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Full Length Research Paper

Investigation of Reclaimed Effluent Water from a Constructed Wetland Domestic Sewage Treatment Plant as Additional Source of Raw Water at the University of Lagos, Nigeria

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Abstract

The University of Lagos, Nigeria (Unilag) mainly depends on internal boreholes and municipal supply (the Lagos State Water cooperation) as sources of water supply to the University. While a number of boreholes serve as the source of raw water to the University's water treatment plants, the municipal water is pumped directly for distribution. In addition to water shortages that do arise occasionally from these sources, the combined quantities of the internal and municipal water supply are far below the current water demand of the University. In this study, we examined the quality and quantity of water reclaimed from the constructed wetland based domestic sewage treatment plant (CWDSTP), which has been further processed through slow sand filters (SSF), as possible source of additional raw water for the University Water Treatment plant. The study revealed that the reclaimed water from the CWDSTP further processed with the SSF is good enough for use as addition source of raw water and conform with both FEPA and WHO standard for water to be further processed for drinking with parameters such as pH, Turbidity, total dissolved solids, colour, iron, nitrate and E. coli. The study also confirms that some additional 385m³/day can be reprocessed from the reclaimed water. The study concludes that the reclaimed water from CWDSTP and SSF can be recycled as additional source of raw water to reduce the existing gap between water demand and supply in the University.

Keyword: *Water supply, water quality, bore raw water, reclaimed sewage effluent, supply and demand gap.*

INTRODUCTION

The importance of water supply to a community cannot be over emphasized. Both humans and every living thing need water to survive. Water covers over 70% of the Earth. The conservation of water is a global issue as global water crisis deepens Fishman (2011). Water is used for domestic activities such as washing (wash our hands, and shower or bathe), bathing, brushing our teeth, flushing, watering gardens and lawns amidst others. Reclaimed water is an important component of water management. Reclaimed water is derived from domestic wastewater, industrial wastewater and storm runoff that have been processed or treated. The process of reclaiming water, sometimes called water recycling or water reuse, involves a highly engineered, multi-step treatment process that speeds up nature's restoration of water quality. The process provides a high-level of disinfection and reliability to ensure that only water meeting stringent requirements leaves the treatment facility Amy *et al*., (2005). Reclaimed water has been employed for various uses around the world, for instance; the Koele Golf Course, on the Island of Lanai, has used recycled water for irrigation since 1994; The Palo Verde Nuclear Generating Station, located near Phoenix Arizona, uses recycled water for cooling purposes and the Montebello Forebay Ground Water

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Recharge Project has for thirty five years recycled water been applied to the Rio Hondo spreading grounds to recharge a potable ground water aquifer in South-Central Los Angeles County (National Water Research Institute, Fountain Valley, California, 1995). Menge (2005) in his study of the treatment of wastewater for reuse in the drinking water system of Windhoek , Namibia found that after a three-month trial period, the water produced is of exceptional high quality measured by national and international water quality criteria with respect to organics, particle(turbidity) and bacterial(faecal coliform) removal. Also Adeniran (2011) reported the reuse of reclaimed domestic sewage effluent under tropical conditions for toilet flushing, flower wetting and catfish farming.

Reused water is usually a constant and reliable supply, particularly with sources such as treated sewage effluent or industrial discharges. Many waters suitable for reuse are produced in large volumes, which if not used, would be merely discharged into the environment or the receiving water bodies. In addition, the reuse of wastewaters for purposes such as agricultural irrigation reduces the amount of water that needs to be extracted from environmental water sources (Gregory 2000, USEPA 1992). The use of recycled water for drinking is less common because many people are repelled by the thought of water that has been in our toilets going to our taps. But a few countries like Singapore, Australia and Namibia, and states such as California, Virginia and New Mexico are already drinking recycled water, demonstrating that reclaimed wastewater can be safe and clean, and help ease water shortages. Eighty percent (80%) of public water supply systems rely to some extent on ground water, which is a form of recycled water in the natural water cycle.

Raw water from a selected source should be of sufficient quality and quantity such that it can be economically treated to produce finished water which complies with the potable water quality requirements. Factors that influence the choice of the raw water source should include reliability, treatability, environmental impact, and economics. Raw water characteristics such as microbiological quality, turbidity, pH, alkalinity, colour, Total Organic Carbon, Total Suspended Solids, iron, manganese, algal counts and temperature determines the type and extent of treatment required for a particular source of water (U.S. EPA, 1992).

In the University of Lagos, Nigeria underground water sources constitute 48% of the water supply to the University, the remaining 52% comes from the municipal source which has to be paid for. The combined internal and external sources can only meet about 30% (3,700m^3/day) of the estimated current water demand (10,750m^3/day) of the University. The objective of this work is to compare the quality of the raw water from underground sources with effluent water reclaimed from the CWDSTP *and* SSF and determine if the reclaimed water is fit for use as raw water and show that in terms of quantity, some existing gap in demand can be met by reuse of the reclaimed water.

MATERIALS AND METHODS

The Study area

The study area, the University of Lagos, Lagos Nigeria, is located in the South Western part of Nigeria on geographical coordinates of 6° 27' 11" North, 3° 23' 45" East and is located in the heart of Lagos metropolis and has a direct link to the Lagos lagoon Figure 1.

