Physico-Chemical and Bacteriological Analysis of Waste water from Hospital "Case of Centre University Teaching Hospital of Kigali"

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***Abstract*—** *Hospitals produce relatively huge amount of wastewater containing pathogenic microorganisms, toxic, laboratory and pharmaceuticals residuals, disinfectants, biodegradable, polluters and radioactive contaminants that are potentially threats to population health and the components of environment when they are discharged without proper treatment.*

The purpose of the study was the assessment of water quality effluent from CHUK wastewater treatment plant (CHUK WWTP) by analyzing physico-chemical and bacteriological parameters. Sampling has been take place at different points and time better understanding of how hospital unit operations affect the effluent quality. A sum of twelve (12) samples were collected in three (3) trials at four (4) different points in Nyarugenge, Gitega and at the border with Kimisagara sector especially Mpazi stream where CHUKWWTP's effluents are discharged. Samples collection, conservation, preparation and measurement took place at university of Rwanda-college of science and technology (CST) laboratory.

The obtained results at WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent were Cu (0.06, 0.07, 0.05 and 0.07mg/l); Fe (0.13, 0.037, 0.037 and 0.034mg/l); Pb (0.021, 0.024, 0.024, and 0.027mg/l); Hg (0.0015, 0.003, 0.003 and 0.004 mg/l) respectively. pH (7.25, 812,7.74 and 7.4); COD (215.5, 122.4, ,145.5 and 187.2mg/l); BOD5 (29.3, 30.85, 29.4 and 27.3 mg/l); TN (3.29, 2.97,3.2 and 3.46 mg/l); TP (1.05, 0.91, 0.92 and1.05mg/l); NH_4^+*(7.46, 8.5,7.5and 8.8 mg/l); TSS (77, 56.5,62.8 and 69.1mg/l); fecal (282, 263,270, and 273 CFU/ml) and TC (233, 213, 224 and 210 CFU/ml). These parameters are prescribed within the reference limits of Rwanda Standard Board (RSB) and World Health Organization (WHO) standards, thus they have no negative side impact and effects on the receiving environments and their components.*

Keywords*— *hospital wastewater, physico-chemical, bacteriological -analysis.

I. INTRODUCTION

Wastewater can be defined as any water, whose quality has affected or being abused by anthropogenic influence (petrovic, 2010). These are liquidious waste released from domestic homes, industries, hospitals, agricultural and commercial sectors (barchelo, 2010). Most of the liquid wastes from hospital are categorized as non-regulated "emerging pollutants (EPA, 2016). According to Amouiei, Barcelo and Petrovic2010: the exposure to hospital wastewater released without adequate treatment in surrounding environment and its components results to adverse effects on the biological balance of aquatic ecosystems, causing imbalance at different trophic levels possibly related to the action of toxic and genotoxic agents and indirectly lead to eutrophication on water bodies surface.

The quality, nature and risk assessment of released effluents are described by its flow, sources of generation, physico-chemical and microbiological characteristics (Galletti ,2010). Addition to this findings of miscellaneous research done on hospital effluent show that effluent discharged from hospitals usually contains certain harmful pollutants such as: pathogenic microbes and bacteria, residues of medicine, laboratory chemicals, pharmaceuticals residues, biodegradable organic materials, carcinogenic metals, and radiation emitting wastes which are danger to the life of the living organisms and environment (Verlicchi ,2010; Kanama,2018).

Hospital effluents are released into water bodies (streams, rivers and lakes) through sewer and cause the deviation from baseline situation of the received environment which is negatively affecting the ecological balance and life if they left with its pathological, radioactive, product of pharmacy, chemical and infectious components lead to diseases, cancer epidemics, skin diseases and contaminate air, water and land holder components (kumar, 2007)

According to (Verlicchi,2015) effluent discharge from hospitals wastewater treatment with low capacities of pollutants removal create high demand for oxygen like BOD, COD in receiving water bodies and deviate the aesthetic value of aquatic ecosystems while research finding of Carraro,2016 state that: some hospital treatment facilities for liquid wastes (HWWTP) are not properly managed and slightly show low removal capacities for common parameters including BOD5, COD, TSS, heavy metals (mercury and lead), coliforms ,total nutrients (total nitrogen, phosphorus and ammonium).

