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Household preference for wastewater reuse/recycling practice determinants in a growing community in Nigeria

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Wastewater recycling has been considered one way of ensuring sustainable water accessibility for domestic purposes through the UN's Sustainable Development Goals (SDGs). This work investigated the factors that guide the preference for water recycling in Iwo, Osun State, Nigeria, to encourage its practice in homes. A survey was conducted among 205 randomly selected respondents in the study area to generate the data required to achieve the objectives of the study. Both descriptive and inferential statistical analyses were used using SPSS version 16.0. The study revealed that 79.3% of the respondents, mostly women, responded "nay" to wastewater reuse, attributing this to good access to fresh water, among other reasons. The factor analysis (FA) of the 13 variables obtained from the field extracted six variables that gave 76.542% of the variance about the respondents' preference for wastewater recycling, namely: 1) method of producing wastewater; 2) proportion of the wastewater available for use; 3) volume of wastewater generated; 4) level of support for the practice of wastewater recycling; 5) perception about wastewater; and 6) reasons for wastewater recycling. Further analysis revealed that the six variables could be summarized into two, with the first three factors forming the first and the last three variables forming the second group: issues related to wastewater production and human attitude-related factors. Therefore, we reject the alternative hypothesis (H_1) and accept the null hypothesis (H_0) that the availability of wastewater does not hinder households' preference for its use. The work concluded that the preferences for wastewater recycling are associated with issues about its production and human attitude/perceptions about wastewater. Public enlightenment and wastewater treatment technology in the study area and similar communities could probably enhance the preference for wastewater recycling.

KEYWORDS

wastewater, water accessibility, household preference, sustainable development goals, water use determinants

Introduction

Water resources are finite in nature and should be used with great caution to meet the demand in space and time (Vickers, 2002; Muta'aHellandendu, 2012; WWAP, 2015). Often, the decision of whether to ration or reuse water in homes arises at a point when fresh water is envisaged to be inadequate in supply with no immediate alternative (Taher et al., 2019). The practice of various water management procedures becomes significantly desirable if the availability of water needed to serve the purposes it is meant to serve in homes becomes limited (Tortajada, 2020). Apart from this, the pressure on the available water resources occasioned by the unabated and incessant rise in the population has also necessitated the practice of different water management practices like water reuse and recycling (Ogunbode and Ifabiyi, 2014; Kimengsi and Amawa, 2015; Ogunbode and Ifabiyi, 2017; Maquet, 2020). Iheukwumere et al. (2018), Olowookere *et al.*(2018), and (Shekhawat et al., 2020) observed that humid tropical regions could be deficient in recycling/reusing wastewater as a result of the humid climate with abundant rainfall (over most months of the year in some places) and abundant surface and subsurface water resources (Ogunbode and Ifabiyi, 2019a; Ogunbode and Ifabiyi, 2019b). Wastewater has been viewed as another way of augmenting water demand for various purposes, such as farm irrigation and domestic use (Jhansi and Mishra, 2013; Kesari et al., 2021). Thus, its use in a given environment is subject to the prevailing conditions, especially the water availability status in the region. Regions of perennial water scarcity have a greater tendency to implement water recycling than areas with abundant fresh water (Jiménez, 2006; Kesari et al., 2021). Thus, the preference for the use of this water management method is dependent on certain variables, of which freshwater availability/accessibility is one. In addition, Taher et al. (2019) and Maquet (2020) revealed that the acceptability of wastewater for use in homes could probably be achieved through proper education and enlightenment. The duo based their observations on people's perception of the unfitness and unsanitary condition of wastewater generated in homes. However, water recycling becomes inevitable when the supply of water is either time-bound, season-dependent or environment-associated, as happens in the arid and semi-arid regions of the world (Ogunbode et al., 2022a; Ogunbode et al., 2022b; Tortajada, 2020). Water reuse or recycling, if properly harnessed in homes, could afford the "use-it-again-the-already-used-water" effort that could minimize pollution in the human environment (Abdul-azeez et al., 2020; Akpan et al., 2020). It is expected that through this effort, fresh water would be conserved and also made available for use in an efficient manner (Ogunbode et al., 2022a).

