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FACTORS INFLUENCING THE ADOPTION OF BONE CHAR TECHNOLOGY BY COMMUNITY BASED WATER PROJECTS IN NAIVASHA SUB-COUNTY

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Abstract

Objective of this study was to determine factors influencing the adoption of the bone char technology by community based water projects in Naivasha Sub-county Kenya. High levels of fluoride in the drinking water cause fluoride poisoning referred to Fluorosis. The Bone Char technology offers a sustainable solution to fluorosis by removing fluoride in the water to permissible levels. The study analyzed the level of awareness, the cost of acquisition and complexity of the technology. A cross sectional survey research design was adopted with a descriptive approach. The study targeted 200 project staff from the existing community water projects operating in Naivasha Sub-county. A stratified random sampling design was used to select a sample size of 67 members. The data collected was processed using SPSS version 20 for descriptive and inferential analysis. The findings were presented using percentages and frequency distribution tables. The response rate was 89.6%. A strong positive significant correlations exists between the level of awareness, cost of acquisition, complexity of the technology and adoption of the bone char technology by community water projects (r = 0.571, 0.61 and 0.511; p < 0.05). The results of the correlation analysis implied that the more *awareness levels are enhanced among community water project beneficiaries, the more they will adopt the bone char technology. The study concluded that addressing the cost of acquisition, level of awareness and complexity of the bone char technology will increase the adoption of the technology.*

Keywords: Level of Awareness; Technology; Adoption; Acquisition cost; Complexity; Bone char

INTRODUCTION

Fluoride is a naturally occurring mineral in the rocks and dissolves in water. Some compounds, such as sodium fluoride and fluorosilicates, dissolve easily into ground water as it moves through gaps and pore spaces between rocks according to Environmental Protection Agency (EPA, 2013).In 1901 Colorado Springs, Colorado, Dr. Frederick S. McKay a dentist noted an unusual permanent stain or mottled enamel termed "Colorado brown stain" by area residents on the teeth of many of his patients. These high levels of fluoride in the drinking water cause fluoride poisoning in a disease called fluorosis. Exposure to excessive consumption of fluoride over a lifetime may lead to increased likelihood of bone fractures in adults, and may result in effects on bone leading to pain and tenderness. Children aged 8 years and younger exposed to excessive amounts of fluoride have an increased chance of developing pits in the tooth enamel.
The World Health Organization (WHO, 2008) recommended a maximum of 1.5mgF/l (Fluoride per litre) of water for Human Consumption. The Kenya Water Services Regulatory Board (WASREB) recommended the same. Fluorosis reduces the ability of the body to absorb the nutrients leading to several malnutrition diseases called maximum contaminant level goals (MCLG). Contaminants are any physical, chemical, biological or radiological substances or matter in water according to (EPA, 2013).

The MCLG for fluoride is 4.0 mg/L or 4.0 ppm, this is according to (EPA, 2013). Data from the WHO in the US, which fluoridates about two-thirds of public water supplies, actually has higher rates of tooth decay than many countries that do not fluoridate their water, including Denmark, the Netherlands, Belgium, and Sweden (Mercola, 2014). In Japan, fluoridation has been virtually non-existent since the 1970s, yet rates of dental caries have declined since that time. In the town of Tiel in the Netherlands, water fluoridation was discontinued in 1973, and by 1993, rates of dental caries had declined. In Canada, "the prevalence of caries decreased over time in the fluoridation-ended community while remaining unchanged in the fluoridated community" (Mercola, 2014).According to CDC (1999), McKay observed that teeth affected by fluorosis seemed less susceptible to dental caries.

The water from most boreholes as well as some surface water contains fluoride exceeding recommended level. High levels of fluoride in the drinking water cause fluoride poisoning in a disease called fluorosis. UNICEF indicates that fluorosis is endemic in at least 25 countries globally, tens of millions of people are affected (Arrenberg, 2010). The highest concentrations are generally found in groundwater, ranging from 1.5 to 36 mg/L in the Ethiopian Rift Valley. Locally, areas along the Kenyan Rift valley have high levels of Fluoride ranging from between 2mgF/l to 30mgF/l. This is because of the geogenic contamination due to elevated concentrations of the element. Fluoride that has adverse health effects to the humans consuming this water according to (MEGC International Workshop, 2012). In Kenya, fluoride occurs at high levels in the Great Rift Valley according to (Tekle-Haimanot et al., 2006). Some of the areas with high Fluoride levels include Naivasha, Nakuru, Baringo, Gilgil, Turkana among others. Residents of Naivasha stand a high chance of developing dental and skeletal problems due to high concentration of the mineral element of Fluoride in the county's boreholes. The bone char technology however provides a solution by defluoridating contaminated water. Adoption of this technology has been slow due to inadequate awareness, high cost of acquisition and complexity of its use.

