Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 5, Issue 03, March -2018

A SURVEY OF PERCEPTION OF WASTEWATER REUSE IN SOUTH-WESTERN NIGERIA: AFE BABALOLA UNIVERSITY AS A CASE STUDY

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Abstract - *Going by the long history of wastewater reuse in many parts of the world, there is a high level of skepticism associated with the safety wastewater reuse mainly because of the quality for intended and desired need of reclaimed wastewater uses. Undoubtedly, the reuse of treated wastewater is particularly attractive in arid climates including Africa which is been faced with demand growth as well as water stress conditions. Unfortunately, there is limited research on the use of reclaimed wastewater in Nigeria. This study aims to investigate the perception and acceptance towards reclaimed wastewater within Afe Babalola University Ado-Ekiti (ABUAD) community, Nigeria. A three-part questionnaire, designed to collect demographic data, awareness about treated wastewater quality (physical, chemical and biological), and information about the Community's willingness to reuse reclaimed wastewater, was distributed among 240 ABUAD residents out of which only 152 was completely filled and returned. The response rate is 63%. The specific needs and purposes of reclaimed wastewater uses identified in this study include artificial wetland creation; irrigate agricultural crops, swimming, bathing, cleaning and laundry, car wash, flush toilet, and landscape irrigation.The results of this study shows that most respondents had little knowledge about the chemical quality (7.9%), or microbial quality(11.3%) of the ABUAD wastewater treatment plant effluent. The maximum acceptance was related to flushing toilet (85.2%), as well as landscape irrigation (79.3%), respectively. The minimum acceptance was related to swimming (9%) and taking bath (11.4%).This study suggests that advertisements in the media, public workshops, and establishment of information campaigns should be embarked upon to increase public awareness. increase support and the likelihood of successful implementation of reclaimed wastewater reuse projects*

Key words:- *awareness, acceptance, reclaimed wastewater, ABUAD, wastewater reuse*

1.0 INTRODUCTION

Water is an odourlessand tasteless liquid, in its pure form. Water is also unique in terms of its physical properties which make it essential for the support of life on earth. In Olasumbo (2001), these properties include: wide range of temperature at which water remains liquid, relatively high boiling points and freezing points, attainment of maximum density at 4^0C, and a decrease of density as water cools between 4^0C and 0^0C, low viscosity that decreases with increasing pressure, an ability to hold a relatively constant temperature changes (i.e. its high specific heat). Other critical properties of water derive from its distinctive chemical structure and its unique high density. The hydrogen bonds themselves make water molecules “dipolar” (slightly positive at one end and slightly negative at the other), which enables water to dissolve more substances than any other liquid on earth. In light of the aforementioned,Olasumbo (2001)purportedthat these properties defines possible human use of water and explains why water can be found as a gas in the atmosphere, as a liquid both above and below ground, and as solid wherever the temperature falls below 0^0C.

In recent times, water scarcity has become an increasingly severe problem in many parts of the country. In future, the situation may become more austere. Figure 1.1 shows the availability of water measured in terms of 1000m^3 per capita/year.