With all these, it is important that if the global target of sustainable household water accessibility by 2030 will be actualized, then water reuse/recycling needs to be incorporated, especially for areas that are water-stressed. Unfortunately, the water supply has been described as determinate globally (Muta'aHellandendu, 2012; WWAP, 2015; Loucks and van Beek, 2017; Ngene et al., 2021). The situation could be detrimental to human survival, especially in areas and regions that are grossly deficient in water resources or where the culture of efficient use of the resource is not implemented. Because an occasional break in the flow of water supply could be a way of achieving efficient use of water resources, as noted by Hutton (2013) and Golin *et al.* (2015), the adoption of wastewater reuse in homes could be beneficial because the practice could be accommodated to fill the gap of freshwater shortage caused by a break. The preference for this technology in water management could further be embraced when there is provision for its after-use treatment (Jhansi and Mishra, 2013; Galkina and Vasyutina, 2018; Iheukwumere et al., 2018).

The common recycling method in Nigeria, in the observations of Idris-Nda *et al.* (2013), Akpan *et al.* (2020), and Abubakar and Mu'azu (2022), is gathering trapped water from baths, laundry, and dishwashing for use in toilet flushing, cleaning of drainages, initial scrubbing of floor and lawn watering, among others. The use of wastewater for other uses in homes (Jhansi and Mishra, 2013; Adewumi and Oguntuase, 2016), especially cooking, is grossly limited in view of people's perception of its unhygienic status. Such used water is not fit for other home uses, such as drinking, cooking, and bathing, without being taken through thorough treatment, the technology for which is lacking (Idris-Nda et al., 2013; Taher et al., 2019).

The techniques of wastewater management for sustainable use of water for domestic purposes remain desirable in view of the seasonality of rainfall and the increasing pressure on the available fresh water occasioned by an increasing rise in population and urban expansion, among other challenges. Many rivers and streams become truncated or braided during the dry season and may not be fit for home consumption; groundwater outlets have a lower yield, and some may even dry out totally and only be replenished during the following rainy season (Woldeab et al., 2018; Ogunbode and Ifabiyi, 2019a; Ogunbode and Ifabiyi, 2019b; Eneogwe et al., 2022). The atmosphere equally becomes dry and dusty as a result of the prevalence of trade winds that lead to dehydration. Some places in the region are grossly water-stressed; hence, the desirability of the culture of wastewater reuse needs to be encouraged. It was on this premise that this work examined those factors that impede water recycling practice: Is it that wastewater is not sufficiently generated in the tropical environment for the consideration for its reusability? Or is it that fresh water is sufficiently available for every home use? Or do factors not yet determined exert influence on people's decision to practice water recycling?

