to maximize the socio-economic well-being in an equitable manner without compromising the sustainability of vital ecosystems. The IMW is at level global, considered to be the lasting solution to the problems of management of our water resources in [5].

5. Thanks

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