JGME Journal of Geography Meteorology and Environment
Vol. 5 No. 1 pp. 1-12, April, 2022. Available online at https://journals.unizik.edu.ng/index.php/jgme

ISSN 2449-2051
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Appraisal of Reticulation and Largescale Reuse of Treated Municipal Wastewater for Nonportable Purposes in FCT, Abuja Nigeria.

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Abstract
Municipal wastewater can be treated and reused for several purposes. This measure does not only reduce pollution, but relieves pressure on fresh waters. This study was carried out to determine treated municipal wastewater reuse schemes in the Federal Capital Territory, Abuja, Nigeria. The study involved interviews and questionnaire administration (30 and 492 respondents respectively). The results show that treated municipal wastewater is only used for generator cooling and watering of lawn within the wastewater treatment facility. Before the installation of water boreholes to supply drinking water for Jidu Village in 2010, the treated wastewater which is discharged into Wupa River was used for washing, bathing, swimming amongst other purposes by villagers who make use of the river where the wastewater is discharged into. The result has shown that no planned large-scale reuse arrangement of the treated wastewater exists in the study area. This can be attributed to lack of infrastructure and arrangement for industrial or agricultural reuse of the treated wastewater. In addition, the result also revealed that fear of billing for reuse and psychological reasons could hinder the use of treated wastewater. Following the schematic model as proposed, the study recommends that the treated wastewater should be reused for agricultural and industrial purposes after political, health/environment, social/economic, and technological considerations as outlined by the proposed schematic.

Keywords: Wastewater, Wastewater Reuse, Urban Water Cycle, Water Management, Abuja

Introduction

In developed countries, municipal wastewater disposal is well planned in a manner that enables the wastewater to be collected centrally either for the purpose of treatment and reuse, or for safe disposal. Municipal wastewater recycling is common in water scarce regions such as in Australia, Middle East, southwest USA, regions with severe restrictions on disposal of treated wastewater effluents, such as Florida with fragile karst systems, coastal or inland areas of France and Italy, and densely populated European countries such as England and Germany (Adewumi and Oguntuase, 2016; Ramos et al. 2019). Many cities in North America and Europe have sufficient supply of water, because of the advancement in technical water supply systems. Thus, it is possible to have fresh drinking water, and on the other hand, the transportation of treated municipal wastewater to urban fringes is also possible, where it is used for many purposes including agriculture (Pedrero, et al, 2010). However, Nigeria continues to have pollution issues stemming from untreated municipal wastewater discharge, and the issue of treatment and transportation of treated municipal wastewater for sustainable use, as can be witnessed in the Federal Capital Territory, Abuja.

The USEPA (2004) stated that the most common form of pollution control in the United States consists of a system of sewers and wastewater treatment plants. The sewers collect municipal wastewater from homes, businesses and industries, and deliver it to facilities for treatment before it is discharged to water bodies or land, or reused. This process of treatment prevents chemical and biological processes that deplete the oxygen content of water bodies. Instead of being a source of pollution, in water scare regions the sewerage system has been transformed to serve as supplements to fresh water sources. The reclaimed wastewater can be used for other purposes than drinking, such as; irrigation of public parks, athletic fields, recreation centres, school yards and playing fields, irrigation of landscaped area surrounding buildings, fire protection, as well as toilet flushing in public buildings (Hespanhol, 1992; Pei et al., 2015; Eldho, 2019).

Ibrahim et al (2014) reported that supply of potable water to Abuja had been a major challenge to the Federal Capital Territory Administration (FCTA) as a result of the overwhelming influx of people into the FCT, thus creating an upsurge in the population of the territory. This rapid population upsurge in the FCT has heightened the need for expansion of water supply structures. Quadri (2013) in an earlier report stated that in FCT, population surge, industrialization and rising standards of living, have put water demand on the rise; though without corresponding increase in the quantity of the resource. It is therefore evident that providing fresh potable water for domestic use will be a daunting task, let alone extending fresh water supply for agricultural purpose. Adequate treatment and reuse of municipal wastewater could facilitate holistic water management in the FCT and aid in protection, sustainable utilization and conservation of portable water. It is the aim of this study to examine the extent to which treated municipal wastewater is used in the FCT, especially as an argumentation strategy to fresh water sources which is falling short in meeting with the demand of the surging population in the FCT. Portable water supply in the FCT is a service rendered by FCT Water Board which serves only a fraction of the territory including industries. Residents and industries outside the city centre and outside the service of the Water Board have been left with the option of water wells, water boreholes and/or water vendors.