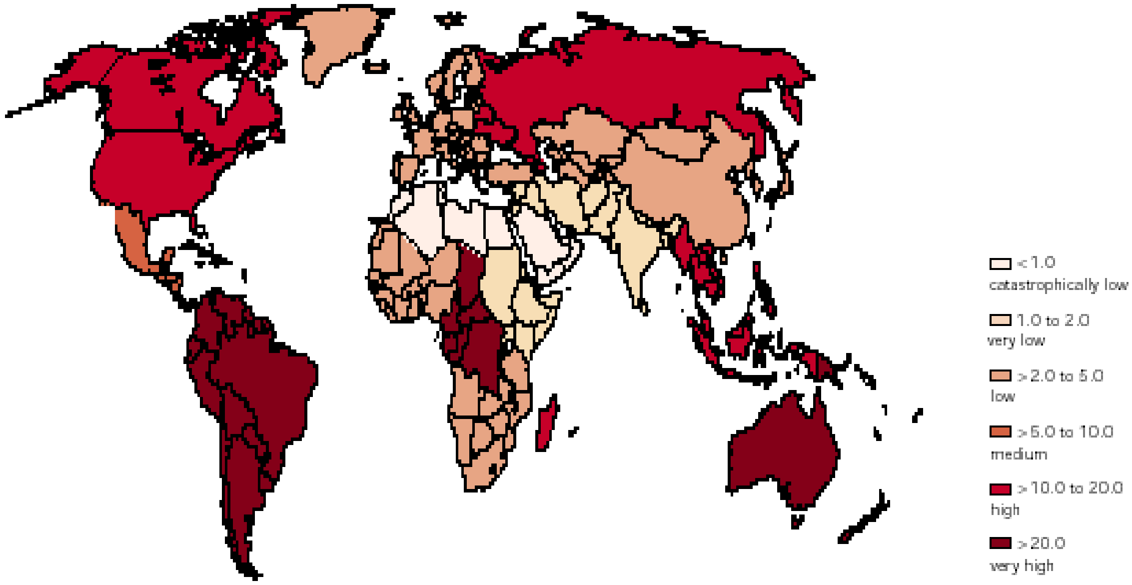

Figure 1.1: Availability of Water (Source: UNEP, 2002)

Figure 1.1 above, shows many countries in Africa and Asia have very low or catastrophically low water availability (UNEP, 2002). Suchscenarios may be accredited to several factors including inadequate water management, and inevitablyaccelerating the depletion of surface water and groundwater resources. Hitherto, water quality is been degraded by domestic and industrial pollution sources as well as non-point sources. In some parts of Nigeria fast growing cities, water is withdrawn from the water sources, which become polluted owing to a lack of sanitation infrastructure and services. Experiencedwater quality degradation caused by salts, pesticides, naturally occurring arsenic and other pollutants is further compounded by over-pumping of groundwater.

In Metcalf and Eddy (1991), the treatment or processing of wastewater to make it reusableis referred to as wastewater reclamation andthe use of treated wastewater for beneficial purposes such as agricultural irrigation, landscape irrigation, industrial cooling, and other applicationsis termed as water reuse.

In Nigeria, many areas with adequate water resources and a growing urban population have experienced increased water consumption, both on a per capita and total basisrequiring the additional development of large-scale water resources and associated infrastructure. At best,water reuse should be considered to meet some of the water demands and efficiency improvement.Similarly, by reusing treated wastewater for some desirable applications, more freshwater can be allocated for uses that require higher quality, such as for drinking and cooking, thereby contributing to more sustainable resource utilization.

2.0 LITERATURE

2.1 Uses of Water

Water is used in many ways for the benefit of mankind and its environment. According to Bolaji (2003), the main uses of water includes

I. Water supply for domestic, commercial, industrial and public purposes.
II. Hydropower for electricity generation.
III. Irrigation to supplement rain feed agriculture and enhance food production.
IV. Navigation for the transportation of goods and services on inland water ways.
V. Wildlife conservation for survival of wild animals in their natural habitat.
VI. Fishing in lakes, rivers and reservoirs which are breeding areas for fish farming.
VII. Pollution abatement and control to protect water sources and enhance good public health.

2.2 Water Sources

Remarkably, the available freshwater supplies are not evenly distributed in time and space. Freshwater sources fall into two basic categories: surface water and groundwater.

2.2.1 Surface water in Nigeria

Surface water occurs as runoff from rainfall and other forms of precipitation. Such runoff becomes water flowing in streams and rivers which eventually flow into seas and oceans. Nigeria is blessed with a number of rivers which are either seasonal or perennial. The major rivers include Niger, Benue, Gongola, Hadejia,Kaduna, Ogun, Osun, Imo, Sokoto, Yobe, among others. The waters of these rivers have been developed to provide water for different purposes such as irrigation, water supply, hydropower, fishing, recreation etc. If these rivers are to continue to serve the nation, they must be protected from activities that will render them unfit for use. Such activities include application of chemicals for food production, industrial waste discharge, domestic sewage and unsafe sanitary and refuse disposal practices.

