QUALITY ASSESSMENT OF A UNIVERSITY CAMPUS WASTEWATER RESOURCE

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ABSTRACT

Vast volumes of freshwater can be conserved if the practice of re-using wastewater is encouraged. In this study, the quality of wastewater from the Covenant University campus was assessed to determine its suitability for landscape irrigation purposes. The university uses a constructed wetland (CW) method in treating both its black-water and grey-water (wastewater). An estimated 874,081 litres/day of wastewater was generated and treated as of 2013, with nearly all of this volume discharged without being re-used. To assess the suitability of the wastewater for reuse, duplicate grab samples of treated effluent from the CW and from the grey water outlet were assessed for physical parameters such as pH, Temperature, Total Dissolved Solid (TDS), Salinity, Conductivity were analysed using handheld Hanna multi-meter instrument (model HI2040). Also, chemical parameters such as Nitrate, Nitrite, Lead, Nickel, Cadmium, Zinc and Copper were tested using Palintest photometer (model 8000). Moreover, total coliform was checked, using standard laboratory methods. Results indicated that none of the tested parameters exceeded the specified limits by Food and Agriculture Organization (FAO) of United Nations and Environmental Protection Agency (EPA) standards for wastewater reuse. Thus, the treated wastewater in Covenant University was found to be a valuable resource for multiple purposes that can add value other than outright discharge. Thus, it was recommended that appropriate infrastructure be put in place to harness and reuse treated wastewater coming from Covenant University.

Keywords: wastewater, quality, reuse, treatment, irrigation, standards, heavy metals, Nigeria, groundwater, effluent.

1 INTRODUCTION

Nearly every activity of man result in waste generation. This is more so in the case of water use as approximately 80% of water ends up as wastewater [1]. The management of this wastewater can constitute a problem, if not well managed. Conversely, wastewater could also constitute a huge resource if plans for reuse is put in place. Domestic wastewater can be classified into two: greywater and black-water [2]. While the former is composed of excreta, urine and sludge, the latter is composed of wastewater originating from kitchen and bathroom sinks [2]. Other forms of wastewater that could arise from human activities include industrial wastewater and agricultural wastewater. All forms of wastewater contain biodegradable contaminants which may be organic or inorganic [3]. The degree of treatment given to wastewater is determined by the contaminant and the intended purpose of reuse. Uses to which treated wastewater may be put include ornamental landscape, fire protection, dust control, concrete mixing, car washing, toilet flushing, machinery coolant, industrial process water, agriculture, and bathing [3]. Wastewater intended for agricultural or domestic use is usually guided by several standard guidelines including the United States Environmental Protection Agency (USEPA) guideline for reuse for irrigation [4], Food and Agriculture Organization (FAO) guidelines [5], and the World Health Organization (WHO) guidelines [6]. The guidelines are required to prevent the spread of diseases and the attendant risk to public health. Although water availability is not a major problem in southwest Nigeria, water infrastructure such as public piped water services is almost non-existent [7]. This factor, therefore, accounts for widespread and unregulated self-service in the provision of water and management of attendant wastewater among nearly every citizen of Nigeria [8]. The current

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study examines the case of covenant university, in Nigeria which is 100% self-serviced from natural groundwater resources [9]. The study examined the volume and quality of treated wastewater generated at the institution with the aim of identifying agricultural and horticultural reuse opportunities for this resource as an alternative to the current practice of discharge into the environment.

2 METHOD AND MATERIAL

2.1 Study area

Covenant University is situated in the Ota district of Ogun state, Southwest Nigeria. Covenant University had 8111 people living on its campus in 2013 [1]. The average volume of water pumped from 11 functional boreholes in 2013 was 1,092,552 litres while 874,081 litres of wastewater was generated per day [1]. Nearly all this wastewater passed through a constructed wetland (CW) wastewater treatment system before discharge into a nearby stream (Figs 1 and 2).

Figure 1: Aerial map showing Covenant University campus and neighbouring communities.

Figure 2: Aerial map showing the wastewater treatment facility of Covenant University and the point of effluent discharge.

2.2 Wastewater sampling and laboratory analysis

Duplicate grab water samples were obtained from the influent inlet into the constructed wetland (CW), the effluent at the point of discharge (Fig. 3), and the greywater discharge point by the roadside open drain (Fig. 2). Sample 1 was the wastewater influent i.e. wastewater entering the treatment plant; Sample 2 was the wastewater effluent i.e. wastewater that had being treated and discharged. Sample 3 represented the Greywater effluent obtained from the roadside open drain beside Daniel Hall. The samples were collected in sterilized 50 cl polyethylene bottles and transported to the Chemistry laboratory of Covenant University. Physical parameters such as Salinity, TDS, pH, conductivity, and Temperature were tested in-situ using handheld Hanna multi-meter (model HI2040). In addition, the wastewater samples were tested for chemical and bacteriological contaminants. Chemical contaminants such as Copper, Lead, Nickel, Zinc, Nitrite, and Nitrate. All samples analyses were done by following standard methods [10]. All tests were carried out in duplicate and the average value was recorded.