Sewage Collection and Treatment in the University of Lagos

The wastewater from the University community are conveyed in sewers ranging from 100mm to 200mm diameter from homes, hostels, offices, classrooms and laboratory to the central sewage pumping sump located at Service Area. The wastewater is pumped to and held in the oxidation ponds, which are planted with water hyacinth to prevent mosquito infestation and to increase the quality of the sewage influent to the anaerobic reactor (Septic Tank). Large particles are screened off in a primary treatment chamber containing stainless steel screen. The pre-treated water is further treated under anaerobic condition in a purposely designed Septic Tank. The effluent from the Septic Tank is then channelled into the constructed wetland system through a 150mm sewer pipe. The wetland was achieved in concrete with waterproof underlay to prevent pollution to the underground water and eliminate water infiltration into ground water. The total area of the nine (9No.) constructed wetland cells is 1540m^2 with an average depth of 0.65m. Water hyacinth is planted on the influent sewage cell while *cyperus papyrus* is planted on the remaining cells containing sand of average grade size 0.1mm to 0.35mm. Figure 2 is the layout of the Constructed Wetland Sewage Treatment system.

Construction of the Constructed Wetland

Due to the high water table and the sandy nature of the soil, as stated earlier, the construction was achieved in reinforced concrete structure Figure 3(a). Waterproofing was achieved by the use of water proof membrane (uPVC mat) for the soffits and walls of each of the cells Figure 3(b).