Statement of the Problem

The high levels of fluoride in the drinking water cause fluoride poisoning. This condition reduces the ability of the body to absorb the nutrients leading to several malnutrition diseases. Failure to remove Fluoride in water leads to dental fluorosis, skeletal fluorosis and non-skeletal fluorosis. Naturally-created veins of fluoride are associated with historical volcanic activity. Soda Lake fluoride levels of Lake Elementaita and Nakuru have concentrations up to 1.64 mg/l and 2.8 mg/l respectively. A survey completed by Nair et al (1982) tested groundwater samples throughout Nairobi, the Rift Valley, and Central Province in Kenya found maximum concentrations reaching between 30 to 50 mg/l. On average, over half of tested sites within these areas reached fluoride levels from 1.1 to 8.1 mg/l. These areas are physically marked by severe dental fluorosis throughout the population (John Hopkins journal 2014 - opinion report)

Ground water is the main water source for most people residing in Naivasha, hence they are vulnerable.A large number are low income earners and unable to access clean water.The people who are affected are underweight (Cao et.al, 2005). High-quality bone char produced in Kenya can reduce the fluoride content of drinking water with a natural fluoride concentration as high as 23 mg/L (Samuel et al., 2009) to a concentration below the international WHO guideline of 1.5 mg/L (WHO, 2008). Despite the fact that Fluorosis is a real problem around Naivasha Sub-County, and there are solutions in the form of Bone char technology, the adoption of the technology is still a problem. Many community water projects have not embraced the technology and this is the main driver towards this study.

General Research Objective

To identify factors influencing the adoption of the Bone Char technology by community based water projects in Naivasha Sub-County.

Specific Research Objectives

i) To determine the influence of the level of awareness of Bone Char technology on its adoption by community based water projects

ii) To establish the effect of cost of acquisition of the Bone Char technology on its adoption by community based water projects

iii) To find out the relation between the complexity of the Bone Char technology to its adoption by community based water projects

THEORETICAL LITERATURE

The study adopted two theories: Diffusion of Innovation (DOI) and Technology Acceptance Method (TAM).The Diffusion of Innovation (DOI) Theory was developed by E.M. Rogers in 1962 explains how, over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system. The end result of this diffusion is that people, who are part of a social system, adopt a new idea, behavior, or product. Adoption means that a person does something differently than what they had previously. The key to adoption is that the person must perceive the idea, behavior, or product as new or innovative, it is through this that diffusion is possible. The adoption of a new idea, behavior, or product (i.e., innovation) does not happen simultaneously in a social system; rather it is a process whereby some people are more willing to adopt the innovation than others. Researchers have found that people who adopt an innovation early have different characteristics than people who adopt an innovation later.

When promoting an innovation to a target population, it is important to understand the characteristics of the target population that will help or hinder adoption of the innovation. There are five established adopter categories, and while the majority of the general population tends to fall in the middle categories. Different strategies are therefore used to appeal to the different adopter categories. Rodger established that the first category comprises of the innovators. These are people who want to be the first to try out the innovation. They are venturesome and interested in new ideas. These people are very willing to take risks, and are often the first to develop new ideas and account for 2.5%. Very little, if anything, needs to be done to appeal to this population. This category is followed by the early adopters. These people represent opinion leaders who enjoy leadership roles, and embrace change opportunities and account for 13.5%. They do not need information to convince them to change (Roger, 2003).

The other category comprises the early majority. These people are rarely leaders, but they adopt new ideas before the average person does. They typically need to see evidence that the innovation works before they are willing to adopt it and account for 34%. Strategies to appeal to this population include success stories and evidence of the effectiveness of the innovation(s). This category is followed by the late majority. These people are usually skeptical of change, and will only adopt an innovation after it has been tried by the majority and account for 34%. Strategies to appeal to this population include information on how many other people have tried the innovation and have adopted it successfully. Last but not least in the category are the laggards. These people are bound by tradition and are very conservative. They are also very skeptical of change and are the hardest group to bring on board, they account for 16%. Strategies to appeal to this population include statistics, fear appeals, and pressure from people in the other adopter groups.

The Technology Acceptance Model (TAM) is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it. These factors include perceived usefulness (PU) and this was defined by Fred Davis as the degree to which a person believes that using a particular system would enhance his or her job performance. Perceived ease-of-use (PEOU) is another factor that influences decision; Davis defined this as the degree to which a person believes that using a particular system would be free from effort (Davis, 1989).

TAM is one of the most influential extensions of Ajzen and Fishbein'stheory of reasoned action (TRA) in the literature. It was developed by Fred Davis and Richard Bagozzi (Davis 1989, Bagozzi, Davis &Warshaw, 1992). In the real world there will be many constraints, such as limited freedom to act (Bagozzi, Davis & Warshaw, 1992).According to TAM (Davis, 1989; Davis et. al., 1989), PEOU and PU are important perceptions determining the adoption of a technology. A later study that expanded on the original TAM studies, (Davis et al., 1992) explained the role of these beliefs, whereby he suggested that user intention to adopt a new technology is affected by both extrinsic and intrinsic motivations.