At the beginning of 1928, University teaching hospitals of Kigali (CHUK)located in Kigali City, Nyarugenge district, Nyarugenge Sector, in its daily activities requires large volume of water, the reason why more wastewaters are generated and use sewer passing through Nyarugenge, Gitega Sectors and meet with Mpazi stream passing through Kimisagara sector and this lead CHUK to be a particular example of hospital discharging effluents into surrounding environment. However, there is no known study done on CHUK hospital effluent and small effluents data exist in Rwanda on hospital effluents characteristics (Aurelian, Sylvie, 2013).

Currently, the statistics data from ministry of health show that the number of patients cared by CHUK hospital have increased at 45% in 10yesars ago while its treatment plant has not expanded and replaced. This cause to higher need of large volume of water and release to much wastewater which can surpass the existing capacity of treatment facilities leading to discharge of effluents which are not matching with required standards of receiving environment and aquatic ecosystems. The population of above stated sectors use Mpazi stream as source of water in their daily activities like watering, washing and cleaning while the quality, physicochemical and bacteriological composition of Mpazi stream water after mixing with the effluent from CHUK water treatment plant are not well already known.

According to water Aid report of 2013, department of water and sanitation report of 2017, Rwanda loses RWF32 billion annually due to poor sanitation and It’s approximated that 7,200 Rwandans including 6,100 children under 5, die each year from poor sanitation related diseases, nearly 90% of which is directly attributed to poor water, sanitation and hygiene.

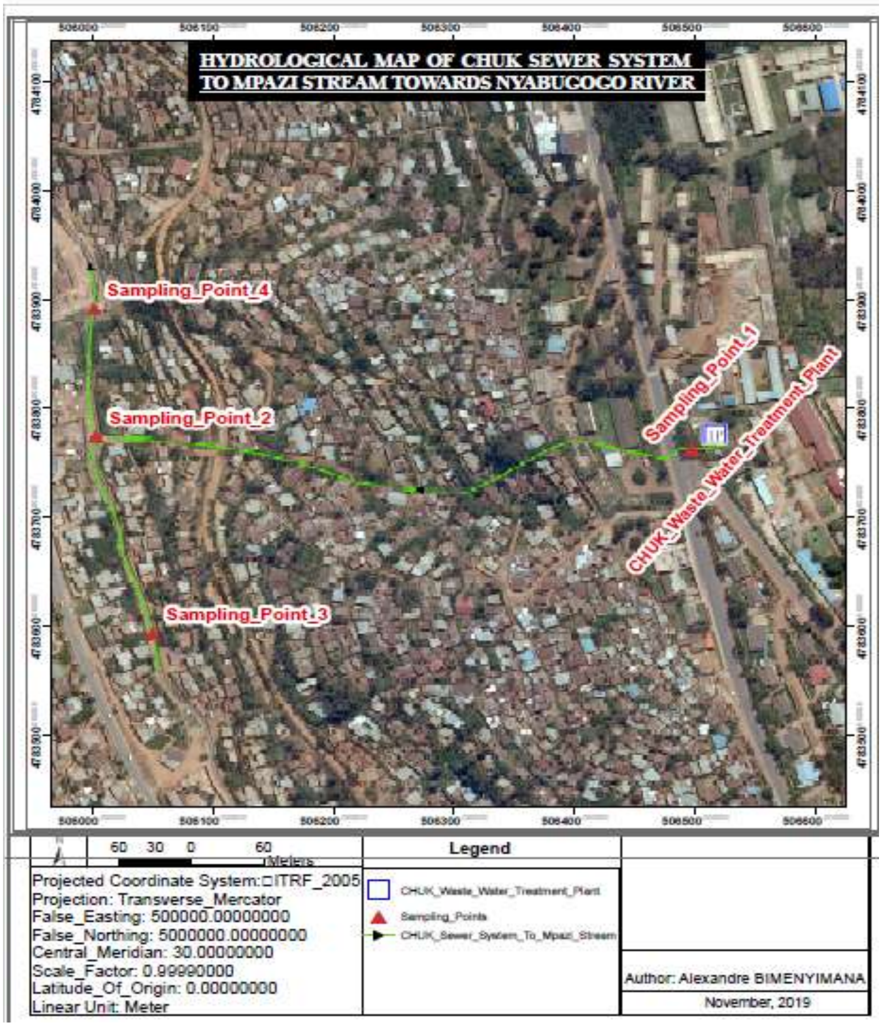
Several research studies have done by analyzing the quality and composition municipal wastewater ’effluents but there is big gap about analyzing hospital wastewater ’effluents in Rwanda Where some parameters like mercury(Hg), Lead (Pb) and other heavy metals were left aside and Kigali city is a part of the above issues.