2.2.2 Ground water in Nigeria

Beneath the surface of the earth is a huge reservoir of freshwater. Groundwater does not rest. It moves continuously, but at a very slow rate, from its point of entry to areas of natural discharge. Wells intercept some groundwater but for most part it continues until it reappears naturally in a spring or a seepage area and joins a water course. Ground water is a major source of water supply throughout Nigeria. Throughout Nigeria, individual, communities, local, state and federal authorities have been sinking wells and boreholes to tap the rich groundwater resources for drinking water supply and also for irrigation purposes.Idris-Nda*et.al.*(2013) recommended wastewater treatment and reuse as a complement for water use.Ngele*et.al.* (2014), revealed future changes in the quality of groundwater due to hydrological stress and contamination.

2.3 Water Crisis

Rapid economic growth and increasing urbanization will aggravate the uneven distribution of water resources between and within communities. Conversely, municipal and industrial water use tends to degrade water quality by introducing chemical or biological contaminants. With respect to these factors, water supplies and water pollution control are under unprecedented pressures. For instance, Longe and Ogundipe (2010) concluded that the Lagos lagoon is being polluted by effluents discharge from the University treatment plant thereby exposing the health of local residents who use it for recreation and for food production purposes.

Faced with these challenges, there is an urgent need to improve the efficiency of water consumption, and to augment the existing sources of water with more sustainable alternatives. Numerous approaches, modern and traditional, exist throughout the world for efficiency improvements and augmentation. Among such approaches, wastewater reuse has become increasingly important in water resource management for both environmental and economic reasons. Wastewater reuse has a long history of applications, primarily in agriculture, and additional areas of applications, including industrial, household, and urban, are becoming more prevalent. Of them all, wastewater reuse for agriculture still represents the large reuse volume, and this is expected to increase further, particularly in developing countries,UNEP (2002).

In cities and regions of developed countries, where wastewater collection and treatment have been the common practice, wastewater reuse is practiced with proper attention to sanitation, public health and environmental protection. The situation is different in many developing countries owing to the lack of appropriate capacity and resources to enforce strict wastewater treatment standards for its reuse.

Despite a long history of wastewater reuse in many parts of the world, the question of safety of wastewater reuse still remains an enigma mainly because of the quality of the reused water. Public health concern has been a major issue in any type of reuse of wastewater, whether for irrigation or non-irrigation purposes, as well as long-term environmental impact of reuse practices. Hence, appropriate treatment techniques with good margins of safety must be incorporated to eliminate, or at least minimize the potential risks or health hazards arising from wastewater reuse. However, economic considerations are also necessary because, when “first-hand” water is available at a cheaper price, it may not be worthwhile to reuse wastewater, unless there are special reasons. The due consideration of hydro-geologic conditions assists to compare the reuse water quality and the quality of alternative sources intended for the same kind of use.