The role of PEOU is more likely to be complex than that of PU. This is because PEOU measures user assessment of ease of use and ease of learning. PEOU thus deals with user motivation that is based on the assessment of the intrinsic aspect of using the technology and the process involved in using it. However, the extrinsic aspect of a technology and not the intrinsic aspect is the main reason why new technology is accepted. This implies that PU and not PEOU should directly affect the adoption of a technology (Gefen& Straub, 2000).

EMPIRICAL LITERATURE

The level of awareness regarding the condition that is facing the community is an important determinant to how people will adopt the technology. This is because if they are not aware of what is causing the fluorosis condition, chances are they will not even bother to acquire the technology. Beale and Bolen (1955) were among the first to synthesize research that awareness was critical first stage in the technology diffusion process. The awareness was presumed to be followed over time by the interest, evaluation, trial, and finally adoption stages. Other researchers suggest that awareness and formation of attitudes is further influenced by the producers' socioeconomic characteristics (McBride et al., 1999; Rogers, 1995)

Technological change is mainly associated with enhanced opportunity for greater productivity and income is of interest to the private sector, researchers and policymakers (Pierce & Nowak, 1999).According to Cowan (2000) he said that decision makers are also interested in the relationship between awareness and adoption. Awareness is derived internally hence the decision to adopt. Thus awareness and adoption are modeled jointly to allow one to interpret awareness as a potential policy variable that can be used to influence the probability of adoption (Morgenstern, 1996)

The Bone char technology uses bones from different animals hence the cultural and religious implications in its adoption. Therefore the defluoridation method should be looked at carefully while considering what community or culture it is going to serve. Defluoridation using Bone Char technologies has been in Kenya since 1998. It was introduced by the Catholic Diocese of Nakuru (CDN) under its Water programme. However the pace of adoption of the technology by the communities is slow and the community members are not aware of the technology. The CDN has therefore invested heavily in education and awareness initiatives in the region. These efforts include the development of a fluoride education theatre group that is able to educate in a way that is appreciated and understood by many different groups in their communities (CDN, 2007).

The benefits from adopting a new technology, e.g. the defluoridation technology, are the flow benefits which are received throughout the life of the acquired innovation. However, the costs are typically incurred at the time of adoption and cannot be recovered (Hall &Khan, 2003). However, the cost of acquiring the defluoridation technology is a limiting factor to the target communities. This has an impact on how the communities embrace the technology. What is affordable to those using other defluoridation options should be an important consideration. The cost of installation of the de-fluoridation filter should also be looked into.Adoption of a new technology is often very costly for various reasons in that; new machines need to be purchased and often the technology is a specific asset; employees need to be trained to operate the new technology; if there are network effects then complementary machines need to be updated or replaced.

A firm will have an incentive to invest in a new technology only if it can later obtain profits that justify the initial investment. Since profits erode in the presence of competition, only firms with sufficient market power would find it profitable to adopt (Hall &Khan 2003). Also, the skill level s of workers is an important determinant in adoption of technology. If a successful implementation of a technology requires complex new skills, and if it is time-consuming or costly to acquire the required level of competence, then adoption might be slow (Rosenberg, 1976). He also stresses the importance of the technical capacity of an industry for adoption. However this may be made easier if there is the knowledge transfer from the experts to a community member in the local community.

Bone char is the oldest known technology for water defluoridation, and has been successfully used since the 1940s (Dahi et.al, 2006). Bone char is produced with animal bones that have passed through calcination or pyrolysis processesBone char is an effective material for removing fluoride provided the bone char is of high quality. According to Dahi (2000) the bone charring process unless carried out properly may result in a product of low defluoridation capacity or deteriorated water quality. Hence the production of bone char is one of the most important steps for future successful de-fluoridation treatment.The colour of bone char has proven to be a simple indicator for its ability to remove fluoride (Jacobsen and Dahi, 1997). Greyish bone char has the highest fluoride removal capacity. For the black bone char, the bones still contain high organic impurities which cause odor and colour to the treated water. White bone char on the other hand has reduced fluoride removal capacity.Bone char Production aims at producing uniform and good quality of the final product

Critique of the Existing Literature Relevant to the Study

TAM has been widely criticized despite its frequent use. This has led the original proposers to attempt to redefine it several times. Criticisms of TAM as a theory include its questionable trial and error value, limited explanatory and predictive power, triviality, and lack of any practical value. According to Chuttur (2009), Benbasat and Barki suggest that TAM has diverted researchers' attention away from other important research issues and has therefore created an illusion of progress in knowledge accumulation. According to (Benbasat & Barki, 2007) the independent attempts by several researchers to expand TAM in order to adapt it to the constantly changing technological environments have led to a state of theoretical chaos and confusion

New technologies are complex and an element of uncertainty exists in the minds of decision makers with respect to the successful adoption of these technologies. Thus, actual usage may not be a direct or immediate consequence of such attitudes and intentions (Bagozzi, Davis & Warshaw, 1992). Diffusion is hard to quantify because the human being and the human networks are often complex. This is because it is extremely difficult to measure exactly what causes the adoption of an innovation (Damanpour, 1996). The diffusion theories can never account for all the variables, therefore it is possible to miss all the critical mass predictors of adoption of a technology.