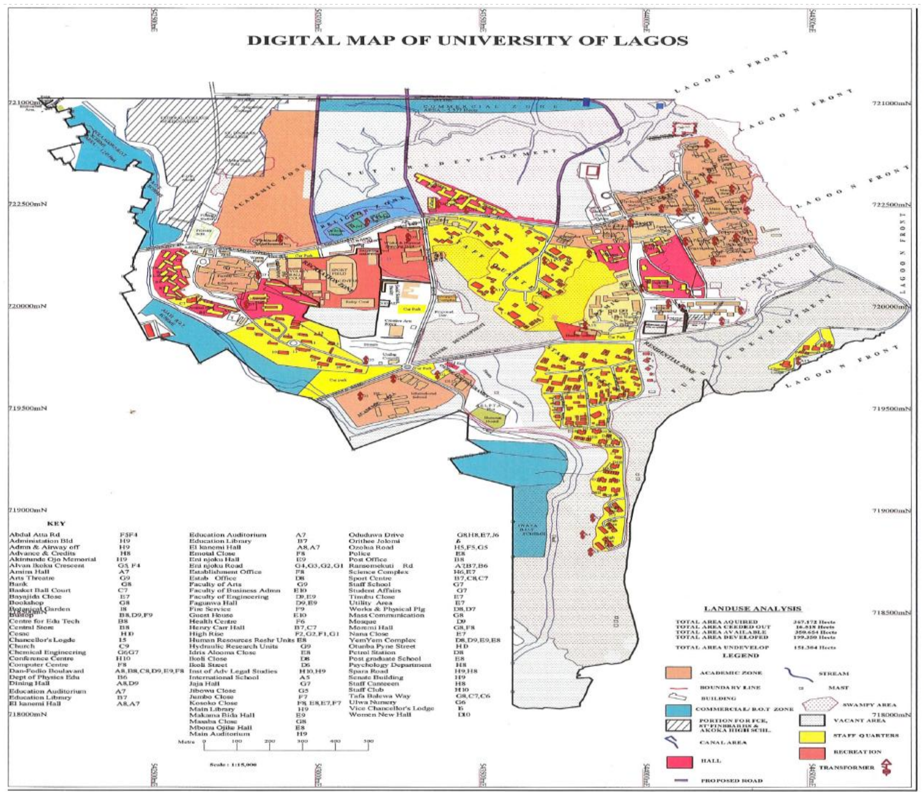

Figure 1. The Study Area - University of Lagos, Nigeria

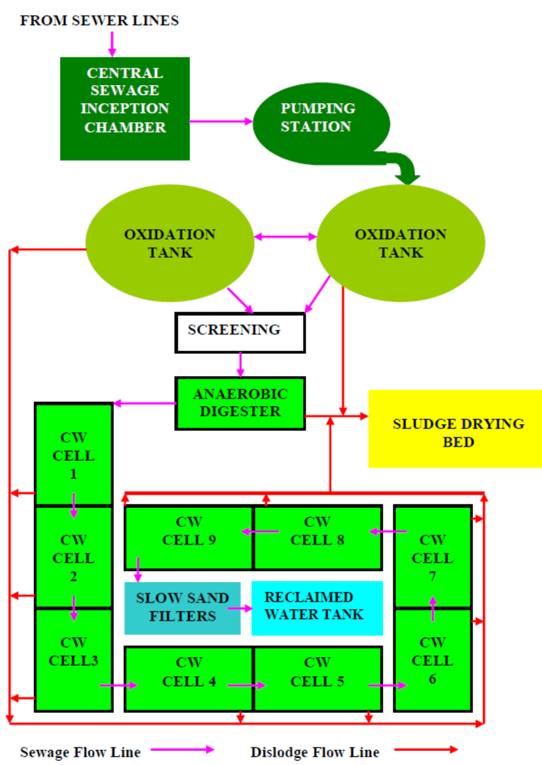

Figure 2. Layout of the Unilag Constructed Wetland Sewage Treatment System

Figure 3(a). Reinforced Concrete Cell

Figure 3(b). Waterproofing Membrane

Sample Collections for Laboratory Analyses

Samples of the constructed wetland reclaimed water (CWRW) and borehole raw water (BHRW) were collected at the final effluent point of the SSF and the water treatment plant raw water tank respectively, using Standard Sampling methods from the hours of 07:30 to 08:30am on a daily basis. The samples were taken to the laboratory for immediate analysis. The analyses of the quality of each of the selected parameters were carried out with the use of Hanna HI 83200 multi-parameter photometer. For each of the chemical parameters, 10ml of the sample was dispensed into the curettes and the corresponding chemical reagents added (in accordance to the manufacturer's specification). Corresponding measurements were read-off the LCD display. The colour of the sample was measure with the HI 83200 multi-parameter photometer after filtering using Whatman No. 42 filter paper. The conductivity, Turbidity, pH and total dissolved solids were also measured using the Adwa conductivity meter, Hanna microprocessor turbidity meter, Beckman 350 pH meter and HM digital TDS meter respectively. The daily raw data for the BHRW and the CWRW obtained from the tests for the parameters (pH, Conductivity, Total Dissolved Solids, Turbidity, Colour, Iron and *E.coli)* were subjected to statistical analysis. The monthly mean, standard deviation, minimum mean and maximum mean were calculated using MS-Excel and presented in Table 1 as Appendix I.

Estimate of Additional Raw Water Supply from the Reclaimed Sewage Effluent

Effluent Flow Meter Readings

Monthly meter readings of the initial and final readings of the effluent from the reclaimed water were taken throughout the duration of the study. Table 2 shows the monthly water meter reading and the volume of the monthly reclaimed water flow.

Estimate of Reclaimable Using Water Budget

The water Budget Equation was also used to estimate of the water outflow from the constructed wetland from rainfall and Evapo-transpiration data for Lagos. The Water Budget Equation is as shown in Equation 1 below.

The Water Budget Equation for Constructed Wetland

$$Q_o = Q_{in} - I + (P - ET)A \quad (1)$$

Where:

Q_o =Sewage influent (m^3/month) = Unknown

Q_{in} =Sewage effluent (m3/month) =380m3/day=380*30/day= 11400m^3/month

I = Average Infiltration through the soil (Zero because of water proofing)

P =Average Precipitation =1300mm/12=108mm/month=0.108m/month

ET =Evapo-transpiration=0.022m/month for SW Nigeria (NIMET)

The Result obtained are presented in Table 3. The real field data from the reclaimed effluent water (meter readings) are then compared with the results obtained from the Water Budget equation.

RESULTS AND DISCUSSIONS

Water Quality

In Table 1 (APPENDIX I) we tabulate, for comparison), the results of the monthly mean of the values for the selected parameters for both the BHRW and the

Table 2. Field Data from Effluent Meters Readings

Months	Initial Reading (m^3)	Final Reading (m^3)	Volume of Reclaimed Water (m^3)
Jan-12	22,947.33	3,936.89	10,989.56
Feb-12	33,936.89	44,950.00	11,013.11
Mar-12	44,950.00	55,920.00	10,970.00
Apr-12	55,920.00	66,700.00	10,780.00
May-12	66,700.00	78,900.00	12,200.00
Jun-12	78,900.00	93,384.02	14,484.02
Jul-12	99,384.02	108,820.33	9,436.31
Aug-12	108,820.33	119,945.33	11,125.00
Sep-12	119,945.33	131,725.33	11,780.00
Oct-12	131,725.33	144,348.21	12,622.88
Nov-12	144,348.21	155,400.93	11,052.72
Dec-12	155,400.93	166,385.89	10,984.96
Jan-13	166,385.89	177,400.00	11,014.11
Feb-13	177,400.00	188,464.50	11,064.50
Mar-13	188,464.50	200,024.53	11,560.03
Apr-13	200,024.53	211,914.51	11,889.98
May-13	211,914.51	224,254.52	12,340.01
Jun-13	224,254.52	236,874.50	12,619.98
Jul-13	236,874.50	249,424.56	12,550.06
Aug-13	249,424.56	260,409.53	10,984.97
Total (Cu.m)			**231,462.20**
Average Monthly (Cu.m)			**11,573.11**
Average Dailyly (Cu.m)			**385.77**