In seeking ameliorative measures to water stress issues, treated wastewater have been integrated into the urban fabric of water management in cities where such facilities are available, not just for pollution prevention but also for alleviating water stress issues. Then comes the question "What is the situation of wastewater reuse in the FCT, Abuja?". "In what areas have treated municipal wastewater been used to augment freshwater supply?".

Conceptual Framework

The Urban Water Cycle

The surface of our planet is covered by more than 70% of water. All living things, from the tiniest insect to the largest of mammals, depend on water for survival. Humans, too, are dependent on water for things like drinking, cooking, manufacturing our materials, growing our crops, energy production, recreation, transportation, etc. But the amount of water that is available on Earth is finite and is essentially the same water that has been here since the beginning of time. The water simply moves from one place and/or form to another through a process known as "the water cycle" (also known as "the natural water cycle" or "the hydrologic cycle"). This process has been in motion for billions of years, yet we recognize now that the process itself is changing due to the urbanization of human beings. Thus, a new cycle has been conceived as "The Urban Water Cycle".

According to Pena-Guzman et al. (2017), the urban water cycle is the spatio-temporal interaction between water and hydrological processes, as well as supply, treatment, distribution, consumption, collection, provision, and reuse carried out in urban or partially urban areas. The urban water cycle integrates all the aspects of the natural water cycle. Besides, it takes into account the fact that in urban areas, humans make man-made lakes (reservoirs) to trap water and then pipe the water from the reservoir to a water treatment plant for purification, and then it piped into storage towers so that purified water is continuously available for household uses. It also takes into account the fact that once the water is used within a home or business, that water must be discharged to a wastewater treatment plant, so that it can be cleaned before being released into creeks, streams and rivers, which eventually flow into the lakes and reservoirs. It is here that the process can begin again; going around and around in an urban water cycle (Figure 1).