The aim of the research study was to assess the quality of the effluent from Centre university teaching hospital of Kigali wastewater treatment plant (CHUKWWTP) by analyzing the physical, chemical and bacteriological parameters and this overcame the gaps appeared on analysis of effluents generated from hospitals in Rwanda and showed the current data of CHUK hospital effluent discharged , and increase the safety of receiving environment, the report is supposed to be used by the ministry of health, water and environment regulating agencies and CHUK hospital to improve the quality of their effluents through regular maintenance of its WWTP.

II. MATERIALS AND METHODS

2.1 Description of case study area

CHUK, the Centre University teaching hospital of Kigali is located in the Centre of Kigali city, District of NYARUGENGE, Sector of NYARUGENGE. It is among the main referral public health institution of the country. It was built in 1918. That time, it was functioning as a health Centre, later 1965 especially from April1994 to 1996; CHUK has served as a health Centre, a district hospital and referral hospital according to MINISANTE report 2013. It is located near Serena hotel, Kigali exhibition, Rwanda meteorology and school of EPA. The effluents from CHUK are discharged into MPAZI stream through sewer system after treatment.



MAP 1: Map of Chuk sewer System

2.2 Wastewater sampling

2.2.1 Sample Collection and sample conservation

a. sampling equipment

Isothermal cooling boxes, stoppers for pipetting and BOD bottles, were used during sampling while P^H meter and thermometer were used for situ measurement.

b. Sample Collection and sample conservation

CHUK hospital effluents samples were collected at 4 points of sampling, at outlet of CHUK wastewater treatment plant in NYARUGENGE sector at the point where MPAZI stream meets with CHUK WWTP effluents, the third sample at Mpazi stream and the last at Mpazi stream after mixing with CHUK effluents. Twelve (12) Wastewater samples were taken within three (3) weeks at 4 different points stated above at 6pm to help the understanding of how hospital unit operations affect the effluent quality, each round of 4 samples were taken s week per week at the same time. Effluent Samples were collected using one litter plastic bottle for each. Plastic bottles were thorough washed and rinsed before use. Dissolved oxygen (DO) and biological oxygen demand (BOD5) samples have been collected in one litter plastic bottles with stoppers and Winkler solution were used to fix the available oxygen at site and keep them in a closed cooling box to avoid cross contamination, thereafter at UR-CST laboratory, pH and temperature measurements were done in situ. Samples are conserved via keeping in refrigerator at 4◦C in laboratory, blanks and reagents were prepared according to the designated protocol of analysis.