Figure 3: Sketched layout of Covenant University's CW. *(Source: [8].)*

3 RESULTS AND DISCUSSION

Results of the in-situ and laboratory analyses of the wastewater were compared to World Health Organization (WHO) standard of wastewater effluent discharge and Food and Agriculture Organization of the United Nations standard for wastewater reuse for irrigation in agriculture amongst other standards [5], [6].

The results obtained from the physicochemical parameters determination on the wastewater samples are presented in Table 1, while Figs 4 and 5 illustrate the comparisons between the standard limits and the measured contaminant concentrations in the treated wastewater.

Table 1: Composition of wastewater quality with WHO [6] standard for irrigation.

Parameters	Units	Sample 1	Sample 2	Sample 3	WHO
Temperature	ºC	29	29	28.7	40
pH	______	6.9	7.01	7.52	6-9*
Conductivity	µS/cm	395	397	324	-
TDS	mg/L	279	280	231	2000**
Salinity	µS/cm	219	219	181	700-3000
Zinc	mg/L	0.01	-	-	2**
Iron	mg/L	0.41	0.15	0.09	5**
Lead	mg/l	0.1	0.1	0.2	5**
Nickel	mg/L	0.00	0.00	0.1	0.2**
Nitrate (NH_3)	mg/L	0.00	0.00	0.003	30*
Nitrite	mg/L	0.00	-	0.06	-
Total coliforms	MPN/100 ml	75	43	-	400***

*WHO [6] citing Jordanian standard (JS: 893/2002) for effluent reuse for irrigation.
**WHO [6] citing FAO Guidelines for trace metals in irrigation water.
***WHO [6] citing Kuwaiti standard.

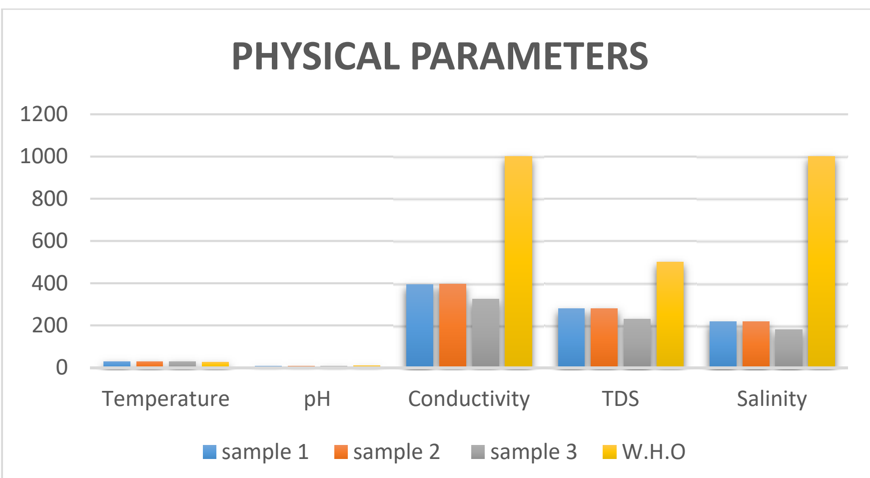

Figure 4: Graphical representation of physical parameters reading.

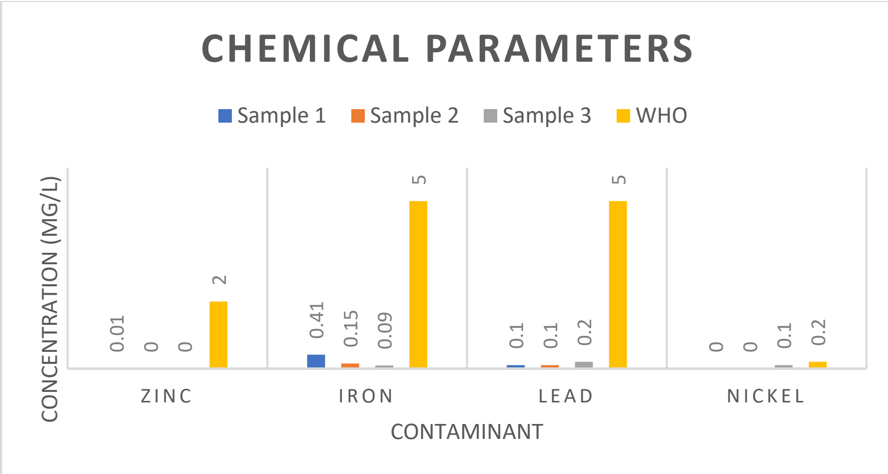

Figure 5: Graphical representation of heavy metal reading.