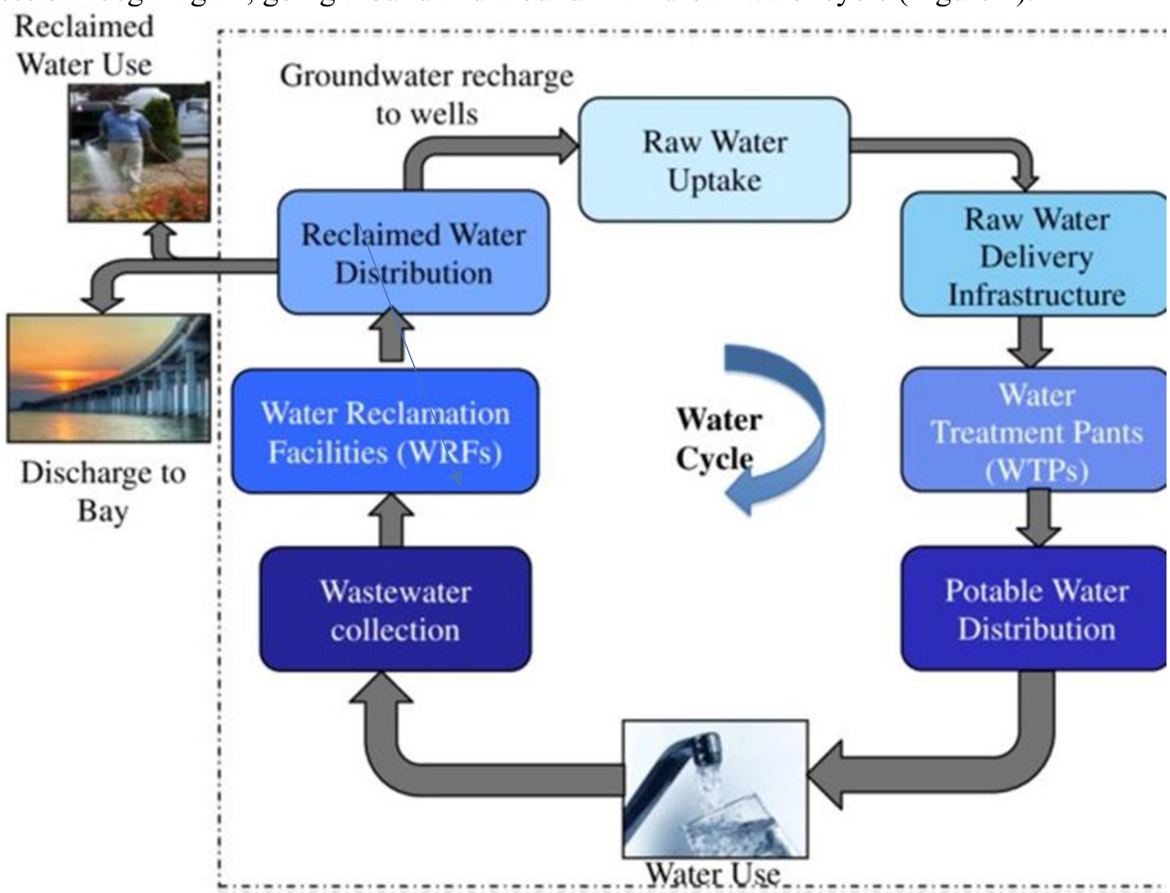

Figure 1: The Urban Water Cycle (source: Zaribaf, et al, 2013)

Methodology

Study Area

Abuja is located on latitudes 8°21′N to 9°18′N and longitudes 6°46′E to 7°37′E. Abuja was created as the new Federal Capital Territory of Nigeria in 1976 after a committee on the location of the Federal Capital of Nigeria carried out an extensive examination of the dual government role of Lagos, and evaluated its suitability as a National Capital, the possibility of an alternative new capital city elsewhere in the country, its accessibility to all and its spaciousness (Oluwadamisi, 2013). At inception Abuja was planned in phases in accordance with the regional master plan (Ejaro and Abubakar, 2013). Following the creation and ongoing construction phase of Abuja, Ibrahim Badamasi Babangida on December 12, 1991, officially declared Abuja as the new federal capital territory. Its territory is about 8000 km^2 (Figure 2). The city is divided into six area councils which are Abuja Municipal (AMAC), Gwagwalada, Kuje, Abaji, Kwali and Bwari Area Councils. Amoo et al. (2017) revealed that the Abuja Master Plan is projected to cater for 3.1 million people when fully developed. AMAC which stands for Abuja Municipal Area Council is the only area council with an existing and functional wastewater treatment plant.

