Domestic Wastewater Treatment and Reuse in Awka Urban, Anambra State, Nigeria

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Abstract

Domestic wastewater can be viewed as an important resource when properly managed; it requires adequate management practice aiming at efficient treatment and distribution for reuse. Treated domestic wastewater reuse with acceptable quality plays a crucial role as an additional water source considering groundwater protection and conservation. The main objective of this study was to investigate treatment and reuse of domestic wastewater, as well as the wiliness and awareness of the public on domestic wastewater treatment, personal reuse and for other purposes such as irrigation in Awka urban of Anambra State, Nigeria. Survey method of research was applied, while statistical analysis involved use of Percentage, Weighted mean, and Mann Whitney test. The researcher found that there is no form of domestic wastewater treatment and reuse in the study area. About 51.39% objected to treatment of domestic wastewater, while 53.40% and 56.68% will not want to use treated wastewater or patronise agricultural products irrigated with treated wastewater respectively. The research concludes that Wise investments in wastewater management will generate significant returns, as addressing wastewater is a key step in reducing poverty and sustaining ecosystem services. It is recommended that centralised wastewater treatment be initiated and public enlightenment on safety and use of properly treated domestic wastewater be organised.

1.0 Introduction

At a time when Sustainable Development Goals are a central issue, integrating effective, efficient and eco-friendly wastewater management practice into the life cycle and operation of the urban system would be a step towards achieving Sustainable Development Goal which will ensure a healthier environment for everyone. Food and water are vital and important for Nigeria and the world, not excluding disease prevention. Wastewater management can and have proven to be a reliable and a veritable tool for achieving sustainable development, by serving as a means of pollution prevention, source of alternative water for non-potable uses and disease prevention.

Jhansi and Mishra’s (2013) publication on wastewater treatment and reuse: sustainability option stated that one approach to sustainability is through decentralization of the wastewater management system. This system consists of several smaller units serving individual houses, clusters of houses, or small communities. Black and grey water can be treated or reused separately from the hygienically more dangerous excreta. Non-centralized systems are more flexible and can adapt easily to the local conditions of the urban area as well as grow with the community as its population increases. This approach leads to treatment and reuse of water, nutrients, and by-products of the technology (i.e. energy, sludge, and mineralized nutrients) in the direct location of the settlement.

Jhansi and Mishra (2013) also pointed out that in water scarce areas; treated effluent becomes a considerable resource for improved groundwater sources. The Gaza Coastal Aquifer Management Program includes treated effluents to strengthen the groundwater, in terms of both quantity and quality. With nitrogen reduction in the wastewater treatment plants, the recharged effluent has a potential to reduce the concentration of nitrates in the aquifer. In water scarce areas such as in the Middle East and parts of Southern Africa, wastewater has become a valuable resource that, after appropriate treatment, becomes a commercially realistic alternative for groundwater recharge, agriculture, and urban applications.
Framework for Efficient Wastewater Treatment and Recycling Systems, a publication by Mekala, Davidson, Samad, and Boland (2008) on wastewater treatment and recycling systems in developed and developing countries, used Melbourne in Australia and Hyderabad in India as case studies for developed and developing countries respectively after a review of the situations in Australia and India.

In developing countries, lack of sufficient funds, high treatment costs of the conventional treatment systems and rapid increases in wastewater volumes that exceed the current capacities of the treatment plants, results in a poor percentage of wastewater undergoing primary/secondary treatment. The farmers whose lands are along these water bodies often channel the partially treated or un-treated wastewater that is released into the rivers and lakes for irrigation. Though in the short run this water provides a reliable source of irrigation and income for these farmers, in the long run, it has adverse effects on the farmers' health, soil and also pollutes the groundwater thereby making the process unsustainable. Their research showed that in Hyderabad, India, less than 10% of wastewater is treated to secondary level due to high treatment costs and as a result pollutes the Musi River and creates environmental and health hazards for farmers who use this water in the downstream areas of the city. However, under a new project called "Save Musi Campaign" (SMC, 2005), four new treatment plants were to be set up and it is mandated that all the wastewater that enters the Musi River will be treated to secondary level.