According to Rogers, contributions and criticisms of diffusion and research are placed into four categories. These categories are namely pro innovation bias, individual blame bias, recall problem and issues of equality. The pro innovation bias implies that all the innovation is positive and therefore should be adopted (Rogers, 2003).The one way flow of information from the sender to the receiver in the innovation theory is another weakness of the theory. The sender of the message usually has a goal to persuade the receiver with little or no reverse flow. Also the person implementing the changes usually controls the direction and the outcome of the campaigns. In some cases this is the best approach but other instances usually require a more participatory approach (Giesler & Markus 2012).

Summary

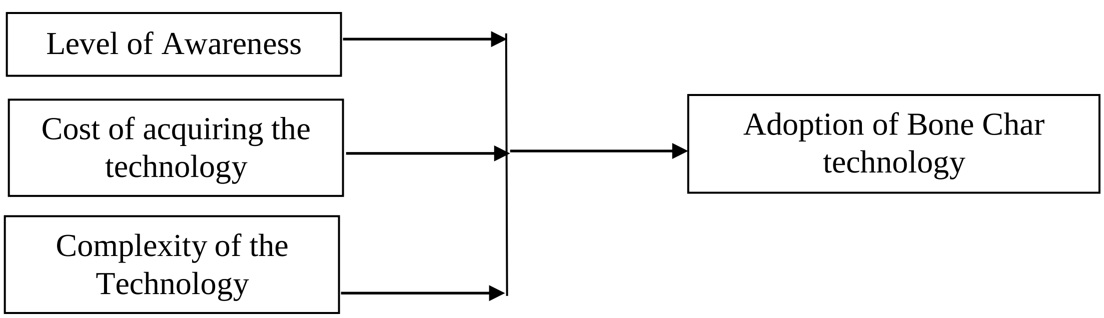
The literature reviewed reveals that the four main elements in the diffusion of new ideas are innovation, communication channel, time and the social context. This process relies mainly on human capital, the innovation must therefore be widely accepted in order to self-sustain. The rate of adoption of an innovation or technology, determines the point within which the innovation reaches the critical mass. This is according to the diffusion of innovation theory. From the literature it was also found that, for any technology to be accepted it has to go through a number of processes and these include knowledge (with regards to awareness), persuasion, decision (to accept or reject), implementation then finally confirmation of the adoption.

Researchers have also found that people who adopt an innovation early have different characteristics than people who adopt an innovation later. Therefore, when promoting an innovation to a target population, it is important to understand the characteristics of the target population that will help or hinder adoption of the innovation. From the literature reviewed it was also found that PEOU and PU also determine whether a technology will be accepted or rejected. This is according to TAM model, further studies from reviewed literature also revealed that the intention to adopt a technology are affected by both intrinsic and extrinsic motivation. However it is preferable for the PU as opposed to PEOU to directly affect the adoption of a technology.

Research Gaps

According to Mehari (2014) he stated that it was necessary to research on a means of removing excess fluoride using locally and available technologies that operate easily and were able to reduce fluoride to an acceptable level both for households and community use. Cherrukimili & Gadgill (2014) on the other hand stated that the ultimate goal of research was to find an appropriate/suitable defluoridation technology that met the requirements of long term sustainability i.e. one that was locally available, easy to maintain and robust culturally appropriate method and that could be scaled up. It is in the light of these gaps identified that necessitated a study to establish why the community water projects were not taking up the existing technology that was meeting the above criteria.

Figure 1. Conceptual Framework



METHODOLOGY

A cross sectional survey research design was adopted with a descriptive approach. This research design was preferred because it will allow for collection of data through questionnaires that will be administered to a sample (Saunders et. al., 2007). The descriptive studies are more formalized and typically structured with clearly stated hypothesis or investigative questions (Schindler & Coopers 2004). This facilitated the collection of considerable data amounts quickly, efficiently and accurately (Oso & Onen, 2005). The study targeted a population of 200 project staff from the existing community water projects operating in Naivasha Sub-County in Nakuru County in Kenya.

The study used stratified random sampling design; this involved the dividing of the target population into relevant strata. Members were then selected from each quota using simple random sampling to ensure representativeness and proportionality (Saunders *et al.* 2009).Using Nassiuma (2000), the sample size was computed as below:

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Where

n = sample size;

N = population size;

C = coefficient of variation which is 50%

e = error margin which is 0.05.

Substituting these values in the equation, estimated sample size (n) was:

$$n = \frac{200\,(0.5)^2}{0.5^2 + (200-1)0.05^2}$$

$$n = 67$$

Table 1: Sampling Frame

Strata	Target Population	Percentage (%)	Sample Size
Project Staff	20	33.3	7
Project committee members	60	33.3	20
Community members	120	33.3	40
Total	**67**	**100**	**67**

The study used both structured and semi-structured questionnaires to collect data. The nature of data was best collected by use of questionnaires as emphasized by Mugenda and Mugenda (1999).Using this method, the researcher was able to collect more data on the phenomena under study. The data collection process also incorporated systematic sampling. This method entails picking every kth element in the population being sampled and begins with a random start of element. This method was preferred because it is simplistic and also flexible enough to work with (Kothari, 2004).