Table 3. Estimate of Reclaimable Raw Water using Water Budget Equation

Month	Rainfall (m)	ET (m)	Q_{in} (m^3)	Area (m^2)	Q_{out} (m^3)
Jan-12	0.014	0.022	11,400.00	1540	11,388.14
Feb-12	0.042	0.022	11,380.00	1540	11,410.80
Mar-12	0.077	0.022	11,275.00	1540	11,359.85
Apr-12	0.142	0.022	11,480.00	1540	11,665.42
May-12	0.205	0.022	12,250.00	1540	12,531.51
Jun-12	0.312	0.022	12,350.00	1540	12,796.91
Jul-12	0.257	0.022	13,500.00	1540	13,861.75
Aug-12	0.112	0.022	11,390.00	1540	11,529.22
Sep-12	0.167	0.022	12,600.00	1540	12,823.45
Oct-12	0.136	0.022	12,420.00	1540	12,595.25
Nov-12	0.054	0.022	10,650.00	1540	10,699.28
Dec-12	0.019	0.022	10,540.00	1540	10,535.38
Jan-13	0.014	0.022	9,980.00	1540	9,968.14
Feb-13	0.042	0.022	11,435.00	1540	11,465.80
Mar-13	0.077	0.022	12,430.00	1540	12,514.85
Apr-13	0.142	0.022	12,620.00	1540	12,805.42

Table 3. Continued

May-13	0.205	0.022	12,310.00	1540	12,591.51
Jun-13	0.312	0.022	12,200.00	1540	12,646.91
Jul-13	0.257	0.022	11,381.00	1540	11,742.75
Aug-13	0.112	0.022	11,412.00	1540	11,551.22
Total Reclaimable Water					**238,483.55**
Average Monthly					**11,924.18**
Average Daily					**397.47**

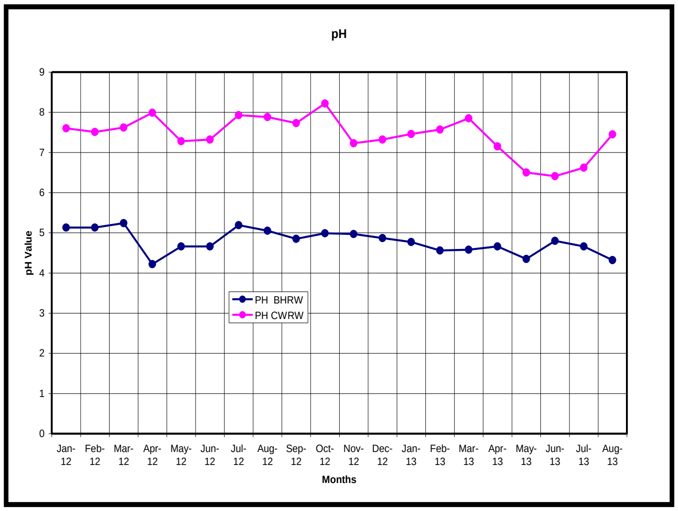

Figure 4. pH Chart of BHRW and CWRW

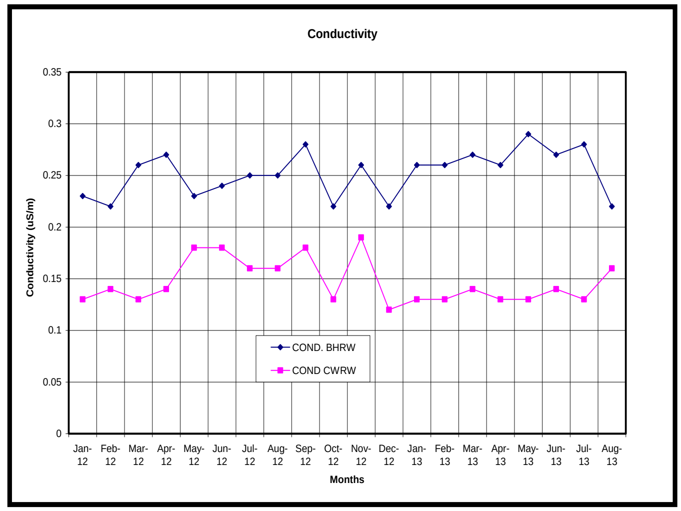

Figure 5. Conductivity Chart of BHRW and CWRW

CWRW. The results for the parameters are discussed below.

pH

The pH level of drinking water reflects how acidic it is. pH stands for "potential of hydrogen," referring to the amount of hydrogen found in the water. pH is measured on a scale that runs from 0 to 14. Seven is neutral, meaning there is a balance between acid and alkalinity. A measurement below 7 means acid is present and a measurement above 7 is basic (or alkaline). From Table 1, it is observed that the mean value of the pH of raw water from borehole (BHRW) is 4.78 ± 0.29 while that of reclaimed water slow sand filtration (SSF) treated constructed wetland effluent (CWRW) is 7.43±0.43. The pH of the BHRW ranges from 4.22 to 5.24 while that of the CWRW ranges from 6.41 to 8.22. Figure 4 compares the BHRW and CWRW graphically. It is noted that the BHRW is acidic requiring chemicals like caustic soda or calcium carbonate to neutralise the pH to non-acidic level. In contrast, the CWRW is already at the reasonable level and hence its use, as raw water source, will little require or no addition cost of neutralisation in the water treatment process.