TABLE 1
LABORATORY MEASUREMENT AND ANALYSIS OF PHYSICAL CHEMICAL AND BACTERIOLOGICAL PARAMETER

Physico-chemical parameters	Equipment	Reagents	Methods
BOD5	incubator	CaCl2, FeCl3, MgSO4 and buffer (the buffer acts as nutrient for bacteria)	The sample is filled in an airtight and incubation at specific temperature for 5days. The dissolved oxygen (DO) content of the sample is determines before and after five days of incubation at 20°C where the starch as reagent were used as food for bacteria to grow which were contributed to the decomposition of the matter (Heberer,2012) .DO and BOD_5 were calculated with the following formula: **CALCULATIONS** The determination of BOD in mg/L was done as follow: BOD, mg/L = [(Initial DO - Final DO) x 300]/mL sample or $DO = V*M*8*(\frac{1000}{Vb-2})$ V: Volume of $Na_2S_2O_3$ M: Concentration of $Na_2S_2O_3$ Vb: Volume of blank solution $BOD_5 = (DO-Sv)*(\frac{Vb}{C})$ DO: Dissolved oxygen at starting $Sv = V*M*8*(\frac{1000}{Vb-2})$: Dissolved oxygen after 5days C: volume of incubated sample
COD	Spectrophotometer at 814nm (DR5000)	mercuric sulfate, silver sulfate, sulfuric acid and chromic acid	The organic compound present in effluents was oxidized completely by strong oxidizing agent of potassium dichromate ($K_2CR_2O_7$) in the presence of sulfuric acid (H_2SO_4), silver sulfate ($AgSO_4$) to produce CO_2 and H_2O. The amount of oxidizing agent used ($K_2Cr_2O_7$) in the medium of sulfuric acid and the excess potassium dichromate ($K_2Cr_2O_7$) will was being determined by titration against ferrous ammonium sulfate, and ferroin after adjusting spectrophotometer (DR5000) at wavelength of 814nm
TSS	Gravimetric and filtration Methods using membrane filters	-	-place effluents sample in oven to evaporate the moisture content leaving the solids. Measure dissolved solids, recuperated solids on filter is dried and weighed. -calculate the suspended solids weigh by subtracting dissolved from total solids (Krishna,2015).
Total phosphorus	Spectrophotometer at 650nm (DR5000)	Buffer, BaCl2, Na2SO4 and potassium persulphate	-well mixed Samples were digested in autoclave for 2hours at 121°C with potassium persulphate to convert all phosphorus to orthophosphate. The orthophosphate was then being analyzed using the ascorbic method and adjust the spectrophotometer (DR5000) at wavelength of 650nm
Total Nitrogen	Spectrophotometer at 420nm (DR5000)	Buffer, BaCl2, Na2SO4 potassium persulphate	Well mixed samples were digested in autoclave for 45 min at 110°C with potassium persulphate to convert all Nitrogenous form to nitrate. Nitrate was then being analyzed using the cadmium reduction method and adjusts the spectrophotometer (DR5000) at wavelength of 420nm before measurements (Kure, 2012).
ammonium	Spectrophotometer at 540 nm (DR5000)	$ZnSO_4$, NaOH,NH4Cl-EDTA and Cadmium regents	-Using filters, transfer sample in a beaker mix with zinc sulfate solution and add NaOH solution the alkalinity. Thereafter add ammonium chloride- EDTA solution with cadmium reagents - Allow 10 minutes for color development within 2 hours pull the sample into sample cell and put to a spectrophotometer, measure the absorbance at 540 nm against a reagent blank. (EPA,1975).
Copper (Cu), Iron (Fe),	Spectrophotometer at 270 nm (DR5000)		After digestion, Set the operating parameters of the instrument and a connected chart recorder. and connect the mercury vapor generation accessory to the instrument. Transfer, by graduated cylinder, 50 ml of the standard to the reaction vessel of the accessory, and add 3 ml of 100 g/l stannous chloride solution. Immediately insert the bung assembly in the reaction vessel and stir the solution vigorously with the magnetic stirrer for 90 seconds. Simultaneously turnoff the stirrer and turn on the air supply to the vessel. Record every absorbance obtained as peak height on the chart recorder. Extract the normality of mercury in each sample by reference by matching the height of peaks with its corresponding concentration

Lead(Pb) and Mercury(Hg)	Inductively Coupled Plasma Emission (Schimadzu,ICPE9000)	stannous chloride	➢ Set the operating parameters of the instrument and a connected chart recorder. and connect the mercury vapour generation accessory to the instrument. Transfer, by graduated cylinder, 50 ml of the standard to the reaction vessel of the accessory, and add 3 ml of 100 g/l stannous chloride solution. ➢ For lead "Aspirate the standard and sample solutions" ➢ Immediately insert the bung assembly in the reaction vessel and stir the solution vigorously with the magnetic stirrer for 90 seconds. Simultaneously turnoff the stirrer and turn on the air supply to the vessel. Record every absorbance obtained as peak height on the chart recorder. ➢ Extract the normality of mercury in each sample by reference by matching the height of peaks with its corresponding concentration
Bacteriological	**Equipment**	**reagents**	**Methods**
Total coliform	incubator	Lactose Broth with bacteriological agar as media and nutrient	Total coliforms were detected by placing the media of Lactose Broth with bacteriological agar to Petri plate. The serial dilution of samples was done for each petri plate, the petri plate of total coliforms were incubated at 37 o C for 24 h and fecal coliforms at 44 o C for 24h. The typical colonies were counted after incubation (Michalke, 2008). The coliforms were calculated using the following formulae. **NCT** $=\frac{\varepsilon TC*100}{d}$, **NCF**$=\frac{\varepsilon FC*100}{d}$ Where N: number of colonies d**:** type of serial dilution/ml FC: Fecal coliform TC: Total coliform NCF: Number of colonies of fecal coliform NCT: Number of colonies of total coliform
Fecal coliform	incubator	Lactose Broth with bacteriological agar as media and nutrient	