A pilot study was conducted to test the reliability of the research instrument (questionnaire). The pilot test will targeted 10 respondents from the community water projects that have been undertaking the defluoridation technology for over 3 years. The data from the pilot test was not included in the final data analysis and presentation of findings. Validity was maintained through rational questions inclusion and pre-testing the questionnaire (Mugenda &

Mugenda, 2003). The data collected was compiled, edited, sorted, classified, coded and tabulated to make it easier for analysis. The data was then analyzed using SPSS version 20 for descriptive analysis, inferential analysis and linear regression. The findings were presented using percentages and frequency distribution tables.

The researcher further used regression analysis to establish the strength of the relationship between the dependent and independent variables.

$Y= \beta_0+ \beta_1 X_1+\beta_2 X_2+ \beta_3 X_3 +\boldsymbol{\varepsilon}$

Where

Y is the dependent variable (Adoption of the bone char technology), β_0 is the regression coefficient/constant/Y-intercept, β_1, $\beta_2$and β_3 are the coefficients of the linear regression equation.

X_1 is Level of awareness

X_2 is Cost of Acquisition of the Technology

X_3 is Complexity of the Technology

$\boldsymbol{\varepsilon}$ is an error term normally distributed about a mean of 0 and for purpose of computation, the $\boldsymbol{\varepsilon}$ is assumed to be 0.

Pilot Test Results

A pilot study was conducted to test the reliability and validity of the questionnaire. A sample of 10 respondents was picked and the return rate was 100%. The Cronbach's Alpha Test was conducted on all measures for the independent and dependent variables with a threshold of 0.7. The higher the score, the more reliable the alpha scores for acceptability of reliability coefficient (Creswell, 2002).

Table 2: Cronbach's Test Results

Variable	**N (Number of Items)**	**Cronbach Alpha**
Level of Awareness	6	0.861
Cost of Acquisition of Technology	3	0.803
Complexity of Technology	4	0.921

Results and Discussion

A total of 67 questionnaires were distributed to the respondents who are involved in water de-fluoridation activities. 60 questionnaires were duly filled and returned. This translated to 89.6% response rate.

Demographic Characteristics of the Respondents

The study sought to establish the demographic characteristics of the respondents covering their age categories, level of education and gender distribution. 57% percent of the respondents were males while 43% were female. Majority of the respondents, 43% were aged 31-35 years and 29% were aged 35 years and above. In addition, majority of the respondents (57%) had attained secondary level education, 21% primary level education while 8% and 5% had attained college and university level of education respectively. The results show the respondents were capable of comprehending and answering the survey questions.

Respondents Duration of participation in the water projects

Table 3: Participation and roles in community water projects

	Category	**Frequency**	**Percent**	**Cumulative %**
Roles in the water project	Project staff	4	6.0	6.0
	Opinion leader	1	2.0	8.0
	Committee member	17	28.0	36.0
	Gate Keepers	4	6.0	42.0
	Community Member	34	58.0	100.0
	Total	**60**	**100.0**	

The distribution of the respondents according to their respective period of participation and roles played in the community water projects was analyzed. 35% of the respondents had participated in community water projects for 2-4 years while 28% had participated for 5-9 years and 9% were involved for 10 years and above. From these results, majority of the respondents have participated between 1 and 9 years respectively**.**

The study further sought to find out the positions held in the water community projects. In Table 3, majority of the respondents (58%) were community members. 28% were committee members while 2% were opinion leaders. The results clearly indicate that the beneficiaries who are the community members are the majority stakeholders of the community water projects.

Level of Awareness of the Bone Char Technology

Table 4: Information awareness on Bone Char Technology

Response	**Frequency**	**Percentage**	**Cumulative %**
Yes	43	72	72
No	17	28	100
Total	**60**	**100**	

The study sought to establish the level of awareness of the bone char technology in the community water projects. 72% of the respondents indicated they were aware of the bone char technology while 28% were not (Table 4).

Source of Information on Bone Char Technology

Table 5: Source of Information on Bone Char Technology

	Information Source	Frequency	Percent	Cumulative percent
Source of information	Media-TV, Radio	8	13.3	13.3
	Neighbor/friend	9	15.0	28.3
	Politician	2	3.3	31.6
	Bone Char Researcher	16	26.7	58.3
	Defluoridation staff	16	26.7	85
	Others	9	15.0	100.0
	Total	**60**	**100.0**	
Recommendation of Bone Char technology	Strongly	43	72.0	72.0
	Moderately	15	25.0	97.0
	Not Recommended	2	3.0	100
		60	**100.0**	

On further analysis, indicates that of the source of information on the level of awareness of the bone char technology, 26.7% of the respondents heard about the technology from bone char researchers and another 26.7% from defluoridation staff (Table 5). 15% learnt about the technology from their neighbors, 13.3% from the media (radio and television) and 3.3% from politicians. Moreover, 72% of the respondents strongly recommended the bone char technology while 3% did not. The results show that information on bone char technology is better known by the experts than the beneficiaries. This will ultimately affect the level adoption of the technology by the community water projects. Further, the results also imply that there is need for more robust sensitization on the benefits and use of the bone char technology. Majority of the respondents supported this view that there was need for more campaigns to markets and clinics, training and capacity building for community members and enhanced use of media.