In developed countries, wastewater recycling is common in Water scarce regions such as in Australia, Middle East and southwest of U.S., regions with severe restrictions on disposal of treated wastewater effluents, such as Florida, coastal or inland areas of France and Italy, and densely populated European countries such as England and Germany. Even in high rainfall countries like Japan whose mean annual precipitation is 1,714 mm, urban wastewater use is common due to high population density in some regions, which suffer from water shortages. Jhansi and Mishra (2013) stated that effective wastewater management is well established in developed countries. The developed countries have generated techniques and guidelines for the safe use of wastewater, which can be adopted by developing countries. This study attempts to examine and analyze the current status of treatment and reuse of domestic wastewater in Awka urban centre, Anambra state, Nigeria. This study will reveal the effectiveness of wastewater treatment and reuse in the study area and the perception of the residents to domestic wastewater treatment and use for irrigation and other purposes.

1.1 Wastewater Management System

Domestic wastewater management system is a wastewater system that processes wastewater from a home, or group of homes Elango (2000). Wastewater management is the collection, transport, processing, recycling or disposal of waste materials. Mekala, Davidson, Samad, and Boland (2008) described wastewater management system to include a network used to bring wastewater to treatment plant. The system also includes the source of wastewater in the home, technologies for treating the wastewater, and technologies and processes for returning the processed wastewater to the environment.

Domestic wastewater management involves the determination of domestic wastewater (source), its threat to the environment, collection systems, treatment and reuse. An improperly managed domestic wastewater has the potential to negatively impact on the natural environment, on human health as domestic wastewater contains disease producing microorganism and chemicals and on the economic environment.

1.2 Domestic Wastewater Treatment Methods

The aim of treatment is to reduce the level of pollutants in the wastewater before reuse or disposal into the environment (UN Water, 2014). The standard of treatment required for domestic wastewater is usually location and use-specific. There are different wastewater treatment methods available, these methods can be simply grouped as aerobic (biological), anaerobic (biological) and physico-chemical processes.

1.2.1 Aerobic Treatment of Wastewater

In aerobic wastewater treatment systems, aerobic organisms in the presence of oxygen convert organics in the wastewater into carbon dioxide and new biomass. Oklahoma Department of Environmental Quality in explaining aerobic treatment puts it as the use of air to treat wastewater. Treatment of the wastewater occurs in the aeration chamber. Air is bubbled through the wastewater allowing the natural bacteria to flourish. This bacteria feed on and breakdown the organic material found in the wastewater. The wastewater then flows to the clarifier where the solids are separated from the liquids. In a similar explanation, Gustafson, Anderson, and Christopherson (2001) said aerobic treatment pre-treats wastewater by adding air to break down organic matter, reduce pathogens, and transform nutrients. Compared to conventional septic tanks, aerobic treatment break down organic matter more efficiently, achieve quicker decomposition of organic solids, and reduce the concentration of pathogens in the wastewater.

1.2.2 Anaerobic Treatment of Wastewater

Wright (2008) and Jhansi and Mishra (2013) described anaerobic method of treatment as a process where anaerobic bacteria degrade organic materials in the absence of oxygen and produce methane and carbon dioxide. The produced methane can be reused as an alternative energy source (biogas). Anaerobic wastewater treatment differs from conventional aerobic treatment. The absence of oxygen leads to controlled conversion of complex organic pollutants, mainly to carbon dioxide and methane. Anaerobic treatment has favourable effects like removal of higher organic loading, low sludge production, high pathogen removal, biogas production and low energy consumption (Mrowiec and Suschka, 2009).

1.2.3 Physico-Chemical Treatment of Wastewater

Physicochemical wastewater treatment is a frequently used technique in the area of wastewater treatment. Physicochemical wastewater treatment techniques are applied for the removal of heavy metals, oils and greases, suspended matter and dissolved organic substances, organic and inorganic components, difficult to decompose, toxic pollutants or high salt concentrations, phosphorus and so on. The physicochemical wastewater treatment techniques are used as pre-treatment, final treatment as well as specific treatment for wastewater reuse as process water. Dhameja (2006) included dilution, sedimentation and filtration as being part of the physical processes. According to Cruden (2015) Physico-chemical treatment of wastewater focuses primarily on the separation of colloidal particles. This is achieved through the addition of chemicals (called coagulants and flocculants). This changes the physical state of the colloids allowing them to remain in an indefinitely stable form and therefore form into particles or flocs with settling properties. In addition to the processes stated by Dhameja (2006), Cruden (2015) further added coagulation (rapid mixing) and flocculation as physico-chemical process.