2.4 Wastewater Reuse

Water from wastewater reuse has various benefits. First, recycled wastewater can serve as a more dependable water source, containing useful substances for some applications. For example, the quantity and quality of available wastewater may be more consistent compared to freshwater, as droughts and other climatic conditions tend to have a less pronounced effect on wastewater generation. With adequate treatment, wastewater can meet specific needs and purposes, such as toilet flushing, cooling water, and other applications. The reuse of treated wastewater is particularly attractive in arid climates, areas facing demand growth and those under water stress conditions. Some wastewater streams also contain useful materials, such as organic carbon and nutrients like nitrogen and phosphorous. The use of nutrient-rich water for agriculture and landscaping may lead to a reduction or elimination of fertilizer applications. The second benefit of wastewater reuse is that it leads to reduced water consumption and treatment needs, with associated cost savings. In many applications, reusing wastewater is less costly than using freshwater, with savings stemming from more efficient water consumption and a reduced volume of additional wastewater treatment, as well as associated compliance cost savings. The infrastructure requirements for advanced water and wastewater treatment may also be reduced. For instance, many areas with adequate water resources and a growing urban population have experienced increased water consumption, both on a per capita and total basis. Meeting such a growing demand often requires the additional development of large-scale water resources and associated infrastructure. Table 2.1 presents eight (8) categories of wastewater reuse. By meeting some of the water demand through wastewater reuse and efficiency improvement, additional infrastructure requirements and the resulting financial and environmental impacts can be reduced or, in some cases, eliminated altogether. Finally, by reusing treated wastewater for these applications, more freshwater can be allocated for uses that require higher quality, such as for drinking, thereby contributing to more sustainable resource utilization.

2.4.2 Agricultural applications of reclaimed water (Tunisia)

Tunisia is one of the very few countries that have elaborated and implemented a national policy for wastewater reuse. The first water reuse regulation was issued in 1989. The reclaimed water has been used mainly for irrigation because some underground water can no longer be used due to an overdraft and saline water intrusion, and wastewater use is now an integral part of the national water resources strategy. Treated water is used for the cultivation of citrus, olives, fodder and cotton as well as for golf courses and hotel gardens. In the wet season except agriculture period, groundwater recharge is carried out. Half of the population of Tunisia lives in the coastal area, and most sewage treatment facilities are located along the coastline to treat wastewater from domestic, tourism, and industrial sources.With regard to regional distribution, urban and peri-urban use of treated wastewater in the capital, Tunis, constituted about 32% of the total treated wastewater quantities used in the country in 2000,Bahri and Brissaud, (1996); Chenini*et al.*(2003).Wastewater reuse for agriculture needs to be planned with attention to target crops and existing water delivery methods. Nutrients in reclaimed water that are important to agriculture include nitrogen, potassium, zinc, boron and sulphur (Asano and Levine, 1998). However, excess nitrogen may cause overgrowth, delayed maturity, and poor quality of crops. While boron is an essential element for plant growth, excess boron becomes toxic FAO(1985).

Table 2.1: Categories of wastewater reuse

Category of reuse	Examples of applications
• Urban use	
Unrestricted	Landscape irrigation of parks, playgrounds, school yards, golf courses, cemeteries, residential, green belts, snow melting
Restricted	Irrigation of areas with infrequent and controlled access
Other	Fire protection, disaster preparedness, construction
• Agricultural	
Food crops	Irrigation for crops grown for human consumption
Non-food crops and crops consumed after processing	Irrigation for fodder, fibre, flowers, seed crops, pastures, commercial nurseries
• Recreational use	
Unrestricted	No limitation on body contact: lakes and ponds used for swimming, snowmaking
Restricted	Fishing, boating, and other non-contact recreational activities
• Environmental enhancement	Artificial wetlands creation, natural wetland enhancement, stream flow
• Groundwater recharge	Groundwater replenishment for potable water, salt water intrusion control, subsidence control
• Industrial reuse	Cooling system water, process water, boiler feed water, toilets, laundry, construction wash-down water, air conditioning
• Residential use	Cleaning, laundry, toilet, air conditioning
• Potable reuse	Blending with municipal water supply, pipe to pipe supply

(Asano and Levine, 1998)
Notably, practices of wastewater reuse is inconsistent among African countries, as target applications and technology options differ significantly depending on socio-economic circumstances, industrial structure, climate, culture, religious preference, as well as policy readiness.