Appropriateness of the Bone Char Technology

Table 6: Appropriateness of the Bone Char Technology

Response	Frequency	Percentage	Cumulative %
Is Appropriate	39	65	65
Not Appropriate	21	35	100
Total	**60**	**100**	

From Table 6, majority of the respondents 65% said the bone char technology was appropriate while 35% said otherwise. The findings reveal that the technology was likely to be accepted and therefore this will promote the adoption of the technology by the community water projects. The findings are consistent with Baggozzi, Davis and Warshaw (1992) that new technologies are complex and an element of uncertainty exists in the minds of decision makers with respect to the successful adoption of these technologies. Thus, actual usage may not be a direct or immediate consequence of such attitudes and intentions.

Descriptive Analysis on Use of the Bone Char Technology

Table 7: Descriptive Analysis on Use of the Bone Char Technology

Statement	N	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Bone Char technology will help solve the problem of fluorosis	60	32.0%	26.7%	28.3%	6.7%	6.3%	100%
Bone char will help improve the quality of water consumed in the area	60	32.0%	28.3%	25.0%	10.0%	4.7%	100%
Benefits of Bone char outweigh limitations/weaknesses of technology	60	30.0%	26.7%	27.0%	11.7%	4.6%	100%
Government and other stakeholders have not been sufficiently involved in promotion of Bone Char	60	58.3%	11.7%	21.7%	5.0%	3.3%	100%

Table 7, the study sought to establish the usefulness of the bone char technology and in terms of solving the problem of fluorosis, 32% of the respondents strongly agreed, 28.3% neither agreed nor disagreed while 6.3% strongly disagreed. Majority of the respondents (58.7%) supported the view that bone char technology will solve fluorosis problems. 41.3% of the respondents are not sure about the usefulness of the technology. From the results, there are clear gaps to be filled for the bone char technology to be adopted and realize its intended usefulness.

Further analysis on how the bone char technology improves the quality of water, 32% of the respondents strongly agreed, 28.3% agreed while 39.7% either were neutral, disagreed or strongly disagreed. Again, the results indicate that the bone char technology needs more awareness among other factors to be widely accepted for adoption. The benefit of the bone char technology outweighs its limitations. This was confirmed by 30% of the respondents, who strongly agreed, 26.7% who agreed while 43.3% of the respondents were either neutral, disagreed and strongly disagreed respectively.

On stakeholder participation and involvement, the study found that 58.3% of the respondents strongly agreed that the government and other stakeholders were not sufficiently involved in the promotion of the bone char technology. 11.7% agreed with this view. 30% of the respondents were either neutral, disagreed or strongly disagreed. The findings support Kenon, Howden& Hartley (2010) who delved on the importance of stakeholder involvement and influence in the success of project implementation.

Cost of Acquiring the Technology

Table 8: Descriptive Analysis of the Cost of Acquiring the Technology

	Responses	Frequency	Percent	Cumulative percent
Cost Limitation and adoption	Yes	54	90.0	90.0
	No	6	10.0	100.0
	Total	**60**	**100**	
Extent of cost of acquiring technology	Very large extent	12	20	20
	Large extent	9	15	35
	Moderate	26	43.3	78.3
	Small extent	8	13.3	91.6
	Very small extent	5	8.4	100
	Total	**60**	**100.0**	

From Table 8, the study also sought to determine the effect of cost on acquisition of the bone char technology. 90% of the respondents felt that cost was a limitation in the acquisition and adoption of the bone char technology. This is consistent with the findings by Hall and Khan (2003) who found that the costs of technology are typically incurred at the time of adoption and cannot be recovered. This tends to keep off most community water projects and therefore the basis of the findings on cost of the technology.

Further analysis on the extent of the effects of cost in acquiring the bone char technology showed that 43.3% of the respondents moderately agreed while 15% and 20% agreed to a large extent and very large extent respectively. The results clearly indicate that cost is a big limitation in the acquisition and adoption of the technology by community water projects. The respondents suggested that the cost of acquisition can be lowered through government interventions, production of smaller and affordable defluoridation equipment, fund raising by community water projects or seeking donor funding to offset financial gaps.