3.1 pH

The normal pH range for irrigation water is from 6.0 to 9.0 [6]. Low pH values can affect the mobility of heavy metals in the soil. The test results indicate that the treated wastewater was slightly alkaline in nature but within the permissible limits.

3.2 Temperature

Extreme temperatures may lead to rapid die-off of bacteria. The bacteria are useful for the breakdown of organic wastes. The tropical temperature, however, is ideal for bacteria activity. The set standard by WHO [6] for temperature is the ambient temperature. The temperature gotten from the samples ranges from 28.7 to 29ºC, which are within prescribed ambient temperature limit.

3.3 Total dissolved solids

Total Dissolved Solids (TDS) is one of the most important agricultural water quality parameters. It is a measure of impurities in a water sample. Prescribed limits for TDS is less than 2000 mg/l and TDS from the laboratory analysis ranges from 279–281 mg/l; hence the range is acceptable.

3.4 Heavy metals

The treated wastewater can be considered as adequate for reuse since the concentrations of all the tested heavy metals, after treatment, were within the WHO [6] permissible limits (Fig. 5). Much of the metal content has been absorbed by the *Eichhornia crassipes* plants used within the constructed wetland [9].

3.5 Salinity

Treated wastewater contains high salt content which can immensely limit crop growth. High salinity may interfere with aquatic vegetation. Generally, if the EC of irrigation water is below 700 µs/cm, it does not affect crop growth; when above 3000 µs/cm, it can cause severe damages [11]. Salinity in the samples vary from 181 to 219 µs/cm; hence it is acceptable.

3.6 Nitrate

Nitrate is also one of the most important parameters of water quality causing diseases particularly blue baby syndrome in infants [7]. WHO maximum permissible limit for nitrate is 2 mg/L and results from laboratory analysis shows that the presence of nitrate in the samples varies from 0.00 to 0.003 mg/l, which is acceptable.

3.7 Biological test

Biological test was conducted on samples from the constructed wetland only, that is the influent and the effluent (Samples 1 and 2) since it was assumed that greywater made no contact with service pipes carrying excreta and urine. The measured values of 75 and 43 MPN/100 ml from the raw and treated wastewater respectively, were lesser than the specified 400 MPN/100 ml [6]. Thus, the wastewater can be considered as suitable for irrigation purposes.

4 CONCLUSION AND RECOMMENDATION

4.1 Conclusions

This study indicates that the wastewater treatment is effective in treating wastewater coming from residential staff quarters and student halls of residence of Covenant University. Constructed wetland system of wastewater treatment is a relatively economical and effective method of treating wastewater in developing countries [12], although it may be cumbersome by taking up a lot of space [9]. In the case of Covenant University wastewater, all parameters which were tested for in this study met the WHO and FAO guidelines for wastewater reuse for agricultural irrigation purposes. The university has a lot of green lawns which is currently being maintained with natural precipitation during the raining season and with freshly pumped groundwater during the dry season. Using fresh groundwater for irrigation can be a waste of valuable resource, when the large volumes of treated wastewater can serve the same purpose. Furthermore, using freshwater to irrigate lawns and farms appear insensitive in a country where millions of citizens have no access to adequate water and sanitation [13]–[15]. Adopting treated wastewater reuse for landscape uses in Covenant University will convert the over 874,000 litres of treated wastewater currently being discharged into nearby streams. This large volume of discharge currently contributes to the wetland problem being experienced at Arobieye community, which is located downstream of the campus (Fig. 6). Another use for the treated wastewater could be the irrigation of peasant farms situated downstream of the discharge point of the university wastewater. Farmers at this location currently use the water to manually irrigate their fruit and vegetable farms (Fig. 7). However, if this wastewater resource is properly developed, it could serve as corporate social responsibility for the campus to provide upgrade the irrigation facility for the farmers.

Figure 6: Wetlands created downstream of the campus in Arobieye community.