2.4.1 Wastewater reuse/application (Namibia)

Namibia, located in south-western Africa, has been suffering from severe water scarcity due to a prolonged drought. In 1968, Namibia became the first country in the world that introduced reclaimed water to supplement the source of potable water. Despite problems of various concerns over health risk and public perception, this project was launched and ever since has produced water for urban residents. To ensure high quality of water, industrial wastewater was separated from domestic wastewater and facilities for reclamation have been developed and improved. All of the system was reviewed in 1995 to expand the capacity from the previous 4,800m^3/day to 21,000m^3/day, the maximum attainable. This system consists of treating sewage after a secondary biological treatment with various technologies such as coagulation and flocculation, dissolved air flotation clarifier, sand filtration, ozonation, activated carbon treatment and chlorine disinfection, which can provide multiple barriers against pathogens, Haarhoff*et al*. (1996).

2.4.3 Wastewater reuse for rice irrigation (Japan)

Experiments on wastewater reuse applications for rice cultivation were carried out in the City of Kumamoto, Japan. Importantly, organic carbon and nutrients like nitrogen and phosphorous are some of the useful materials contained in wastewater streams thereby providing nutrient-rich water for agriculture and landscaping which may in-turn lead to a reduction or elimination of fertilizer applications. The combined nitrogen content of wastewater and fertilizer is crucial for successful rice cultivation, as excessive fertilization is known to cause low pest resistance, ripening lesion, and lodging (i.e. falling down) of plants due to excessive growing, as well as poor crop quality.The effluent from a treatment plant was introduced to the rice field to cultivate rice under different conditions. The resulting rice crop was satisfactory when 50 to 70% less basal fertilizer was applied to the crop. The experiments demonstrated that successful rice cultivation could be achieved with treated wastewater applications, thereby reducing river water volume as well as fertilizer applications, Kumamoto Municipal Government, (1983).

2.4.4 Enquiry into wastewater management (Minna, Nigeria)

Idris-Nda (2013):Presently domestic wastewater management in the area consists of the use of septic tanks, unplanned and partially planned open drainage systems. While 35% of domestic wastewater generated goes into the septic tank, the remaining 65% flows freely and sometimes pond on the surface forming stagnant pools. The inhabitants in some areas resort to manually digging channels to convey wastewater away from residential areas. Both the unplanned and partially planned drainage system end up forming pools of water at the terminal end since there is no systems in place to collect the wastewater. Even though 37% of the respondents in the area seem to be concerned about how wastewater is being discharged in the area, majority (63%) of the respondents seem not to be concerned as long as the wastewater is conveyed away from their immediate residence. This implies that majority of the people are not aware of any consequences of wastewater as a threat to them and the environment and are not even sure if it could be put to any other purpose. Virtually all the residents say they are not aware of any government regulations on wastewater management. These by implication shows that government at all levels have not been doing much in terms of wastewater management. Also the health problems that have been identified include malaria, typhoid and diarrhea. These have been found to be directly or indirectly linked to wastewater. For example stagnant pools of wastewater form a good habitat for vector reproduction and growth. Wastewater in the area is also associated with odour which is what the inhabitants are more concerned about and aesthetically not a pleasing sight to behold. Wastewater infrastructure is generally poor and in some cases nonexistent. The large volume of wastewater generated in this area with proper infrastructure can be channeled and treated for reuse even though most of the inhabitants do not believe it can be reused for any other purpose.

3.0 METHODOLOGY

3.1 Characteristics of Location

Afe Babalola University Ado-Ekiti (ABUAD) is located in Ekiti State in South-Western part of Nigeria. The average annual precipitation in Ado-Ekiti is about 1330mm. ABUAD has been in existence for seven years and has a growing population of over 6000 people. Agriculture plays a major role in the city's economy.

3.2 Questionnaire and Sampling

To measure ABUAD community’s willingness to reuse reclaimed wastewater, a multiple choice questionnaire was prepared. The questionnaire had three main parts: the first one determined the respondents demographic data, including age and gender. The second part determines the level of respondents’ awareness about environmental issues including awareness about wastewater treatment purposes, treated wastewater quality (physical, chemical and biological) and shortage of water resources in halls of residence within the ABUAD community. The third part determined the community’s willingness to use reclaimed wastewater for 8 different purposes.