III. RESULTS AND DISCUSSIONS

TABLE 2
THE AVERAGED VALUES OF ALL PHYSICO-CHEMICAL PARAMETERS STUDIED

Parameter / Site	P^H	T (^{0}C)	TSS(mg/l)	EC(Us/cm)	TP(mg/l)	TN(mg/l)	NH_4^+(mg/l)	Cu(mg/l)	Fe(mg/l)	Pb(mg/l)	Hg(mg/l)	BOD(mg/l)	COD(mg/l)
At WWTP Outlet	7.25	26.4	77.0	442.5	1.05	3.29	7.86	0.06	0.13	0.021	0.0015	29.3	215.25
At point of meeting with MPAZI stream	8.12	26.8	56.5	350	0.91	2.97	8.5	0.07	0.037	0.024	0.003	30.85	122.4
Mpazi Stream	7.74	26.9	62.8	394.7	0.92	3.2	7.9	0.05	0.037	0.024	0.003	29.8	145.5
Mixture of Mpazi stream and CHUK effluent	7.4	26.5	69.1	419.7	1.05	3.46	8.5	0.07	0.034	0.027	0.004	27.3	187.2
WHO standard	5-9	-	100	-	6	10	9	3.5	3	0.035	0.006	34	60

3.1 pH Value

The acidity or basicity of wastewater always disrupt and damages the wastewater collection and treatment facilities and disturb the designed treatment processes (Onesios, 2009). The range of pH value at WWTP outlet, point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent were 7.25, 812,7.74 and 7.4 respectively and and it is suitable from the viewpoint of wastewater treatment processes comparable to WHO limit standards (WHO, 2009).

3.2 Total suspended solids

One among of the common parameters used in defining effluents is TSS as illustrated in Fig. (3), the total suspended solids (TSS) concentration of the CHUK outlet, point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent were77, 56.5, 62.8 and 69.1mg/l respectively.

The decrease of value of TSS from sampling point 1 to sampling point 2 showed a contribution of environmental treatment that worked properly to remove total suspended solids. The increment from sampling point 2 to to Mpazi stream showed that the quality of CHUK effluent is differ from the quality of Mpazi stream caused by the other discharge from nearby Mpazi and anthropogenic activities carried around stream system, but these results are prescribed WHO limit (100mg/l) (WHO, 2009).