Complexity of the Bone Char Technology

Table 9: Descriptive Analysis on Complexity of the Bone Char Technology

	Response	**Frequency**	**Percent**	**Cumulative percent**
Role of PEOU in adoption of technology	Yes	41	68.3	68.3
	No	19	31.7	100
	Total	**60**	**100**	
Ease of use of the technology	Very easy to use	15	25.0	25
	Easy to use	27	45.0	70
	Moderate	9	15.0	85
	Hard to use	6	10.0	95
	Very hard to use	3	5.0	100
	Total	**60**	**100.0**	
Role of perceived useful of technology	Yes	42	70.0	70
	No	18	30.0	100
	Total	**60**	**100.0**	
Extent of Usefulness of technology to the community	Very large extent	21	35.0	35
	Large extent	13	21.7	56.7
	Moderate	13	21.7	78.4
	Small extent	9	15.0	93.4
	Very small extent	4	6.6	100
	Total	**60**	**100.0**	

The researcher sought to find out the complexity of the bone char technology in terms of use and adoption. From Table 9, on the PEOU (Perceived ease of use), 68.3% felt that the bone char technology had ease of use in adoption. With regard to ease of use of the bone char technology, 25% found it very easy to use, 45% ease to use while 15% found moderate ease of use. The results show that the technology was easy to use by majority of the respondents.The study also sought to analyze the role of perceived usefulness (PU) in the adoption of the bone char technology. 70% of the respondents felt PU played a role in the adoption of the bone char technology. The researcher further sought to find out the extent of the usefulness of the bone char technology to the community. 35% of the respondents felt that the technology was useful to a very large extent while 21.7% felt it useful to a large and moderate extent. Overall, the technology was found to be useful to the community. If a successful implementation of a technology requires complex new skills, and if it is time-consuming or costly to acquire the required level of competence, then adoption might be slow.

Davis et al, (1992) suggested that user intention to adopt a new technology is affected by both extrinsic and intrinsic motivations. The extrinsic motivation refers to the performance of an activity because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity. This explains the study findings on perceived ease of use and perceived usefulness of the bone char technology.

Adoption of the Bone Char Technology

Table 10: Descriptive Analysis on Adoption of the Bone Char Technology

Category of Questions	Response	Frequency	Percent	Cumulative percent
Adoption of technology	Yes	39	65	65
	No	21	35	100
	Total	**60**	**100**	
Factors for the adoption of the technology	Level of awareness	6	10	10
	Cost of acquiring the technology	30	50	60
	Complexity or ease of use	18	30	90
	Others(specify)	6	10	100
	Total	**60**	**100**	
Reason for not adopting bone Char technology	No benefit	1	1.7	1.7
	High technology costs	15	25	26.7
	Not aware of the technology	2	3.3	30.0
	Find it Not appropriate	2	3.3	**33.3**
	Others(specify)	1	1.7	**35.0**
	Total	**21**	**35.0**	

From Table 10, the study sought to find out the level of adoption of the bone char technology by water projects and the determinant factors. 65% of the respondents indicated they could adopt the bone char technology in their water projects. On the factors that determine whether or not the water projects will adopt the bone char technology, 10% indicated level of awareness, 50% cost of acquiring the technology, 30% the complexity of use while 10% indicated there were other factors like level of acceptance and attitude by the community and availability of bones.

Correlation Analysis

Relationship between Level of Awareness and Adoption of Bone Char Technology

Table 11: Correlation between Level of Awareness and Adoption of Bone Char Technology

		Level of Awareness
Adoption of technology	Pearson Correlation	.571**
	Sig. (2-tailed)	.000
	N	60
	Sig. (2-tailed)	.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

According to Table 11 above, there is a strong and positive significant relationship that exists between the Level of awareness and the Adoption of Bone Char technology. This implies that with creation of more awareness about the bone char technology to the community, more water projects are likely to appreciate its benefits and adopt it. Therefore the concerned parties should do more with regards to increasing the level of awareness within the community members.

Relationship between Cost of Acquisition and Adoption of Bone Char Technology

Table 12: Correlation between Cost of Acquisition and Adoption of Bone Char Technology

		Cost of Acquisition
Adoption of Technology	Pearson Correlation	.601*
	Sig. (2-tailed)	.043
	N	60

*. Correlation is significant at the 0.05 level (2-tailed).

According to Table 12, there is significant positive correlation exists between the Cost of acquisition of the technology and the Adoption of Bone Char Technology. The result implies that the higher the cost of acquisition of the technology, the harder the community water projects will find it difficult to adopt it. This finding correlates with the descriptive analysis result on the factors affecting the adoption of the bone char technology. The analysis found that the cost of acquisition of the technology greatly affected the adoption of the Bone Char Technology and is also consistent with Hall & Khan (2003).

Relationship between Complexity of the technology and Adoption of Bone Char Technology

Table 13: Correlation between Complexity and Adoption of the Bone Char Technology

		Complexity of Technology
Adoption of technology	Pearson Correlation	.511*
	Sig. (2-tailed)	.021
	N	60

*. Correlation is significant at the 0.05 level (2-tailed).