1.3 Domestic Wastewater Treatment Stages

The aim of domestic wastewater treatment is the removal of contaminants from the water which is either reused or discharged into the environment without fear of causing long or short term environmental degradation. The wastewater treatment process is carried out in three stages. Dhameja (2006), Sincero and Sincero (2008), and Evanylo (2009) put the three stages of domestic wastewater treatment as: Primary treatment, Secondary treatment and Tertiary treatment.

1.3.1 Primary Treatment of Domestic Wastewater

Primary treatment involves the removal of a portion of the suspended solids and organic matter from the wastewater. Wastewater contains a wide variety of solids of various shapes, sizes and densities (Dhameja, 2006). The purpose of primary treatment is the removal of the suspended solids, scum, grit, oil and grease, the removal is done by use of bar screens, skimming tanks, grit chamber, and floatation/sedimentation unit respectively. Sincero and Sincero (2008) noted that preliminary treatment also constitutes part of the primary treatment.

1.3.2 Secondary Treatment of Domestic Wastewater

According to Dhameja (2006), secondary treatment involves removing, stabilizing, and rendering harmless very fine suspended matter. Sincero and Sincero (2008) added that secondary treatment involves removing leftovers from the primary treatment. These leftovers are composed of colloidal and dissolved organic matters which cannot be removed in the primary treatment stage. Asano *et al.* (1985), Dhameja (2006), Sincero and Sincero (2008), and Jhansi & Mishra (2013) have all highlighted various methods for achieving secondary treatment to include:

- Constructed wetland
- Activated sludge system
- Aerobic granulation
- Aerated lagoon
- Rotating biological contactor
- Membrane bioreactor
- Sequencing batch reactor
- Trickling filter
- Bio-towers

1.3.3 Tertiary Treatment of Domestic Wastewater

Tertiary treatment which is also called advanced wastewater treatment is required when reclaimed water is to be put to direct use, (Dhameja, 2006). Tertiary treatment is initiated after secondary treatment for further purification and decontamination. The goal of tertiary treatment is to reduce unwanted elements such as Suspended Solids, Chemical Oxygen Demand (COD) (solid and colloidal), Biological Oxygen Demand (BOD), phosphorus and specific compounds (pesticides, metals, detergents, and so on), this is in accordance with Dhameja (2006). Kamyotra and Bhardwaj (2011) further explained that tertiary wastewater treatment is employed when specific wastewater constituents which cannot be removed by secondary treatment must be removed. The treatment processes are necessary to remove nitrogen, phosphorus, additional suspended solids, refractory organics, heavy metals, and dissolved solids. It is designed to improve the quality of purified water so that it can be discharged into the natural environment or re-used.

1.4 Uses of Treated Wastewater

Wastewater can be recycled/reused as a source of water for a multitude of water-demanding activities such as agriculture, aquifer recharge, aquaculture, firefighting, flushing of toilets, snow melting, industrial cooling, parks and golf course watering, formation of wetlands for wildlife habitats, recreational impoundments, and essentially for several other non-potable requirements.

1.5 Advantages of Wastewater Treatment and Reuse

According to Academic Research paper writing services (May 20, 2015.) Wastewater recycling can be categorized and viewed from three perspectives of: environmental benefits, social benefits and economic benefits.