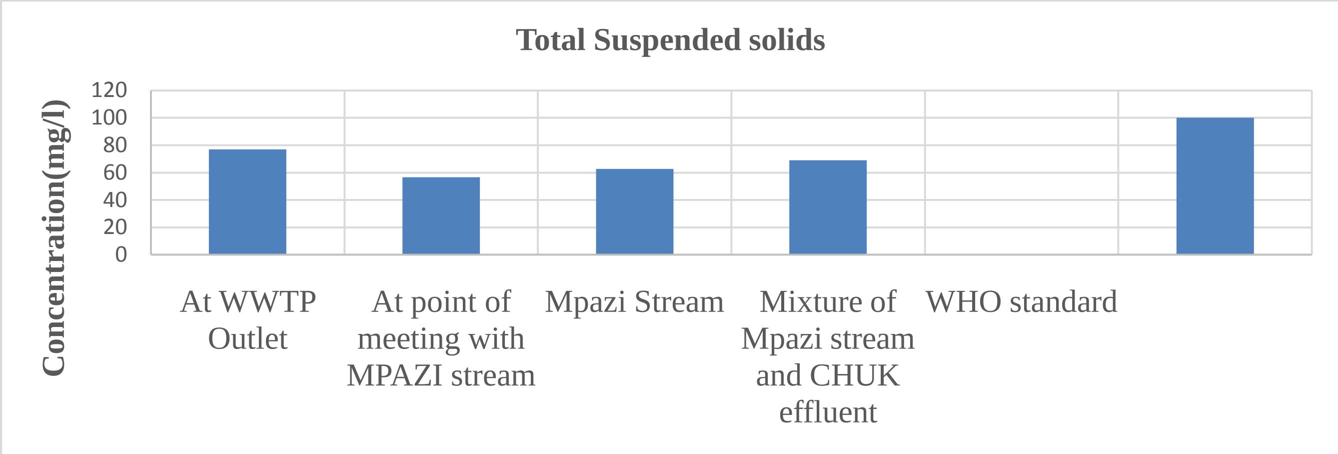


FIGURE 1: Total suspended solid variations at all sites

3.3 The total phosphorous, total nitrogen and ammonium

The total phosphorous, total nitrogen and Ammonium are the major indicator of nutrients load to any receiving environment, the higher concentration lead to rapid growth of plants on water surface and cause the depletion of oxygen, this condition endangers the aquatic organisms. The Fig (4) shows averages concentration results of total phosphorous, total nitrogen and ammonium measured WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent. Total phosphorous was 1.05, 0.91, 0.92 and1.05mg/l, total nitrogen was 3.29, 2.97,3.2 and 3.46 mg/l respectively while ammonium was 7.46, 8.5,7.5and 8.8 mg/l respectively.

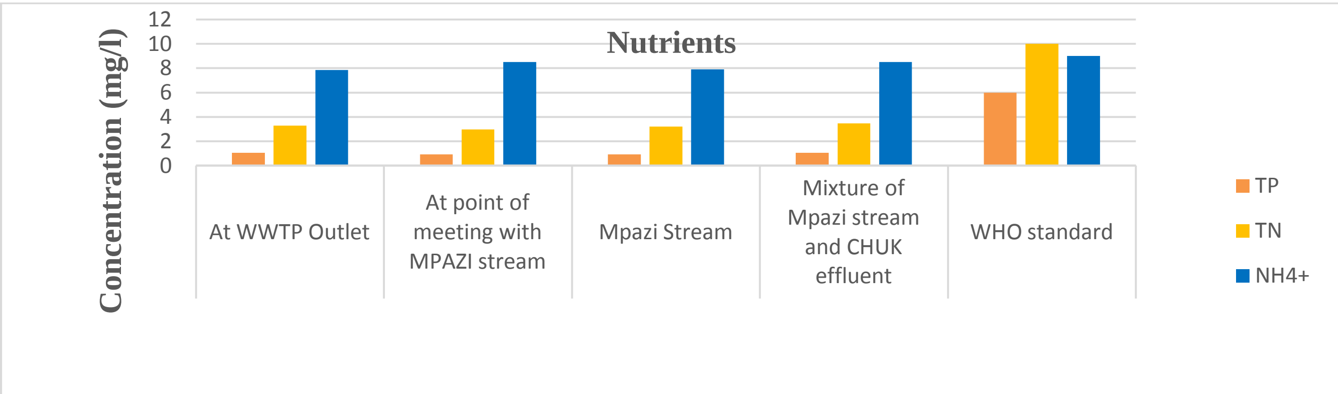


FIGURE 2: The total phosphorous, total nitrogen and ammonium variations in all point of sampling

The variability of these results for nitrogen, phosphorous and ammonium for point1 to point 4 of sampling show that the quality of CHUK effluents are different from quality of Mpazi stream while they are complying with recommended standard of WHO (6-10mg/l) respectively (WHO, 2009) and showed highly performance of CHUK WWTP spite of that the quality effluent from CHUK is affected by other surroundings.