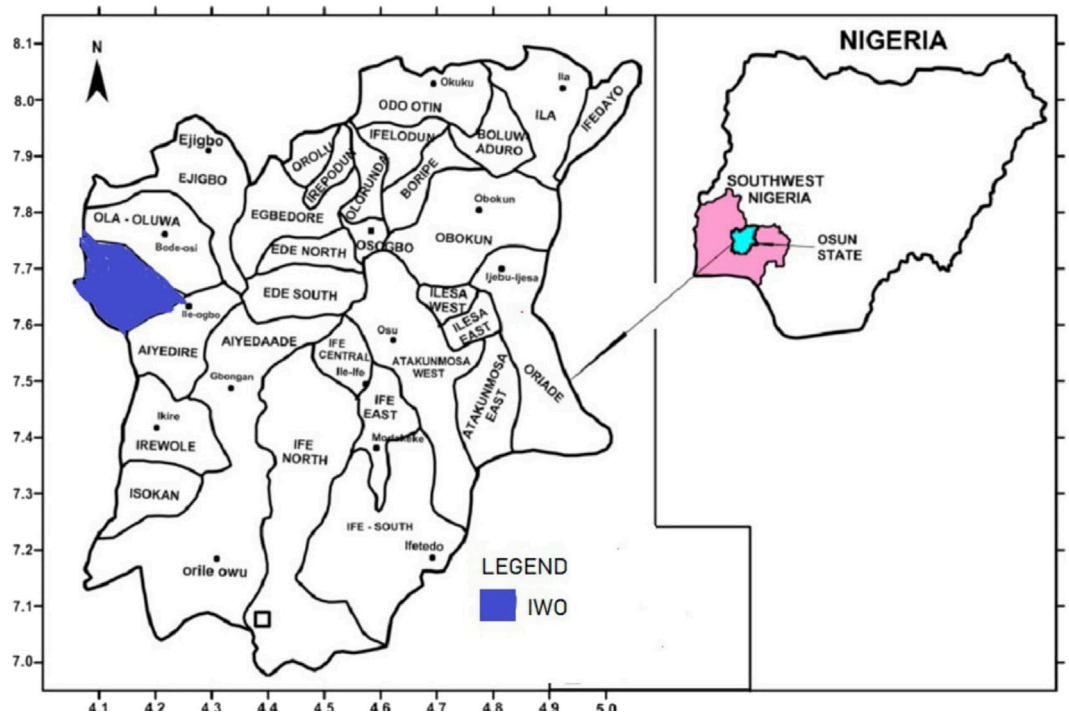

FIGURE 1
Map of Osun State showing the location of Iwo. (Inset: Map of Nigeria showing the location of Osun State).

These and many other questions were posed to examine the factors that will encourage the people's preference for water recycling or otherwise in the study area.

The specific objectives are to 1) identify the variables that dictate home preferences for water recycling, 2) quantify and rank the variables that influence households' preference for wastewater recycling, and 3) state the implications of the objectives for water resource management in the study area. These objectives are geared towards identifying factors that could guide water reuse for effective related policy formulation for sustainable, efficient use of water in homes.

Method of study

Study area

This research was carried out in Iwo, the administrative center of Iwo Local Government Area of Osun State, Nigeria (Figure 1). It has an area of 245 km^2 with a population of 191,348 according to the 2006 population census and is located at 7°38′N and 4°11′E. Like other locations in the zone, Iwo is in a tropical environment with two distinct seasons in the year. These are the dry period (November to February) and the rainy period (March to October). Iwo enjoys double maxima of rainfall spanning through eight months, with annual total rainfall as high as 2000 mm Ogunbode (2015). The people living in Iwo are mostly farmers with high dependence on rainfall for agricultural practices. The characteristic hardwood forest is found in Iwo, some of which has been reduced to secondary type in view of intensive agriculture, urbanization, and poor management of the forest resources. The Aiba Water Reservoir (AWR), constructed and commissioned in 1955, was meant to provide potable water for the Iwo community and the surrounding communities (Ogunbode and Ifabiyi, 2019c). The AWR has become grossly unsatisfactory as it failed to supply water to the Iwo community as a result of poor management and apparent abandonment by successive governments (Ogunbode and Ifabiyi, 2019c). With the town's population growth and the accompanied expansion, the waterworks may need to be overhauled completely to support the teeming population. To ensure water supply for home use, most homes have resorted to hand-dug wells and deep boreholes. Corporate organizations, including religious bodies, politicians, government agencies, non-governmental organizations (NGOs), and philanthropists, have not neglected water provision in the town. Despite all these efforts, there is still evidence of water scarcity for home use, especially in the dry season. These include long queues

TABLE 1 Demographic attributes of the respondents.