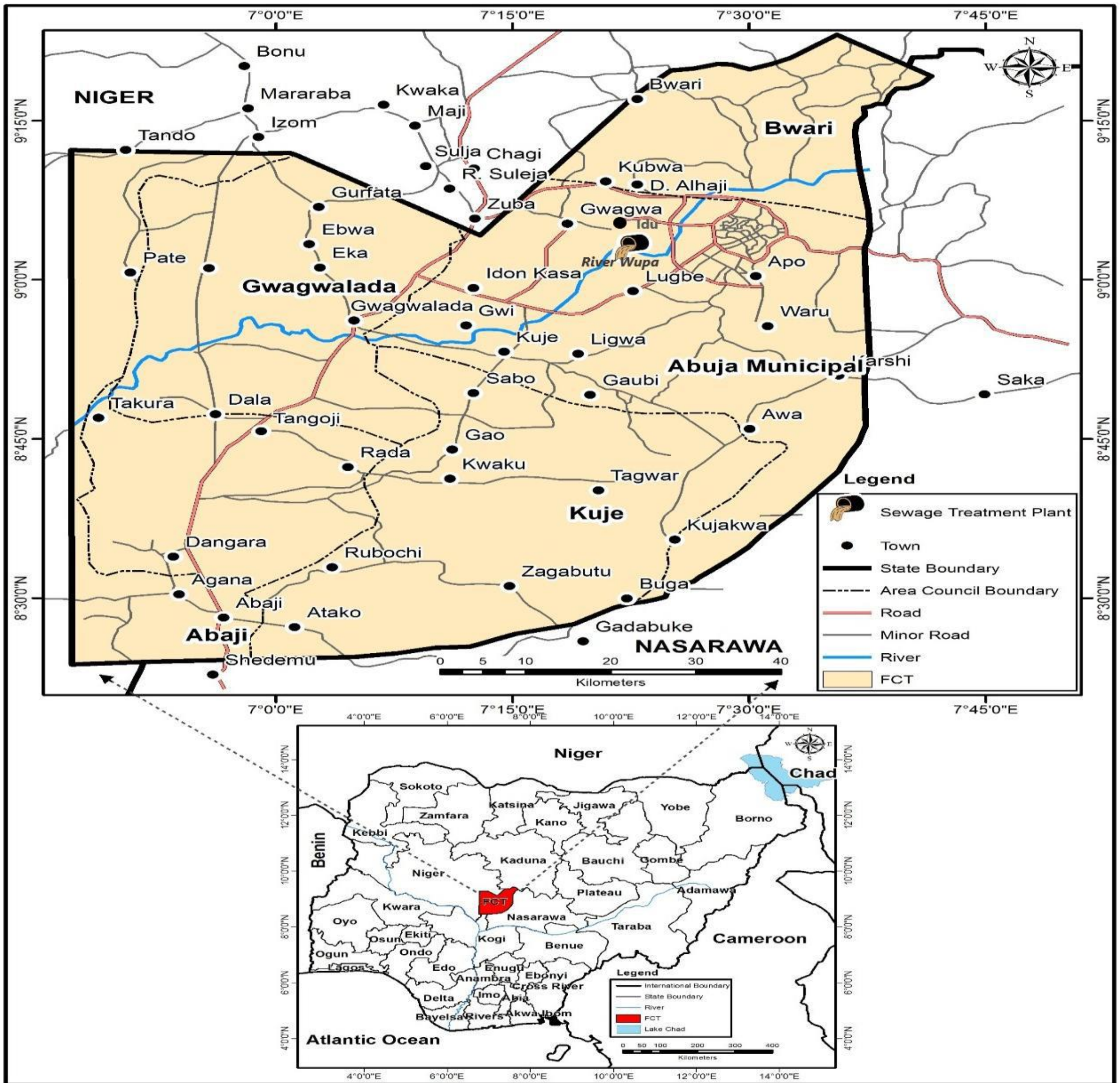

Figure 2: The Federal Capital, Abuja, is located in central Nigeria.
(Source: Adapted from Audu 2016)

The River Gurara and River Usman drain the area, which join to form a tributary of River Niger in the south. Smaller rivers are also located in the FCT (e.g., Rivers Gwagwa, Kubwa, Jabi and Wupa) which all drains into one of the two main rivers.

In the area of Abuja two seasons are characteristic: the rainy season begin in April and ends in October, whereas the dry season lasts from November to March. The highest daily temperature in the area was 34℃ during the dry season, but during the rainy season the maximum daily temperature drops to about 24℃ (Dan-Hassan, et al., 2012). The total annual rainfall varies between 1100 to 1600 mm (Dan-Hassan, et al., 2012).

FCT, Abuja lies within the Guinea Savanna vegetation belt. The soils of Abuja are basically alluvial and luvisols. Soils on the Gwagwa plain are however deep and clayey; thus, fertile and productive (https://www.nigeriaonline.com/abuja). The indigenous people of Abuja are originally known to be farmers and hunters. The fertile soils of the area support cultivation of crops such as yam, maize, millet, sorghum, plantain and banana. With adequate treatment of municipal wastewater and well-integrated system of Urban Water Cycle, treated effluent could be used amongst other things for agricultural irrigation. The result of this environmental management strategy will not only encourage sustainable development but also increase agricultural yield.

Methods

The research adopted survey method which involved a four-point likert scale questionnaire for perceived hindrances to wastewater reuse, while interview method was adopted for the uses of wastewater. Altogether 30 staff members of the wastewater treatment plant and residents of Jidu Village were interviewed, while the questionnaire had 492 respondents. Jidu village was chosen due to its proximity to the treatment plant, about 1km away from the plant. The questions were designed in a way that the respondents could opt for as many options that are suitable. Therefore, the analysis captured only the multiple responses rather than the respondents. Descriptive statistics was used to analyse the data generated.