3.4 Heavy metals

Copper, Iron, Lead and Mercury was the heavy metals investigated in the study. The average concentration of Copper was WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent was 0.06, 0.07, 0.05 and 0.07mg/l, Iron was 0.13, 0.037, 0.037 and 0.034mg/l, Lead was 0.021, 0.024, 0.024, and 0.027mg/l while Mercury was 0.0015, 0.003, 0.003 and 0.004 mg/l respectively. The capacity of CHUK WWTP to remove heavy metals in its wastewater before release effluent is enough as the average levels of these metals in hospital wastewater were within permissible levels of WHO (3.5, 3, 0.035 and 0.006 mg/L).

3.5 Chemical oxygen demand and Biological oxygen demand

BOD5 and COD parameters are widely used to characterize the organic content of wastewater (Puangrat, 2010). Figure (7) demonstrated the average concentrations of BOD5 and COD obtained from WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent. The results BOD5 were 29.3, 30.85, 29.4 and 27.3 mg/l respectively while COD were 215.5, 122.4, 145.5 and 187.2mg/l respectively. The biodegradability of organic compounds BOD5/ COD ratio in the study was 0.13, 0.25, 0.20 and 0.15 which reported the speed and completeness of their degradations by microorganisms and described the potential impact on the WWTP efficiency.

The ratio 0.5-0.6 of BOD5 / COD is the threshold value to study the biodegradability of organic compounds hospital effluents (Seiss, 2001). Therefore, the organic content of CHUK effluent had high biodegradability and ratio obtained was very desirable from the viewpoint of treatment process and promotes the efficiency of WWTP.

3.6 Bacteriological parameters

TABLE 3
RESULTS OF BACTERIOLOGICAL PARAMETERS

Location / Parameter With Unit (cfu/mL))	At WWTP Outlet				At point of meeting with MPAZI stream				Mpazi Stream				Mixture of Mpazi stream and CHUK effluent			
	S1	S2	S3	Average	S1	S2	S3	Average	S1	S2	S3	Average	S1	S2	S3	Average
Total coliform	227	231	241	233	211	220	207	213	221	241	211	224	211	210	208	210
Fecal coliform	297	280	269	282	287	258	243	263	287	260	272	270	297	268	253	273

Wastewater of treating patients with enteric diseases is a particular problem during outbreaks of diarrhea disease so the microbial quality of hospital effluents is very critical (Pauwels, 2006). Therefore, some bacteriological indicators are used to reflect the occurrence of pollution accompanying pathogens such as FC and TC that are the most world-wide approach to detect contamination of water resources.

Figure (5) illustrated the average number of TC and FC in CHUK hospital effluents which were obtained to be 233, 213, 224 and 210 CFU/ml for total coliform and 282, 263,270, and 273 CFU/ml for Fecal coliforms respectively, that was comparable to the standards WHO (400*10^2, 1000*10^2) (WHO, 2009). The performance of CHUKWWTP was justified by the greater reduction of coliforms from WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluents while environmental treatment was justified by the reduction of coliforms from effluent to Mpazi stream. This showed that there were no negative effects on receiving environment and their components

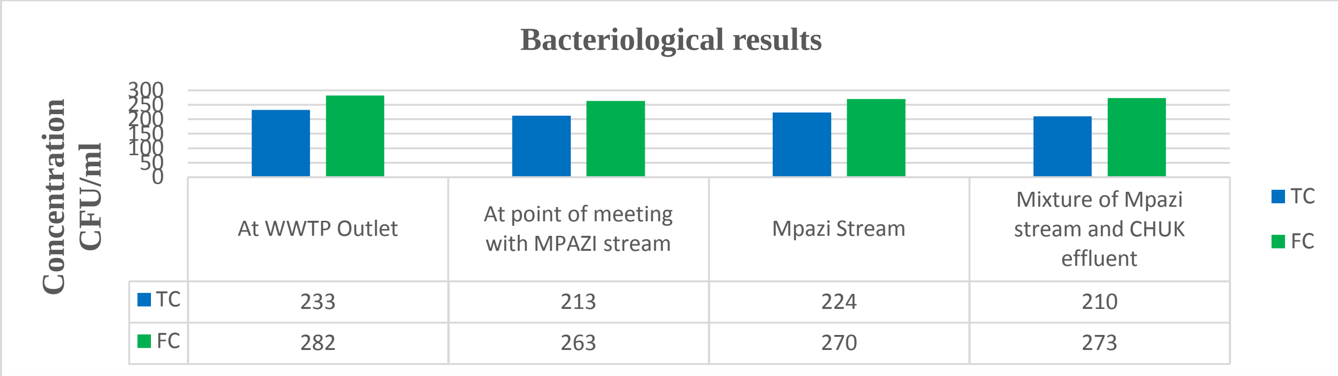


FIGURE 3: Variations of biological parameters cfu/1ml for both total and fecal coliforms at all point of sampling