Categorization		Distribution	
		Sample size	% of total in the category
I	**Occupation**		
	Trading	67	32.7
	Civil servants	102	49.8
	Farming	26	12.7
	Others	10	4.9
II	**Level of education**		
	No formal education	32	15.6
	Primary	41	20.0
	Post-primary	90	43.9
	Post-secondary	42	20.5
III	**Age range**		
	18 to 30	114	55.6
	31 to 45	76	37.1
	46 to 65	15	7.3
IV	**Preference for wastewater recycle**		
	Yes	43	21.0
	No	162	79.0
	Indifference	0	0
V	**Reasons for the preference**		
	Inadequate water	65	31.7
	Available channel for reuse	140	68.3
VI	**Reason for declining reuse**		
	Availability of fresh water	116	56.6
	It is not hygienic	32	15.6
	Wastewater adds dirt	21	10.2
	No treatment facilities	36	17.6

Source: Field survey, 2022.

at water points, early morning search for water, fighting at water points, and so on.

Method of data collection

A structured questionnaire was designed to generate data for the purpose of this study. In total, 205 copies of the questionnaire were retrieved from the survey, which cut across the 10 wards at an average of 40 responses per ward. The first part of the questionnaire was about personal details of the respondents, such as name, household size, educational status, religion, and occupation. The second part was mainly questions bordering on issues that are related to wastewater recycling and reuse at the household level, such as conditionality for their respective preferences for wastewater reuse, sources of wastewater, volume produced and the method of collection and storage, treatment method, and beliefs about wastewater. The survey only involved female heads of randomly selected households in Iwo, Osun State, Nigeria. The reason for this is that women are

traditionally believed to be in charge of issues about water in the house and are passionately observing this (Ogunbode et al., 2022a). However, where the female head was not available, any other adult woman or man was made use of in the survey.

Method of analysis

Both descriptive and inferential statistical analyses of the data were carried out. The descriptive analysis includes tabulation, mean and percentages, while the inferential statistical analysis used the Special Package for Social Sciences (SPSS version 16.0) to carry out multivariate analysis using factor analysis (FA). It should be noted that the variables associated with wastewater alone were used to determine the predictive factors for household preferences for the reuse of wastewater. This work was based on two hypotheses. The null hypothesis (H_0): wastewater availability was not a hindering factor in the household decision on wastewater reuse. The alternative hypothesis (H_1): wastewater availability hinders household decisions on its reuse. The effectiveness of FA in data reduction and ranking of the extracted factors cannot be disregarded. FA has been widely used by many researchers to identify variables that should be considered in explaining a situation or event under discussion. Examples of scholars using FA include Ogunbode and Ifabiyi (2014), Ogunbode and Ifabiyi (2017), and Chfadi *et al.* (2021), and Ogunbode *et al.* (2021) used the statistic and found it effective.

Results and discussion

Respondents' characteristics

Table 1 shows some demographic attributes of the respondents involved in the investigation. Each category has a sample size of 205 and a total percentage of 100%. Details of each category are presented below:

Occupational distribution

Table 1 shows that nearly half of the respondents are civil servants, with a total of 102, which is 49.8% of the respondents surveyed. This was deliberately done to select people who could read, interpret, and write to minimize the need for field assistants to complete the questionnaire for respondents. Other employment categories are traders (67; 32.7%), most of whom could complete the questionnaire by themselves, and farmers (26; 12.7%), most of whom were assisted in the completion of the questionnaire. The "Others" in the occupational distribution indicates those who did not select any option in the question. Occupational distribution has been found to exert an influence on the pattern of water use in homes, as observed by Blakeney and Marshall (2009), and this could also induce the quantity of water being used for different domestic purposes. Buttressing this assertation, Istifanus *et al.* (2019) discovered a positive relationship between the quantity of water use in homes and occupation, amongst other variables.