4.0 RESULT AND DISCUSSION

Out of 420 questionnaires circulated within the ABUAD community, a total of 152 questionnaires were successfully completed by respondents and analysed. The total response rate was 63%. Demographic data obtained from questionnaires are shown in Table 1. A slightly higher percentage of women than men participated. Figure 4.1a and Figure 4.1b, presents the spread of age and gender of survey/respondents.

Table 4.1: demographic information of respondents

	Frequency/survey	Percentage
Gender		
Male	67	44
Female	85	56
Age Group		
Under 20	15	9.9
20-24	32	21.0
25-29	28	18.4
30-34	24	15.8
35-39	14	9.2
40-44	19	12.5
45-49	13	8.6
50+	7	4.6

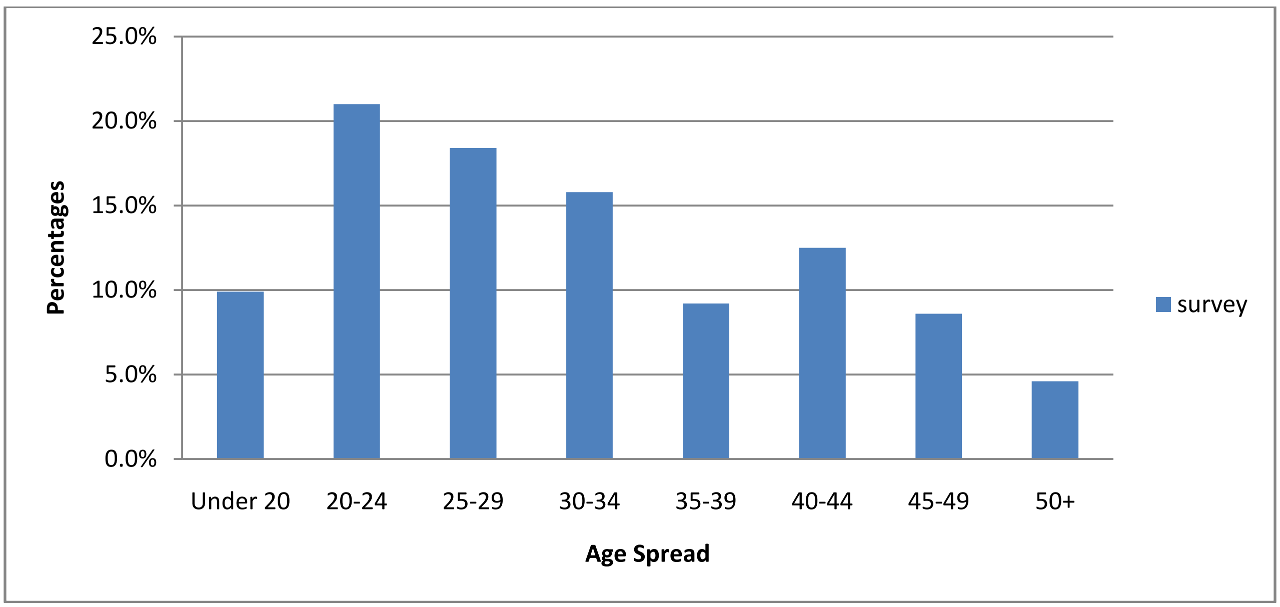

Figure 4.1a, Age Spread

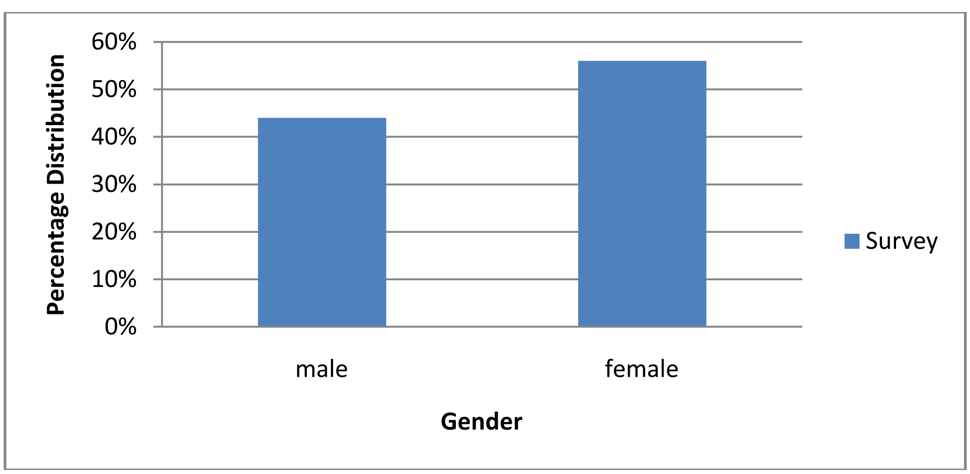

Figure 4.1b, Gender Distribution