Result and Discussion

Uses of Treated Municipal Wastewater in the FCT

Based on the open end interview carried out on respondents at the Treatment Plant and Jidu village, the various uses of the treated municipal wastewater from the treatment plant include: for watering lawn within the treatment plant facility (20.0%), for washing and cooling of power generating set for the treatment plant (26.7%), for washing clothes (through using discharged effluent into Wupa River) mostly during the dry season before the installation of borehole in 2010 in Jidu village (40.0%), for fishing/fish farming by residents (by using river Wupa) (46.7%), for bathing and swimming before borehole installation in 2010 (40.0%), for domestic purpose aside drinking (33.3%), for drinking before construction of boreholes in 2010 in Jidu village (53.3%). Meanwhile, 50.0% of the respondents stated that not much of the treated wastewater is used since there is plenty of fresh water in the FCT. 53.3% opined that dwellers rely on other sources, as such not everyone uses the river or water from the treatment plant (Figure 3).

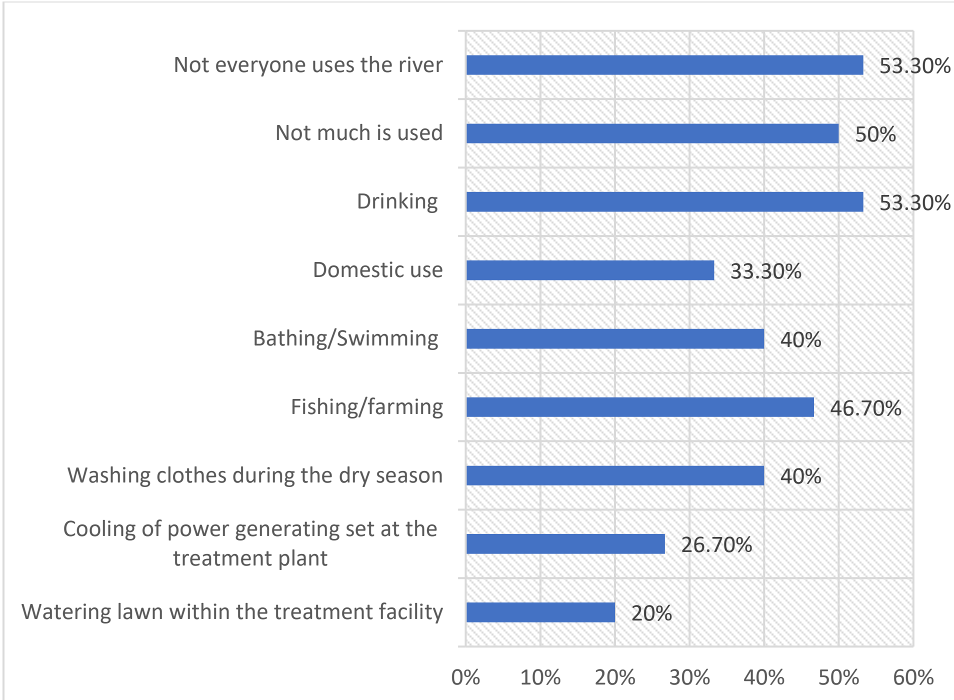

Figure 3: Uses of the treated wastewater according to the responses of the respondents.

The result shows no planned large-scale use of the treated wastewater beyond the vicinity of the treatment plant. This can be attributed to lack of infrastructure and arrangement for treated waste water reuse in industries or for agricultural purposes, as well as the perception of fresh water abundance in the FCT. The treated wastewater discharged into the Wupa River, was majorly used by residents of Jidu village before a water borehole was constructed in year 2010 to extract groundwater for domestic purposes. This finding negates the principles of water sensitive urban design and urban water cycle. It also deviates from the practices in other countries where wastewater has been successfully integrated into urban water management not just for pollution prevention but also to relieve water stress as reported, for example by Salama et al. (2014); Nelson (2017); Ramos et al. (2019).