Level of education

Table 1 shows that 32 (15.6%) respondents had no formal education, 41 (20.0%) had primary level, 90 (43.9%) had post-primary education, and 42 (20.7%) had post-secondary education. The total number of respondents who could complete the questionnaire with little or no aid included respondents with post-primary and post-secondary education, or 132 (64.6%) of the total surveyed. However, some of those in the primary education category also could complete their questionnaire on their own, while some in the category of "no formal education" received assistance. Level of education has been noted as one of the household characteristics that explain domestic water use quantity and access affordability (Ogunbode and Ifabiyi, 2017; Melissa et al., 2021).

Age distribution

Table 1 revealed that most of the respondents were 18–45 years of age (92.7%) after combining those in the 18–30-year category with those between 31 and 45 years of age. People in these age groups are more agile and active in attending to the questionnaire administrator and are likely to be more involved in house chores, especially in relation to water use in the house. People older than 46 years made up 7.3% of the respondents, especially where they were the only available option in the house. Browne *et al.* (2014) and Istifanus *et al.* (2019) observed that, as people age, there is a tendency for a lifestyle change and less water is likely to be required for life activities. For instance, children have been found to spend more time in the shower than adults (Mayer et al., 1999).

Preference for wastewater recycling

Table 1 shows that 162 (79.0%) respondents indicated their non-preference for the reuse of wastewater, while 43 (21%) respondents indicated that they have a preference for the recycling of wastewater in their homes. The reasons for their decision were also revealed in the table. While 65 (31.7%) of the respondents preferred recycling because of inadequate fresh water for some house chores like cleaning floors and drainage channels, 140 (68.3%) attributed their preferences for water recycling to the availability of an avenue for its use when produced in their home, indicating that there is no provision for wastewater storage in their homes. Taher *et al.* (2019) and Maquet (2020), in separate investigations, revealed that people's choice for water recycling is poor in view of the unhygienic status of the already-used water, and public enlightenment was recommended. The fact that there is unhindered access to the

TABLE 2 Variables extracted by factor analysis and their respective weights.

S/No	Variable description	RCM[a]	Eigenvalue[b]	% Variance explained[b]	Cumulative %[b]
1	Methods of collecting wastewater	.805	3.980	19.078	19.078
2	Proportion of wastewater often used	.821	1.691	15.054	34.132
3	Volume of wastewater often generated	.923	1.448	12.740	46.871
4	Level of support for the use of water reuse	.776	1.203	10.891	57.863
5	Personal perception about water recycle	.845	1.128	9.630	67.493
6	Reasons for water reuse	.927	1.000	9.050	76.542

Source: [a]Results of the rotated component matrix.
[b]Results of the total variance explained table.

source of fresh water will continue to impede water recycling technology in the study area.

Table 1 further shows the reasons why respondents could decline the reuse of wastewater in their homes. Reasons include unhindered accessibility to fresh water (56.6%), wastewater not being hygienic (15.6%), and the belief that wastewater could compound the dirt in any material it is applied to (10.2%), while some respondents attributed their reasons for declining to the fear that wastewater could pose health challenges because it is not treated for further use (17.6%).

Determinants of the respondents' preference for wastewater reuse

Results of factor analysis

The data set was subjected to the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) and Bartlet's test of sphericity (BTS). The results showed a KMO value of 0.742 and a significant BTS value with a p-value < 0.001. Thirteen (13) variables were analyzed, of which six were identified by FA as significant in the explanation for the respondents' preference for the practice of wastewater recycling in the study area. These are presented in Table 2:

Table 2 shows the six (6) variables extracted from the thirteen (13) analyzed. The first three variables are related to wastewater production, with a total explanation of 46.871% of the entire 76.542%. The variables are methods of collecting wastewater with an RCM of .805, the highest of the 13 variables in the analysis. The methods of collecting wastewater has the highest eigenvalue of 3.980 and offers the highest explanation (19.078%) of the six variables extracted. The importance of this variable in the issue of wastewater reuse in the study area cannot be overlooked in view of the weight attached to it by the FA. The variable with the next-highest eigenvalue (1.691) was the proportion of wastewater reused by the respondents. The variable with an RCM of .821 offered 15.054% of the total variance in the preference for wastewater reuse. This was closely followed by the volume of the wastewater generated with an RCM of .923, an eigenvalue of 1.448, a predictability strength of 12.740%, and a total variance of 76.542%.