Environmental Benefits: Reuse of wastewater can be a supplementary source to existing water sources, especially in arid/semi-arid climatic regions (Vigneswaran and Sundaravadivel, 2004). Through provision of extra water source, the practice of water recycling helps in discovering methods of reducing diversion of water from sensitive ecosystems. Fish, plant and wildlife what's more, depend on sufficient flow of water in their ecosystem to live and reproduce (Academic Research paper writing services, May 20, 2015). Therefore, recycling provides adequate supply of water to prevent water resource diversion for urban, industrial and agricultural use, which can easily deteriorate water quality and health of a given ecosystem. Jhansi and Mishra (2013) Benefits of safely recovering and reusing human wastes include the reduction in effluents to bodies of water and the opportunity to re-build soil with valuable organic matter. The recycling process also helps in eliminating discharge of waste water to the ecosystem while preventing pollution. The recycled wastewater can be used to enhance or create wetlands habitat and enhance breeding grounds of fisheries. Not forgetting its capacity to recharge ground water. Reuse of wastewater can be a supplementary source to existing water sources, especially in arid/semi-arid climatic regions.

Social Benefits: Reused water meets the needs of majority of human use as well as domestic applications (drinking water). The water must nevertheless be recycled properly to gain its benefit. The recycled water can be used to maintain public parks and gardens, golf courses and other recreational centres meant for social activities and gathering for fun seekers (Academic Research paper writing services, May 20, 2015)**.**

Economic Benefits: Since recycled water is often used for irrigation purposes, it benefits different economies because they use the water to enhance their agricultural sector through increased crop production in and out of wet season and in areas affected by water scarcity, additionally can serve for cooling purposes in industries, can also be used in paper mills, concrete block making industries and so on (Academic Research paper writing services, May 20, 2015, UN Water, 2014). Industries are very vital for economic growth of any country even as Nigeria is industrializing. UN Habitat (2010) expressed that smart and sustained investment in wastewater management will generate multiple dividends in society, the economy and the environment. It can involve private and public sectors, fulfilling public needs as well as social equity and enhance food security.

2.0 Materials and Method

Awka urban is located within the capital territory of Anambra State, Nigeria. Awka urban serves as the administrative hub and seat of power in Anambra state created in 1991. Awka urban is geographically located between latitudes 6°06` N and 6°15` N and longitudes 7°05'E and 7°15'E. Awka urban centre which is located in Awka South local government area is bounded by Awka North to the North, Njikoka to the West, Anaocha to the South and Oji River in Enugu State to the East. The population of Awka was stated as 189, 654 thousand (96, 902 males and 92, 752 females) in the National Population Census of 2006. The indigenous people of Awka urban are typically Igbo speaking people. However, immigration and civilization are two major reasons accounting for the inclusion of English language as a medium of communication. According to Ezenwaji, Enete, Okafor, and Awopeju (2015). Awka urban has both clustered and scattered settlement patterns.

This research work is delimited to ten selected locations in Awka urban centre, namely: Agulu-Awka, Amaku, Amenyi, Amikwo, Ezioka, Ifite, Nkwelle-Awka, Temp site, Umudioka, and Umuokpu. The content covered 400 questionnaire administration (with 397 retrieved) and interview on domestic wastewater treatment and reuse for residents. The data gathered from the survey research was subjected to statistical analysis using tools such as: Percentage, Weighted Mean, and Mann Whitney.

3.0 Results and Discussion

3.1 To identify the prevailing uses of domestic wastewater in Awka Urban.

The purpose of this objective was to examine and ascertain if there is any form of domestic wastewater treatment and/or reuse in Awka urban. The result of the finding is presented in tables 1 and 2.

Table 1: Response for untreated domestic wastewater reuse

S/N		Frequency	Percentage (%)	Remark
1	Gardening	20	4.524887	Low
2	Aquaculture	3	0.678733	Low
3	Not used	242	54.75113	Very High
4	Flushing of toilet	131	29.63801	High
5	Mopping of floor	29	6.561086	Low
6	Washing of toilet	13	2.941176	Low
7	Dust control	4	0.904977	Low
		442	100%	

Two hundred and forty two (242) respondents agreed that untreated wastewater is not used while significant number of one hundred and thirty one (131) respondents also agreed that they used domestic wastewater mostly from cloth washing for flushing of toilet.

Table 2: Response for treated domestic wastewater reuse

S/N		Frequency	Percentage (%)	Remark
1	Gardening	5	1.278772	Low
2	Aquaculture	2	0.511509	Low
3	Not used	384	98.20972	Very High
		391	100%	

The option with the highest percentage response is NOT USED which implies that most of the respondents do not use treated wastewater. To further identify why residents do not use both untreated and treated domestic wastewater, an inquiry into domestic wastewater treatment was carried out. The question was on the presence of a functional centralized treatment plant or privately owned treatment plant. The result is presented in Table 3.