Ramos et al. (2019) in analysing potential uses of treated municipal wastewater in Mexico highlighted the most favourable areas to include agriculture, industry, and watering urban green areas. According to Salama et al. (2014) the use of treated wastewater in Morocco affects the agricultural sector (covering an area of approximately 550 hectares and will reach 4,000 hectares in 2020), watering golf courses and green areas, groundwater recharge and recycling industry. Nelson (2017) revealed that following the surging population and the accruing water stress, wastewater is treated for potable use in Singapore. Nelson (2017) projected treated wastewater reuse to meet 55% of the water demand by 2060. When population strength creates fresh water stress, treated municipal wastewater should be considered as an alternative as seen in wastewater reuse programmes of developed countries. Abuja, as Nigeria's capital city is expected to participate in the global trend of sustainable environmental improvements in areas such as water supply augmentation, sanitation, and access to means of livelihood. As such the wastewater treatment facility can provide the fulcrum for the integration of treated wastewater into the urban water cycle of the FCT.

The treatment plant can accommodate an average dry weather inflow of 5,500 cubic meters per hour or 131, 250 cubic meters per day (with a wet weather peak inflow of 9,000 cubic meters). The treated municipal wastewater can be utilized in the FCT following a proposed scheme (Figure 4). This can be actualized using constructed canals or other forms of reticulation to sites of concern. The wastewater treatment plant is located few kilometres away from the Idu industrial Zone. The construction of this channel to the industrial zone will aid the transportation of the effluent to points of use. Kubwa axis with its concentration of construction companies could use the treated waste water for construction, block moulding and dust control.

The treated wastewater discharge can as well be put to agricultural use to ensure food production all year round instead of depending on rain feed agriculture. At a time when global warming and climate change is at the fore burner, urban foresting has been viewed as a path way to ameliorating the effects of global warming, as the treated wastewater could be instrumental towards sustaining urban forests. From the treatment plant's discharge point into upstream section of Wupa River, the water is collected from the downstream section of the river for use in irrigated plantations, construction sites (e.g., for block production, dust control, and other water requiring activity in construction), industrial usage including firefighting. The river could be maintained as means of conveyance or through reticulation such as pipes or constructed canal.

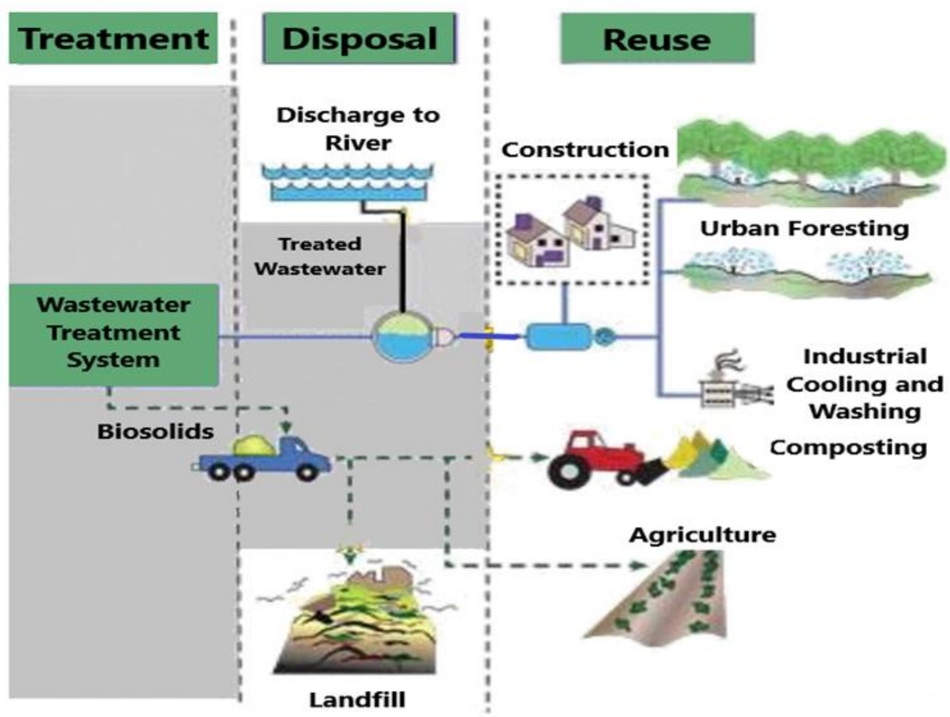

Fig. 4: Suggested reuse scheme of treated municipal wastewater in the Federal Capital Territory

The successful implementation of Figure 4 will depend on factors which needs to be considered (Figure 5).