Findings on hospital physical chemical and bacteriological available in effluents vary from one area to another, Outside Rwanda, miscellaneous research studies have been done on hospital effluents in different side of the world such as Ethiopia, France, India, Nigeria, Iran, Morocco, Indonesia and Korea. Research findings showed that BOD values are most varying from 242 mg/L to 632 mg/L and COD value varies from 616 mg/L to 1388.75 mg/Metals classified as (Lead, Copper Mercury) concentrations were also found in hospital effluents [1-17, 36,] (UN water, 2012).

In Rwanda –Kigali city, the research findings done obtained by Alice U, Ming Y, Nestor U, Donath N, Narcisse N (2017) on Liquid Wastes Treatment and Disposal in Rwanda show that TSS mg/l was≤ 720, pH≤8, Total Nitrogen mg/l ≤36, Ammonium mg/l ≤10, Total phosphorus ≤8.9, lead mercury, and iron was≤03,4.6,0.1mg/l respectively, Temperature variation of treated water compare to ambient temperature of water ≤3, BOD5 mg/l ≤70, COD mg/l ≤500 total and fecal Coli forms number/100ml ≤400 and they are all exceeding the recommended standards of discharge .

Thus for CHUK effluents it is not the case of the area stated above as all parameters studied are prescribed with the limit of standards.

IV. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The physico-chemical and bacteriological parameters analyzed from CHUK WWTP effluents discharged in Mpazistream towards Nyabugogo River were measured, analyzed, interpreted in the research study. After data analysis and compared with the WHO standard, the effluents result of Cu, Fe, Pb,Hg, COD, BOD5, and TSS, total nitrogen, phosphorous ,ammonium and microbiological concentrations were all meet the limit of standard recommended WHO and RSB and have no negative effects on the receiving environment. The decrease in concentration for all parameters from initial point (point one) of sampling to Mpazi stream justified the performance and effectiveness CHUK WWTP with environmental treatment while the increment from effluent to Mpazi stream are suspected to be originated from other discharge of nearby institutions and anthropogenic activities carried around sewer system.

As stated in the hypothesis, the pollution was supposed to be evaluated based on comparison of effluents results with the standard, therefore comparison shows that as all results of CHUK effluent are prescribed within the limit of WHO and local standard from Rwanda standard board, thus CHUK Hospital is not polluting the environment and its component at all.

5.2 Recommendations

After evaluating the quality effluents from CHUK WWTP and those received by Mpazi stream the following recommendations should be noted, act on that and take into account.

- CHUK should measure the effluents released from their wastewater treatment plant week per week because the results of the research are based on the samples taken weekly and show high variability.
- CHUK should offer trainings to their employees about cleaner production while ensuring maintenance of WWTP by regular replacing the oldest deteriorated equipment, this will reduce the volume wastewater generated and cut treatment cost.

- Interested parties should sensitize the people located in NYARUGENGE, GITEGA, and KIMISAGARA sectors that using Mpazi stream as source of water for drinking and washing is not allowed and forbidden.
- Rwanda environmental, health regulatory agencies should do surprise consultancy and inspections provide the reports to ensure that the obtained results are reliable and consistent.
- Discharge standards must be based on current scientific data.
- It supposed to be an obligation for the industries to have laboratories which can be used to prove whether their discharge are proportional to those required standards.
- The penalties should be increased to the extent of being a preventive mechanism.
- The technology about treatment of liquid wastes should be specific and the monitoring system should be improved in different institutions
- The polluter pay principle and cleaner mechanism should be applied in order to minimize the quantity of waste generated.
- More research should be done periodically in different season to support and update the current results.
- The last one, fences must be constructed nearby CHUK sewer system to avoid accident as it is crosscutting habitant area in Gitega sector.

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