According to Table 13 above, there is a significant positive correlation between the Complexity of the technology and the Adoption of Bone Char Technology. This implies that the more the communities find the technology easy to use, the more likely the community water projects will adopt the technology. These findings also tallied with the Descriptive analysis on Adoption of Bone Char Technology (Table 10) that indicated that the level of adoption of the bone char technology was also influenced greatly by the complexity of the technology. Therefore once it is known by the community members that the technology is easy to use, they are more likely to adopt the technology this supported what was stated by Rosenberg (1976) where the author suggested that if a technology requires complex skills then the uptake of this technology might be slow.

Regression Analysis

The researcher conducted a multiple regression analysis so as to determine factors influencing the adoption of the bone char technology. Coefficient of determination explains the extent to which changes in the dependent variable can be explained by the change in the independent variables. The three independent variables studied, explains only 83.2% of the adoption of the bone char technology in Table 14. Therefore, further research should be conducted to investigate the other factors (16.6%) that influence the adoption of the bone char technology.

Table 14: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.912	0.832	0.749	0.4526

Table 15: Regression Coefficients

Model	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
	B	**Std. Error**	**Beta**		
(Constant)	1.308		1.341	1.622	0.357
Level of Awareness	0.557	0.311	0.171	4.342	.0276
Cost of Acquisition of Technology	0.784	0.323	0.067	3.541	.0202
Complexity of the Technology	0.730	0.155	0.210	3.531	.0285

Multiple regression analysis was conducted as to determine the relationship between technology adoption and the three variables. As per Table 15, the equation (**$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \varepsilon$**) becomes:

$Y= 1.308+ 0.557X1+ 0.784X2+ 0.730X3 +0$

The regression equation above established that taking all factors into account (Level of awareness, Cost of acquisition of the technology and Complexity of the technology) at zero, the constant is 1.308. The findings presented in Table 15 also shows that taking all other independent variables at zero, a unit increase in level of awareness will lead to a 0.557 increase in adoption of the bone char technology; a unit increase in cost of acquisition will lead to 0.784 increase in reduced levels of adoption of the technology while a unit increase in adoption of the technology will lead to 0.730 increase in levels of reduced technology adoption.

The findings infer that cost of acquisition of the bone char technology and complexity of its use greatly hinders the adoption of the bone char technology by the community water projects.

CONCLUSIONS

The study concluded that there was a strong positive correlation between level of awareness, cost of acquisition of technology and the complexity of the technology with regards to the adoption of Bone Char technology. Therefore on level of awareness, more needs to be done for the technology to be widely accepted by the community water projects. The findings also highlighted the role of sensitizing the community water projects on the importance and benefits of the bone char technology. The cost of acquisition was found to be the major limiting factor in the acquisition and adoption of the bone char technology. Suggested remedial actions to lower the costs are; government interventions, production of smaller and affordable equipment, fund raising by community water projects or seeking donor funding to offset financial gaps. The findings also indicated that perceived ease of use, and perceived usefulness of the technology were adequate. However, there were others who were not ready to adopt the bone char technology. They cited high technology acquisition costs, complexity of use, lack of awareness and appropriateness of the technology as the main impeding factors. In conclusion, the successful adoption of the bone char technology is possible. The project implementers should address the cost of acquisition, complexity, awareness and appropriateness on the use of the technology.

The study also established the level of adoption of the bone char technology by water projects and the determinant factors whereby majority of the respondents indicated they were willing to adopt the bone char technology in their water projects. Other respondents were skeptical about adopting the technology due to various factors. They cited some reasons ranging from high technology acquisition costs, complexity of use, lack of awareness and appropriateness of the technology. Others were undecided on the benefits and usefulness of the technology. The respondents also cited other factors like level of acceptance of the technology, attitude by the community and availability of the bones plus the associated costs.

RECOMMENDATIONS

It is recommended that the community water projects should be involved in the implementation of the Bone Char technology. This will empower them to address the issues surrounding its adoption especially when creating awareness. Use of media especially radio and television was recommended to reach many people on the benefits of the bone char technology. Further, the study recommended that simplification of the complexity, cost reduction and addressing appropriateness of the technology will enhance its adoption. Other stakeholders like government ministries and development agencies should form partnerships to promote this technology.

The study also recommended that the community water projects should become more innovative and start income generating activities or resource mobilization projects. These projects will help them pool their resources together and acquire better technologies easily. More trainings and campaigns should be enhanced to schools and hospitals to create awareness.

FURTHER RESEARCH

In line with the findings of this study, more research should be done on ways in which the cost of acquisition of the technology can be reduced. This is because according to the study the cost of acquisition was a major inhibitor to the adoption of the Bone Char technology. It is also advisable to conduct a comparative study on challenges facing Bone char technology and its adoption by community water projects. This will help to establish where more emphasis should be placed in terms of intervention by the relevant or concerned authorities.

Further research also needs to be done to establish the link between the high levels of Fluoride and increased cases of children with low levels of Intelligence Quotient (IQ). This is because there have been speculations that there is a likelihood of a link but that needs to be validated through a research process on the same. This will go a long way in addressing the fluorosis as a social problem because by providing the link then Bone char technology as a relevant technology will be validated and will also give value for money for investment in that particular technology.

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