Figure 7: Fruit and vegetable farm manually irrigated from CU wastewater. *(Source: [1].)*

4.2 Recommendations

To optimize the benefits of the large volume of treated wastewater being generated by covenant university and in order to simultaneously minimize adverse environmental and public health impact which may be caused by its discharge, the following recommendations are proffered:

i. The University Management should pay more attention in ensuring the efficient performance of the CW. Monthly, or possibly, weekly physicochemical analysis of wastewater samples should be carried out for quality assurance.
ii. The current facilities should be upgraded to include storage and re-distribution of treated wastewater for irrigation and ornamental landscape purposes.

iii. The University Management should monitor the volume of wastewater discharge from the institution, as this may lead to water-based diseases, loss of farmlands, flooded homes etc. downstream if adequate monitoring and controls are not put in place.
iv. Awareness for water conservation from source should be driven within the university to reduce volume of wastewater being generated. Privileged persons should learn to be responsible and sensitive to the water requirements of less privileged individuals in the society.

REFERENCES

[1] Emenike, P., Tenebe, I., Omole, D., Ndambuki, J., Ogbiye, A. & Sojobi, A., Application of water recovery option for agricultural use in developing countries: Case study of a Nigerian community. *Conference on International Research on Food Security, Natural Resource Management and Rural Development*, Humboldt University of Berlin and the Leibniz Centre for Agricultural Landscape Research (ZALF), 2015. http://www.tropentag.de/abstracts/full/490.pdf
[2] Hoek, W., A framework for a global assessment of the extent of wastewater irrigation: The need for a common typology. Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities, eds C.A. Scott, N.I. Faruqui & L. Raschid-Sally, International Water Management Institute (IWMI): Bierstalpad, the Netherlands, p. 11, 2004. http://dx.doi.org/10.1079/9780851998237.0011
[3] Haering, K.C., Evanylo, G.K., Beham, B. & Goatley, M., Water reuse: reclaimed water for irrigation. Virginia cooperative extension. Publication 452-014, 2009. https://pubs.ext.vt.edu/452/452-014/452-014.html. Accessed on: 30 Dec. 2016.
[4] US EPA, Guidelines for Water Reuse. EPA 645R-04-108, US Environmental Protection Agency: Washington, DC, 2004. www.epa.gov/ORD/NRMRL/pubs/625r04108/625r04108.pdf
[5] FAO, Wastewater quality guidelines for agricultural use, 2016. http://www.fao.org/docrep/T0551E/t0551e04.htm. Accessed on: 3 Dec. 2016.
[6] WHO, A compendium of guidelines for wastewater reuse in the eastern Mediterranean region. Document WHO-EM/CEH/142/E, 2006. http://applications.emro.who.int/dsaf/dsa1184.pdf. Accessed on: 31 Dec. 2016.
[7] Omole, D.O., Ndambuki, J.M., Badejo, A.A., Oyewo, D.O. & Soyemi, T.O., Public feedback on state of domestic water supply in Lagos: Implications for public health. *Indian Journal of Traditional Knowledge*, **15**(2), pp. 245–253, 2016.
[8] Omole, D.O. & Ndambuki, J.M., Nigeria's legal instruments for land and water use: implications for national development. *In-Country Determinants and Implications of Foreign Land Acquisitions*, ed. E. Osabuohien, IGI GLOBAL: Hershey, PA, Business Science Reference, pp. 354–373, 2015. DOI: 10.4018/978-1-4666-7405-9.ch018.
[9] Isiorho, S.A., Omole, D.O., Ogbiye, A.S., Olukanni, D.O., Ede, A.N. & Akinwumi, I.I., Study of reed-bed of an urban wastewater in a Nigerian community. *Proceedings of IASTED's Environmental Management and Engineering* (EME 2014), **821**, pp. 143–147. Conference held in Banff, Canada from 16–18 July 2014.
[10] APHA, *Standard Methods for the Examination of Water and Waste Water*, 21st ed., American Public Health Association: Washington, DC, 2005.
[11] Ayers, R.S. & Westcot, D.W., *Water Quality for Agriculture; Food and Agriculture Organization of the United Nations*, Rome, Italy, 1985.
[12] Badejo, A.A., Omole, D.O., Ndambuki, J. & Kupolati, W., Municipal wastewater treatment using sequential activated sludge reactor and vegetated submerged bed

constructed wetland planted with *Vetiveria zizanioides*. *Ecological Engineering*, **99**, pp. 525–529, 2017.
[13] Omole, D.O., Sustainable groundwater exploitation in Nigeria. *Journal of Water Resources and Ocean Science*, **2**(2), pp. 9–14, 2013.
[14] Omole, D.O. & Ndambuki, J.M., Sustainable living in Africa: Case of water, sanitation, air pollution & energy. *Sustainability*, **6**(8): pp. 5187–5202, 2014.
[15] Omole, D.O. & Longe, E.O., Reaeration coefficient modeling: A case study of River Atuwara in Nigeria. *Research Journal of Applied Sciences Engineering and Technology*, **4**(10), pp. 1237–1243, 2012.