Table 3: Weighted Mean of treatment of wastewater

S/N	Yes	No	Weighted Mean
1	0	384	1.0

The YES and NO response was coded 2 and 1 respectively. The mean result gave 1.5 as the decision rule. The result on table 3 implies that there is no treatment of domestic wastewater in the study area since the mean response is less than 1.5. This result is in contrast with the situation in many advanced cities of the world (as seen in Sweden, Australia, United States, Japan, and Britain) where domestic wastewater is usually treated and disposed or reused, as presented and supported by Vigneswaran and Sundaravadivel (2004); Wright (2008); Yang et al (2010); and Ebie (2013).

3.2 To ascertain the level of public awareness of domestic wastewater management in Awka urban.

Hypothesis

Null: The level of awareness of domestic wastewater management is not significantly high among the residents.

Table 4: Data for awareness on domestic wastewater management

Question Items (On Questionnaire)		**YES**	**NO**
1	Should domestic wastewater be treated?	173 (43.58%)	204 (51.39%)
2	Will you want to use treated domestic wastewater?	132 (33.25%)	212 (53.40%)
3	Will you knowingly buy food products from treated wastewater irrigated farms?	160 (40.30%)	225 (56.68%)

Result output for level of domestic wastewater management awareness.

Mann-Whitney Test and CI: Yes, No

	N	Median
Yes	3	160.00
No	3	212.00

Point estimate for ETA1-ETA2 is -52.00
91.9 Percent CI for ETA1-ETA2 is (-92.99,-30.99)
W = 6.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.0404

The output shows that the response "NO" is significantly higher than "YES". This implies that the level of awareness of wastewater treatment and reuse is significantly low among the respondents. Most respondents see no reason why domestic wastewater should be treated/reused rather than disposed. The usage of treated domestic wastewater was rejected by majority, and also rejected the conscious patronage of agricultural projects from treated domestic wastewater irrigated lands. The field observation also showed that residents are not concerned with domestic wastewater management so far as it does not interfere with their daily activities, as such they do not see domestic wastewater as a refine-able resource which can be used in the bid to achieve sustainable development.

Conclusion

It is therefore expedient that necessary steps be taken by developing countries like Nigeria by using the most appropriate technology for wastewater management. Considerations should be made to the Environmental, Social and Economic benefits of the technology and method to be used. There is no doubt that Nigeria has little or nothing to show in wastewater management and recycling. This has been proven by the investigation of Adesogan (2013) who made an inventory of domestic wastewater treatment plants across Nigeria.

Elika (2013) believes that Nigerian cities can achieve centralized wastewater management through proper Government policies, public-private sector partnership investment and could succeed in turning wastewater to potable water as many developed nations have done. This research therefore suggests that centralized treatment of domestic wastewater in Awka should be initiated in the light of sustainable development. This can be achieved by the government or through public private partnership. Wise investments in wastewater management will generate significant returns, as addressing wastewater is a key step in reducing poverty and sustaining ecosystem services. Instead of being a source of problem, well-managed wastewater will be a positive addition to the environment which in turn will lead to improved food security, health and functioning of the bio-system. The sludge from the treatment process can and should be utilized in improving agriculture in the state. The reclaimed/recycled water can also be used for irrigation purposes and other non-potable uses like firefighting, Park watering and so on. Public enlightenment can also be organized to educate on the safety and use of properly treated domestic wastewater.

References

Academic Research Paper Writing Services (2015). Domestic Wastewater Reuse and Recycle. Retrieved form: https://www.linkedin.com/pulse/domestic-wastewater-reuse-recycle-paper-writing-services.

Adesogan, S. (2013). Sewage technology in Nigeria: A pragmatic approach. *Science Journal of Environmental Engineering Research*. doi: 10.7237/sjeer/266. Retrieved from: http://www.sjpub.org/sjeer/sjeer-266.pdf.