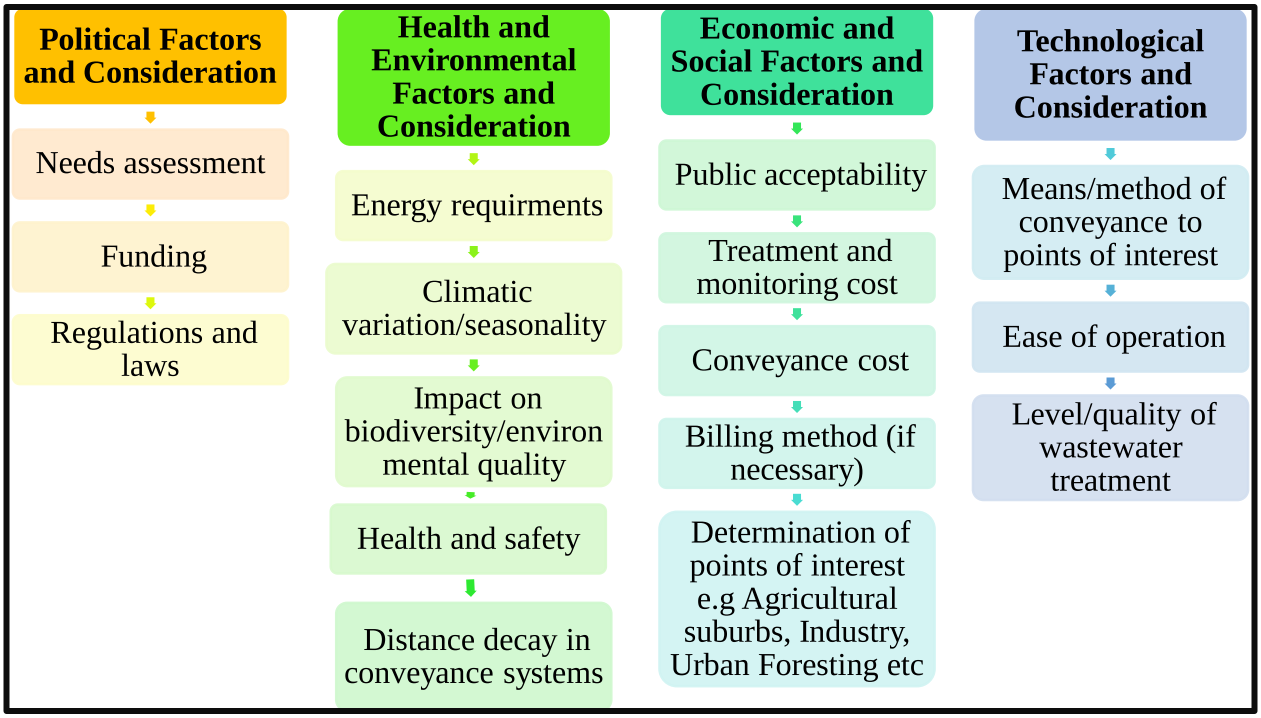

Figure 5: Municipal waste water reuse implementation plan

Wastewater reuse has been implemented in several countries including African countries like Morocco, Egypt, Tunisia, and Ghana (Adewumi, and Oguntuase, 2016; Amoah, et al, 2021). However, such implementation cannot be executed without adequate considerations to factors that could make or mar its implementation. Figure 5 highlights the factors proposed by us to be considered before and during the implementation of municipal wastewater reuse scheme in the FCT. These factors are political, environmental, economic/social, and technological factors.

- ❖ Political factors: Cover all aspects of governance in terms of approval, conducting the necessary assessment to determine areas of applicability, and importantly funding the project.
- ❖ Health and environmental factors: This cover measures related to mitigating and remediating impact to the environment and health.
- ❖ Economic/social factor: The seamless integration and acceptability of the project will to a large extent determine project success, as well as its cost implication.
- ❖ Technological factor: This covers means/technic and technical knowhow involved in the operation of the municipal wastewater reuse scheme for ease of operation

Perceived Impacts of Municipal Wastewater Reuse

This objective examined respondents' perceived impacts and hinderances to municipal wastewater treatment and reuse. Table 1 presents the results for perceived impacts/hinderances. Based on the weighting of the four-point likert scaled response, mean values below 2.5 are interpreted as negative while higher mean values are interpreted as positive.