The 20-24-year-old group with 32(21%) respondents had the maximum percentage of respondents; the 45-49 and older than 50-year-oldgroups with 13(8.6) and 7(4.6) respondents, respectively, had the minimum percentages of respondents.
Also, the results showed that respondent's awareness about physical, chemical and biological quality of wastewater treatment plant effluent was 42%, 7.9% and 11.3%, respectively. Figure 4.2 presents information about respondents over the awareness of wastewater reuse. Figure 4.3 shows the willingness of the community respondents to use reclaimed wastewater for different purposes when asked which use they would support if a decision is made to recycle ABUAD wastewater.

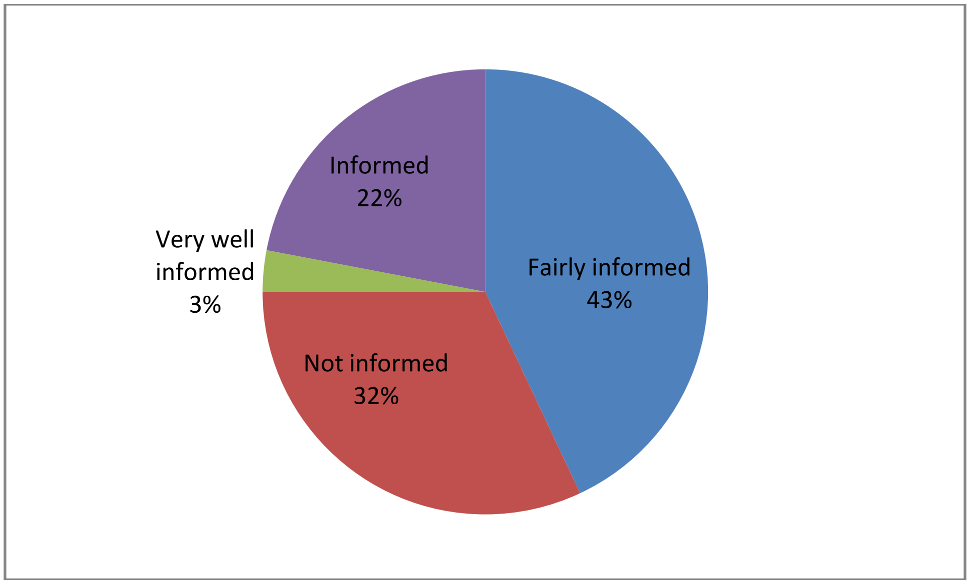

Figure 4.2, Awareness of Wastewater Reuse

Based on the issue of awareness32%, 41%, 19%, and 8% of the respondents were not informed, fairly informed, informed and very well informed respectively.