Conductivity

Conductivity of a substance is defined as '*the ability or power to conduct or transmit heat, electricity, or sound*'. Its units are Siemens per meter [Sm^{-1}] or [μS^{m-1}] in SI. In water and ionic materials or fluids a net motion of charged ions can occur. This phenomenon produces an electric current and is called ionic conduction. Pure water is not a good conductor of electricity. Because the electrical current is transported by the ions in solution, the conductivity increases as the concentration of ions increases. It implies that the lower the conductivity in water, the purer the water. From the summary analysis presented in Table 1 (Appendix I), the mean value of conductivity of the BHRW is 0.0.25±0.02μSm^{-1} and that of treated sewage is 0.15±0.03μSm^{-1}. The conductivity of the BHRW ranges from 0.22μSm^{-1} to 0.29μSm^{-1}, while that of the CWRW ranges from 0.12μSm^{-1} to 0.19μSm^{-1}. Figure 5 compares the BHRW and CWRW graphically. The conductivity of both BHRW and CWRW are within

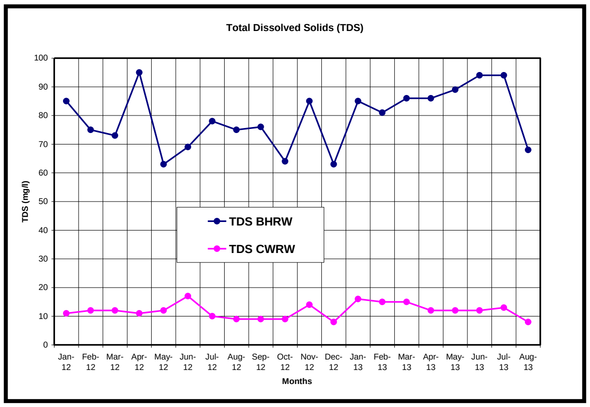

Figure 6. TDS Chart of BHRW and CWRW

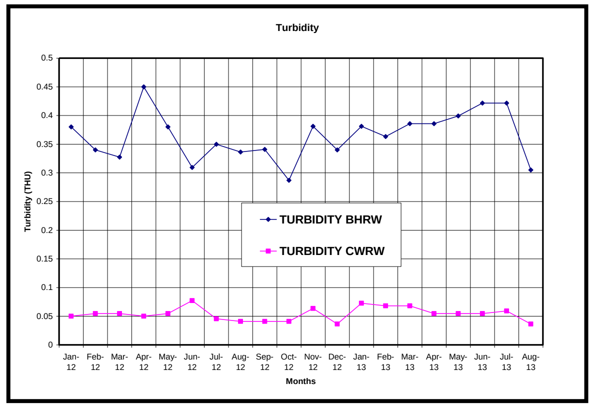

Figure 7. Turbidity Chart of BHRW and CWRW

the FEPA limits. However, the CWRW is a better source of raw water than the BHRW source.

Total Dissolved Solids (TDS)

Total dissolved solid (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen-carbonate, chloride, sulfate, and nitrate anions. The presence of dissolved solids in water may affect its taste. The palatability of drinking- water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/l; good, between 300 and 600 mg/l; fair, between 600 and 900 mg/l; poor, between 900 and 1200 mg/l; and unacceptable, greater than 1200 mg/l (WHO, 1996). From the summary analysis presented in Table 1 (Appendix I), the mean value of TDS of the BHRW is 79.20±10.20mg/l and that of CWRW 11.85±2.60mg/l. The TDS of the BHRW ranges from 63mg/l to 95mg/l, while that of the CWRW ranges from 8mg/l to 17. Figure 6 compares the TDS of the BHRW and TDS of the CWRW graphically. TDS of both BHRW and CWRW are within the FEPA limits. However, it is noted that the CWRW TDS is a lower than the TDS of the BHRW source.

Turbidity

Turbidity is defined as the percentage of light that is deflected more than 2.5° from the incoming light direction. Turbidity is a measure of the cloudiness of water. It can come from fairly benign sources, such as suspended sediment in the water, or from high levels of disease-causing organisms. All are generated as water moves through soil and into your ground water supply. Turbidity caused by high levels of organic matter can protect microorganisms from the effects of drinking water disinfection. It can even stimulate bacterial growth. Therefore, it is critical to successful water treatment and disinfection to keep turbidity levels low. Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause nausea, cramps, and diarrhea (WHO, 1996). From the summary analysis presented in Table 1 (Appendix I), the mean value of Turbidity of the BHRW is 0.36±0.04FTU and that of CWRW 0.05±0.01FTU. The Turbidity of the BHRW ranges from 0.29FTU to 0.45FTU, while that of the CWRW ranges from 0.04FTU to 0.08FTU. Figure 7 compares the Turbidity of the BHRW and Turbidity of the CWRW graphically. The Turbidity of both BHRW and CWRW are within the FEPA limits. However, it is noted that the CWRW Turbidity is a lower than the TDS of the BHRW source.