The last three extracted variables shown in Table 2 were related to the respondents' attitude to wastewater reuse in the study area, with a variance of 29.571% of the total. The three variables in order of their ranks are levels of support given to wastewater recycling with RCM of 0.776, an eigenvalue of 1.203, and a predictive strength of 10.891%, the highest in the second grouping. The second variable in the category is the respondents' respective perceptions about wastewater recycling/reuse. This variable has the highest weight of 0.845 in the array of the thirteen variables analyzed, with an eigenvalue of 1.128 and 9.630% of the entire total explanation for the respondents' preference for wastewater recycling. The last explanation in the analysis presented in Table 2 was given by the respondents' reasons for their support for wastewater reuse. It has an eigenvalue of 1.000 and 9.050% in the predictability of the preference for wastewater reuse by the respondents, although it also has the highest RCM value (0.927) of the thirteen variables analyzed by the FA.

The results of the investigation implied that the preferences for wastewater reuse were primarily determined by issues of wastewater production and availability and the attitude to wastewater reuse, with the first carrying the heavier weight of 46.871% of the entire 76.542%. In short, the respondents will only consider reusing wastewater when it seems sufficient for flushing and other cleaning purposes; otherwise, it is thrown away. This view is corroborated by Adewumi and Oguntuase (2016) and Akpan *et al.* (2020). Apart from this, Hartley (2005) and Taher *et al.* (2019), in separate findings, reported that there was wide acceptance of the use of grey water for flushing but not for any other domestic purposes such as drinking and cooking, thus suggesting public enlightenment and appropriate treatment technology for improved acceptance of wastewater for further domestic uses. In view of this observation, it can, therefore, be established that the preference for wastewater

reuse is heavily dependent on the way it is generated and the volume that is available and also the attitudes or opinions of the respondents about wastewater reuse. Therefore, we reject the alternative hypothesis (H_1) and accept the null hypothesis (H_0) that the availability of wastewater does not hinder households' decisions on its use. Similarly, Po *et al.* (2003), Chfadi *et al.* (2021), and Abubakar and Mu'azu (2022), corroborating the effect of human attitude on wastewater reuse, discovered that the uses that involve direct or indirect skin contact are less accepted.

Conclusion and recommendation

An investigation into the factors that influence the preference of people in wastewater recycling in Iwo, Nigeria, was carried out. It was observed that respondents generally did not prefer wastewater reuse due to reasons such as appreciable access to fresh water and unhygienic attributes of the wastewater. However, the results of FA showed that six (6) variables extracted from thirteen (13) analyzed explained 76.542% of what guided the preference of the respondents in their decision on wastewater recycling in their respective homes. Further analysis revealed that the six (6) variables could be grouped into two (2) categories, namely: production-related and attitude-related. The first three variables, the method of collecting wastewater, the proportion of the wastewater utilized, and the volume of wastewater often generated, dominated the explanation of the respondents' preference for water recycling practice with a weight of 46.871% of the entire 76.542%. The second three extracted variables, levels of support given to wastewater recycling, perception about water recycling and respondents' reasons for water reuse, accounted for the remaining variance of 29.571%. Hence, we reject the alternative hypothesis (H_1) and accept the null hypothesis (H_0) that the availability of wastewater does not hinder households' decisions on its use. It can, therefore, be concluded that the preference for wastewater reuse is heavily dependent on matters associated with the production in terms of the method of collection, volume produced and the proportion willing to be reused, and the attitudes of the respondents about wastewater reuse. It is suggested that better education and improved technology in wastewater treatment could possibly change people's attitudes about the significance of water recycling in enhancing sustainable household water accessibility.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material; further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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