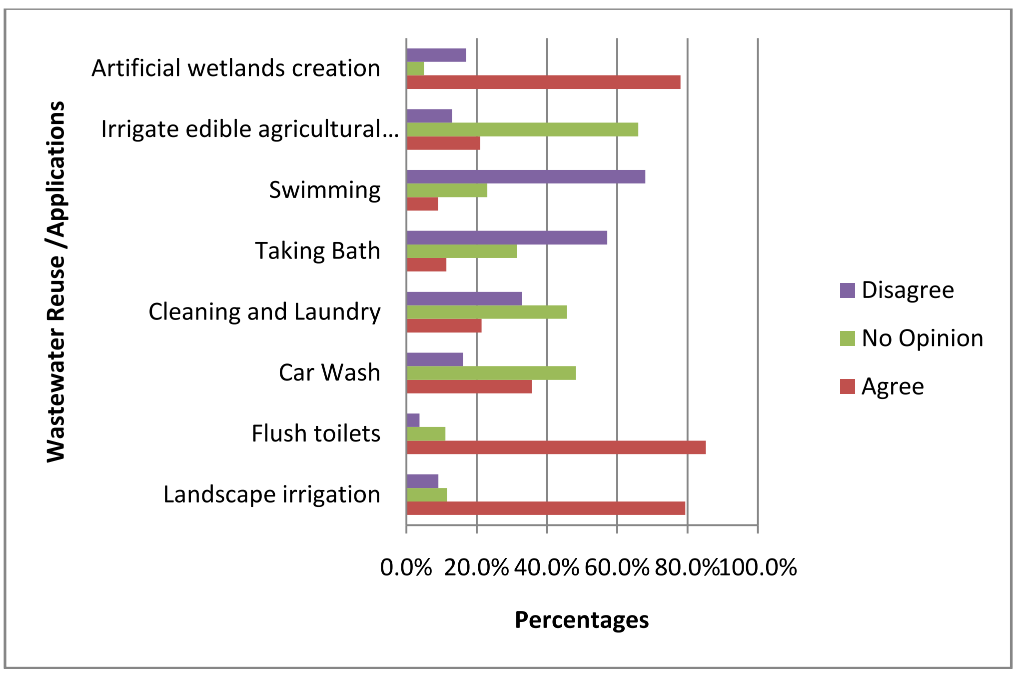

Figure 4.3, Response on Various Applications of Wastewater Reuse

On the average, 42.63% of respondents agreed with reclaimed wastewater reuse in various applications, only 27.1% of the respondents disagreed and 30.3% had no opinion. Remarkably, 85.2%, 79.3% and 78.0% were the maximum willingness of respondents whom agreed to using reclaimed wastewater for flushing toilet, landscape and irrigation, and artificial wetlands respectively.

CONCLUSION AND RECOMMENDATION

Public support is one of the major prerequisite in addition to economic and technological aspects for successful implementation ofany project including wastewater reuse projects. Thus, engaging with proposed community and determining their interest for such projects before implementation is very crucial. Undoubtedly, the reuse of treated wastewater is particularly attractive in arid climates including Africa which is been faced with demand growth as well as water stress conditions. Unfortunately, there is no study on the acceptability of reclaimed wastewater uses among Nigerian citizens. The present study selected Afe Babalola University Ado-Ekiti, Located in the South-western part of Nigeria as a case study and investigated community's acceptance of reclaimed wastewater reuse for a variety of applications. The result shows that on the average, 42.63% of respondents supported the use of reclaimed wastewater for various applications, 30.3% were undecided, and a relatively small number (27.1%) opposed such projects. Based on this study it can be deduced that ABUAD as a community supports reclaimed wastewater use well for flushing toilet, and landscape irrigation. This study therefore recommends that awareness, advertisement and enlightenment campaigns should be embarked upon to increase support and the likelihood of successful implementation of reclaimed wastewater reuse projects.

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