Colour

Colour in water is be due to the presence of coloured organic substances; the presence of metals such as iron, manganese and copper; or the presence of highly coloured industrial wastes, the most common of which are pulp and paper and textile wastes (Black and Christman, 1963). Although the presence of colour in drinking water may be indirectly linked to health, its primary importance in drinking water is aesthetic. Sources of raw water with high colour level should be avoided when selecting raw water supply sources. The avoidance of excessive colour prior to treatment process will reduce drastically the cost of treatment (AWWA Standards Methods, 2012). From Table 1 (Appendix I), the mean value of Colour of the BHRW is 3.82±0.44PCU, while that of CWRW 0.08±0.13PCU. The Colour of the BHRW ranges from 3.01PCU to 4.73PCU,

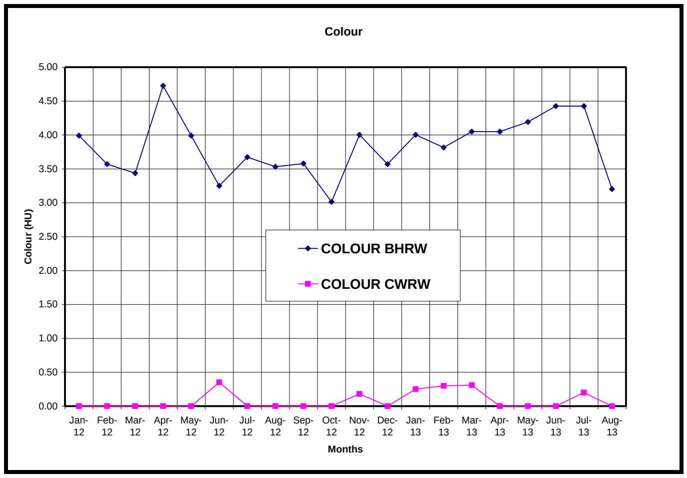

Figure 8. Colour Chart of BHRW and CWRW

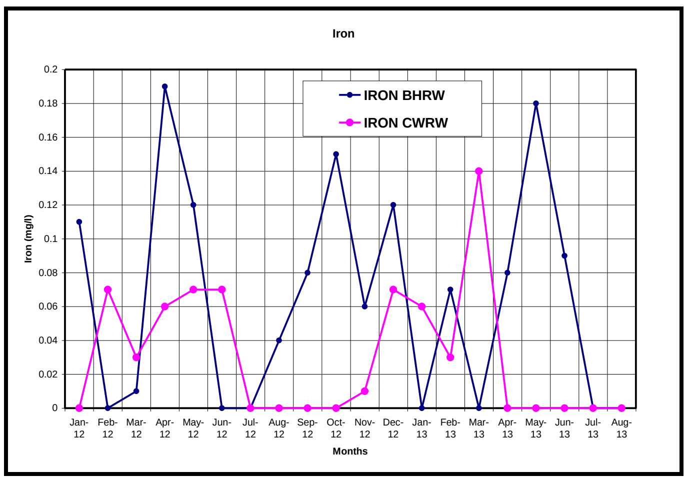

Figure 9. Iron Chart of BHRW and CWRW

while that of the CWRW ranges from 0.0PCU to 0.o.35PCU. Figure 8 compares the Colour of the BHRW and Colour of the CWRW graphically. The Colour of both BHRW and CWRW are within the FEPA limits. Again, it is noted that the CWRW Colour is a lower than the Colour of the BHRW source.

Iron

Iron is not a desirable element in water because it stains the sanitary wares and give brown coloration to water. It affects the aesthetics of water. Hence preliminary treatment is required to remove iron and similar metals from raw water before further treatment. In Table 1 (Appendix I), the mean value of Iron of the BHRW is 0.07±0.06mg/l and that of CWRW 0.03±0.04mg/l. The Iron of the BHRW ranges from 0.0mg/l to 0.19mg/l, while that of the CWRW ranges from 0.0mg/l to 0.14mg/l. Figure 9 compares the Iron of the BHRW and Iron of the CWRW graphically. Iron of both BHRW and CWRW are within the FEPA limits. It is noted that the CWRW Iron content is a lower than the Iron content of the BHRW source. The water from the CWRW may not required aeration before further water treatment thus reducing the cost of treatment.

E-coli

E-coli, is a measure of bacteriological pollution of water. While the raw water source is not expected to be completely free of pathogens pollution, the level of pollution must be minima to avoid high cost of disinfectant. It should be noted that disinfection is terms of chlorination, ozonization, UV ray etc is the highest single cost in water treatment. Table 1 (Appendix I), the mean value of E-coli of the BHRW is