Table 1: Perceived impacts/hinderance to municipal wastewater reuse

PERCEIVED EFFECTS	SA	A	D	SD	Mean	Inference
Reuse of municipal treated wastewater will save the environment from pollution	264	135	69	10	3.37	Positive
Using treated municipal wastewater can cause health issues/concerns	48	156	216	68	2.38	Negative
Treated municipal wastewater can pollute water sources	37	119	263	37	2.34	Negative
Using treated municipal wastewater for irrigation will result in contamination of groundwater	60	23	241	168	1.95	Negative
Using treated municipal wastewater for irrigation will result in production of contaminated crops	12	60	168	252	1.66	Negative
Treated municipal wastewater standard does not meet federal regulations for protection of public health	36	168	216	72	2.34	Negative
Standard of treatment could hinder reuse of treated municipal wastewater in the FCT	108	169	180	35	2.71	Positive
Psychological reasons could hinder reuse of treated municipal wastewater in the FCT	144	216	72	60	2.90	Positive
Religious beliefs could hinder reuse of treated municipal wastewater in the FCT	33	180	144	135	2.23	Negative
Economic reasons (fear of billing cost for treatment) could hinder reuse of treated municipal wastewater in the FCT	115	221	108	48	2.82	Positive
Using treated municipal wastewater will bridge water demand and supply gap in the FCT	215	121	108	48	3.02	Positive
Cultural belief/practices will hinder reuse of treated municipal wastewater in the FCT	25	215	156	96	2.34	Negative

SA= Strongly Agreed, A= Agreed, SD= Strongly Disagreed, D= Disagreed
Source: Field Survey

The survey results show that the respondents were of positive perception that: reuse of municipal treated wastewater will save the environment from pollution (mean = 3.37), standard of treatment could hinder reuse of treated municipal wastewater in the FCT (mean=2.71), psychological reasons could hinder reuse of treated municipal wastewater in the FCT (mean=2.90), economic reasons (fear of billing cost for treatment) could hinder reuse of treated municipal wastewater in the FCT (mean = 2.82), and that using treated municipal wastewater will bridge water demand and supply gap in the FCT (mean = 3.02>2.50). On the other hand, they were of negative perception for: using treated municipal wastewater can cause health issues/concerns (mean = 2.38), treated municipal wastewater can pollute water sources (mean = 2.34), using treated municipal wastewater for irrigation will result in contamination of groundwater (mean = 1.95), and that using treated municipal wastewater for irrigation will result in production of contaminated crops (mean=1.66). They also disagreed that treated municipal wastewater standard does not meet federal regulations for protection of public health (mean = 2.34), that religious beliefs could hinder reuse of treated municipal wastewater (mean = 2.23), and that cultural belief/practices will hinder reuse of treated municipal wastewater in the FCT (mean = 2.34).

Alhumoud and Madzikanda (2010) noted that two major reasons and objections to use treated wastewater included psychological and health reasons. The result in Table 1 shows that psychological reasons (with a high mean of 2.9) could hinder the successful implementation of municipal wastewater reuse scheme in FCT, Abuja. Adewumi and Oguntuase (2016) outlined several countries and cities with treated wastewater reuse programmes. However, Abuja, the federal capital city of Nigeria is not on the list. The findings of this study have elucidated the reason why Abuja is not on the list. The findings reveal that treated wastewater is not put to any large-scale reuse programme in the FCT. Standard of treatment could hinder the reuse of treated municipal wastewater, especially when it is grossly inefficiently treated. Psychological reasons could also hinder reuse of treated municipal wastewater in the FCT. Treated municipal wastewater will enhance agricultural output by ensuring all year-round production instead of solely depending on rain fed agriculture.

Conclusion

Advances in wastewater treatment has enabled treated wastewater to be integrated into the urban water cycle; thereby making wastewater a resource rather than a waste. Municipalities can amongst other applications use treated wastewater for firefighting, agriculture, and construction. This study discovered that the treated wastewater from the wastewater treatment plant in Abuja has no significant use to which it is put to. It is therefore recommended, that the treated wastewater be put to a beneficial use in agriculture, industry and construction works. However, there should be political, environmental/health, socio-economic, and technological considerations. These factors, when considered and managed properly will largely determine the success of the reuse programme to be implemented.

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