Bhardwaj, R.M. and Kamyotra, J.S. (2011). *Municipal wastewater management in India*. Retrieved from: http://www.idfc.com/pdf/report/2011/Chp-20-Municipal-Wastewater-Management-In-India.pdf.

Cruden, A. (2015). Physico-chemical water treatment processes. Available at http://www.iwawaterwiki.org/xwiki/bin/export/Articles/Physico%2DchemicalWaterTre atmentProcesses?format=pdf&pdfcover=1&pdfcover=0&pdftoc=1&pdftoc=0&comments=1&comments=0&attachments=1&attachments=0.

Dhameja, S.K. (2006). Environmental studies (3rd Revised Edition). New Delhi, India: Katson Books.

Ebie, Y. (2013). Effective Japanese domestic wastewater treatment technology. National Institute for Environmental Studies, Japan. Available at http://news.ubmthailand.com/Newsletter/2013/TW/Files/SessionII/02-Presentation_Mr.%20Y.%20Ebie.pdf. Accessed 5th October, 2015.

Elango, S.S (2000). Urban Water Management (Final Thesis). Atlantic International University. Retrieved from: http://aiu.edu/publications/student/english/Urban%20Water%20Management.html.

Elika, M. (2013). Wastewater management possible in Nigeria. Retrieved from: http://maryelikafoundation.org.ng/waste-water-management-possible-in-nigeria/

Evanylo, G.K (2009). Agricultural land application of biosolids in Virginia: Production and characteristics of biosolids. Virginia State University. Available at: http://pubs.ext.vt.edu/452/452-301/452-301_pdf.pdf. Accessed 28th September, 2015

Ezenwaji, E.E., Enete, I.C., Okafor, C.V., and Awopeju, A.K. (2015). Household water demand and supply model for Awka South Local Government Area, Nigeria. *Journal of Geography, Meteorology and Environment.* Vol. 1. 49-61

Gustafson, D.M., Anderson, J.L. and Christopherson, S.H (2001). Aerobic treatment unit. University of Minnesota Extension. Available at http://www.extension.umn.edu/environment/housing-technology/moisture-management/aerobic-treatment-unit/.

Jhansi, S. C. and Mishra S.K (2013). Wastewater treatment and reuse: sustainability options. *Journal of Sustainability Development.* 10(1) pp1-15.

Mekala, G.D., Davidson, B., Samad M., and Boland, A.M. (2008). *A Framework for Efficient Wastewater Treatment and Recycling Systems*. Colombo, Sri Lanka: International Water Management Institute. (IWMI Working Paper 129).

Mrowiec, B., and Suschka, J. (2009). Anaerobic wastewater treatment process. Retrieved from: http://rymd.lwr.kth.se/forskningsprojekt/polishproject/rep16/mrowiecsuschka.pdf.

Refsgaard, K. (2001). Evaluation of sustainability in farm and wastewater systems – decision theoretical applications. Ås, Norway: Department of Economics and Social Science, Agricultural University of Norway.

Sincero, A.P. & Sincero, G.A. (2008). *Environmental Engineering*: A Design Approach. (Eastern Economy Edition). New Delhi, India: PHI learning private limited.

UN Habitat (2010). Sick Water. Retrieved from: www.unep.org/pdf/sickwater_screen.pdf.

UN Water (2014). Wastewater Management: A UN Water Analytical Brief. Retrieved from http://www.unwater.org/fileadmin/user_upload/unwater_new/docs/UN-Water_Analytical_Brief_Wastewater_Management.pdf.

Vigneswaran, S.,and Sundaravadivel, M. (2004), Recycle and reuse of domestic wastewater, in *Wastewater Recycle, Reuse, and Reclamation*, [Ed. Saravanamuthu (Vigi) Vigneswaran], in *Encyclopaedia of Life Support Systems (EOLSS)*, Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford ,UK, [http://www.eolss.net]

Wright, R.T. (2008). *Environmental Science: Towards a sustainable future* (10th edition). New Delhi: Prentice Hall Inc.

Yang, X.M., Morita, A., Nakano, I., Kushida, Y., and Ogawa, H. (2010). History and current situation of night soil treatment in Japan. *Water practice and technology*. 5(4) doi: 10.2166/WPT.2010.096