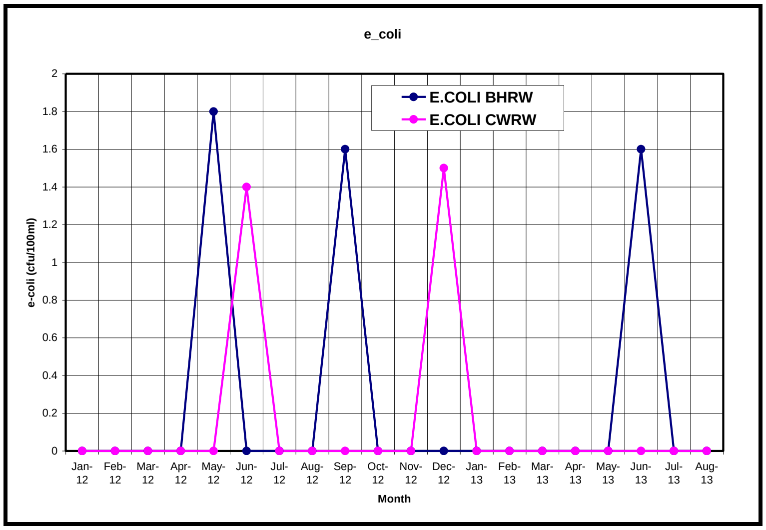

Figure 10. e-coli Chart of BHRW and CWRW

0.25±0.61cfu/100ml and that of CWRW 0.15±0.45cfu/100ml. The E-coli of the BHRW ranges from 0.cfu/100ml to 1.8cfu/1000ml, while that of the CWRW ranges from 0.0cfu/100ml to 1.5cfu/100ml. Figure 10 compares the E-coli of the BHRW and E-coli of the CWRW graphically. E-coli of both BHRW and CWRW are within the FEPA limits. It is noted that the CWRW E-coli content is a lower than the E-coli content of the BHRW source.

Reclaimable Water Quantity from the CWRW

Actual Effluent Flow

The volumes of the actual water reclaimed from the effluent of the constructed wetland after passing through a tertiary treatment of slow sand filtrations are calculated per month and shown in Table 2. From Table 2, it is observed that an average of about 385.77m^3/day can be reclaimed from the constructed wetland after further treatment by a slow sand filtration system. This is an addition of about 10.43% to the existing water supply of about 3,700m^3/day to the University.

Estimate of Reclaimable Water Using Water Budget Equation

Using Equation 1, the reclaimable water from the Constructed wetland was estimated. The data available for Lagos from the Nigerian Meteorological Department was used in carrying out the estimate. Table 3 shows the results of the reclaimable water for each month of the study period. From Water Budget equation it is estimated that about 397.47m3/day is reclaimable from the CWRW.

Comparison of Reclaimable Raw Water from Field Data with Water Budget Equation

From the Water Budget equation, an average of about 397,470 litres/day of water can be reclaimed. Also, it is seen that the from the field data an average of about 385,7700 litres/day of water can be reclaimed. It will therefore be a reasonable assumption that an average of about 385,000 litres/day can be reclaimed as source of raw water to the University's water treatment plant. Figure 11 is a graph of the results of the field data and the Water Budget Equation estimated value.

CONCLUSION

From the study it is concluded that the treated sewage from the constructed wetland at the University of Lagos can be recycled for use in the entire University community as the qualities of the critical parameter considered meet with standards for water that can be used as raw water. Currently the total water production from the University’s Service Area waterworks which is the source of the sewage generated for treatment in this study is an average of 3,700m3/day. From the water budget equation and the effluent meter readings, it is possible to reclaim about 385m3/day i.e. 10.42% of the current production. This will reduce the stress of water shortage as such reclaimed water could be use for gardening, fish farming, toilet flushing and car wash.

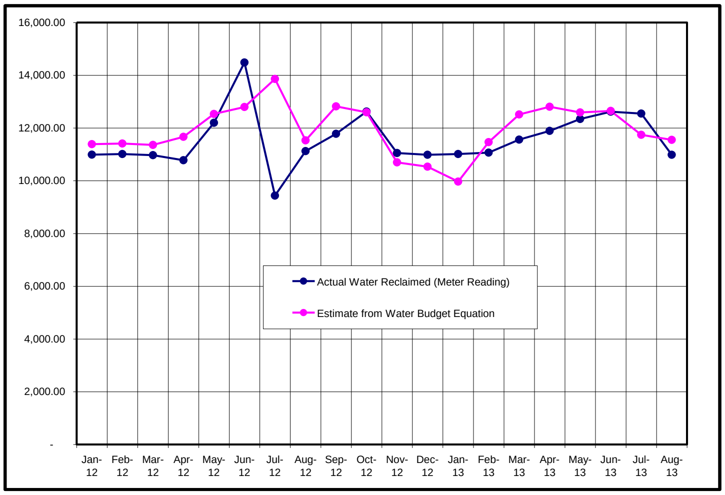

Figure 11. Actual and Estimated Reclaimable Raw Water

It should however be noted that the treated sewage should be subjected to chemical treatment, especially chlorination, before re-use. A multi disciplinary team approach should be adopted if a reclamation/reuse scheme is going to be implemented to ensure that the technology employed is operating properly and that the necessary monitoring is conducted to ensure that the product is safe for its intended use.

REFERENCES

Adeniran AE (2011). The effect of Water Hyacinth in the Treatment of Domestic Sewage in an African University. Proceedings of the AWRA Annual Conference, Albuquerque, NM, USA November, 7-10.

American Water Works Association (2012). Standard methods for the examination of water and wastewater, 22nd edition. Washington, DC. pp 1:38-43.

Amy G, Asano T, Gerba C, Haas C, Rose J (2005). Chemical and Microbial concerns in Wastewater Reclamation/Reuse. *Presentation at a strategy workshop of the Global Water Research Coalition (GWRC) on the Role and Status of Water Reuse-An International Review*. Utrecht, the Netherlands.

Black AP, Christman RF (1963): Characteristics of colored surface waters. J. Am. Water Works Assoc., 55: p.753.

Colombia Water Centre (2012). www.blogs.ei.colombia.edu/2011/04/04/from-wastewater-to-drinkingwater. accessed 16/10/2012.

Fishman C (2011). The Big Thirst - The Secret Life and Turbulent Future of Water. Free Press, New York.

Gregory A (2000). Strategic direction of Water Recycling in Sydney. In Water Recycling Australia. Proceedings of the First Symposium Water Recycling. Adelaide, Australia 19-20, October.

Menge J (2005). Treatment of wastewater for reuse in the drinking water system of Windhoek. City of Windhoek, PO Box 59, Windhoek, Namibia. www.wwreclamation.com accessed on 16/10/2012.

National Water Research Institute (1995): Water from Water: Recycling at Fountain Valley, California, 1995.

U.S. EPA, Offices of Water and Wastewater and compliance (1992): Guidelines for water reuse. U.S. EPA, Washington.

WHO (1996). Guidelines for drinking-water quality, 2nd ed., World Health Organization, Geneva.

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APPENDIX I

Table 1. Monthly Mean of Quality Parameters of Borehole Raw Water (BHRW) and the Constructed Wetland Reclaimed Water (CWRW) January 2012-August 2013

MONTHS	pH		CONDUCTIVITY μSm^{-1}		TDS mg/l		TURBIDITY FTU		COLOUR PtCo Units (PCU)		IRON mg/l		E.COLI cfu/100ml	
	BHRW	CWRW	BHRW	CWRW	BHRW	CWRW	BHRW	CWRW	BHRW	CWRW	BHRW	CWRW	BHRW	CWRW
Jan-12	5.13	7.6	0.23	0.13	85	11	0.38	0.05	3.99	0	0.11	0	0	0
Feb-12	5.13	7.51	0.22	0.14	75	12	0.34	0.05	3.57	0	0	0.07	0	0
Mar-12	5.24	7.62	0.26	0.13	73	12	0.33	0.05	3.44	0	0.01	0.03	0	0
Apr-12	4.22	7.99	0.27	0.14	95	11	0.45	0.05	4.73	0	0.19	0.06	0	0
May-12	4.66	7.28	0.23	0.18	63	12	0.38	0.05	3.99	0	0.12	0.07	1.8	0
Jun-12	4.66	7.32	0.24	0.18	69	17	0.31	0.08	3.25	0.35	0	0.07	0	1.4
Jul-12	5.19	7.93	0.25	0.16	78	10	0.35	0.05	3.67	0	0	0	0	0
Aug-12	5.05	7.88	0.25	0.16	75	9	0.34	0.04	3.53	0	0.04	0	0	0
Sep-12	4.85	7.73	0.28	0.18	76	9	0.34	0.04	3.58	0	0.08	0	1.6	0
Oct-12	4.99	8.22	0.22	0.13	64	9	0.29	0.04	3.01	0	0.15	0	0	0
Nov-12	4.97	7.23	0.26	0.19	85	14	0.38	0.06	4.00	0.18	0.06	0.01	0	0
Dec-12	4.87	7.32	0.22	0.12	63	8	0.34	0.04	3.57	0	0.12	0.07	0	1.5
Jan-13	4.77	7.46	0.26	0.13	85	16	0.38	0.07	4.00	0.25	0	0.06	0	0
Feb-13	4.56	7.57	0.26	0.13	81	15	0.36	0.07	3.81	0.3	0.07	0.03	0	0
Mar-13	4.58	7.85	0.27	0.14	86	15	0.39	0.07	4.05	0.31	0	0.14	0	0
Apr-13	4.66	7.15	0.26	0.13	86	12	0.39	0.05	4.05	0	0.08	0	0	0
May-13	4.35	6.5	0.29	0.13	89	12	0.40	0.05	4.19	0	0.18	0	0	0
Jun-13	4.8	6.41	0.27	0.14	94	12	0.42	0.05	4.43	0	0.09	0	1.6	0
Jul-13	4.66	6.62	0.28	0.13	94	13	0.42	0.06	4.43	0.2	0	0	0	0
Aug-13	4.32	7.45	0.22	0.16	68	8	0.30	0.04	3.20	0	0	0	0	0
Mean	***4.78***	***7.43***	***0.25***	***0.15***	***79.20***	***11.85***	***0.36***	***0.05***	***3.82***	***0.08***	***0.07***	***0.03***	***0.25***	***0.15***
STD	***0.29***	***0.49***	***0.02***	***0.02***	***10.39***	***2.60***	***0.04***	***0.01***	***0.44***	***0.13***	***0.06***	***0.04***	***0.61***	***0.45***
Max	***5.24***	***8.22***	***0.29***	***0.19***	***95***	***17***	***0.45***	***0.08***	***4.725***	***0.35***	***0.19***	***0.14***	***1.8***	***1.5***
Min	***4.22***	***6.41***	***0.22***	***0.12***	***63***	***8***	***0.29***	***0.04***	***3.013***	***0***	***0***	***0***	***0***	***0***