AMERICAN UNIVERSITY OF BEIRUT

PUBLIC PERCEPTION ABOUT TREATED WASTEWATER REUSE IN BEIRUT, LEBANON

by
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"Gratitude is not only the greatest of virtues, but the parent of all others."

—Marcus Tullius Cicero

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AN ABSTRACT OF THE PROJECT OF

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The problem of water shortage has been aggravated in most countries in the Middle East and Lebanon is no exception. Treated wastewater reuse, an unconventional source of water, could provide a viable and sustainable option in water demand management.Perceived health risks, confidence and trust authorities (MPs, municipalities, NGOs, media), public knowledge and education are considered to be the major social drivers that might affect the perceptions of the community. This study is the first of its kind in Lebanon to shed light on the perception of the community to use treated wastewater for various purposes within the Administrative Beirut Area. Survey results revealed that there is an inverse relation between the degree of human contact with the treated wastewater and the public acceptance. People are more inclinedtowards the reuse for purposes with minimal human contact such as landscaping and agriculture.Willingness to use treated wastewater in general was found to vary as a function of disgust factor, religion, and diseases.Willingness to use for non-potable purposes was found to vary as a function of education and respondents' awareness. Respondents who stated a willingness to use treated wastewater for domestic purposes generally trust non-governmental organizations and academicians more than members of the parliament, municipalities and media. Disgust factor alone does not explain the negative public response of the community members. Had people heard more about successful implementation stories they would have become less reluctant towards using treated wastewater. Awareness campaigns designed to promote the water reuse projects in the country should be transmitted by environmental and public health NGOs. Ultimately, collaboration and coordination between all stakeholders are crucial to ensure social acceptability towards wastewater reuse. This research laid down the foundations for further in-depth research to better design appropriate strategies, measures, policy reforms and incentive schemes needed to implement and manage water reuse projects.

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CHAPTER I

INTRODUCTION

Water resources, in general, are becoming scarce due to climatic variations (droughts, unequal rainfall), economic development, population growth, pollution and poor water management practices. It is estimated that by 2025, nearly 1,800 million people will be living in regions with absolute water scarcity (UN-Water, 2006). Consequently, water management challenges will increase, driving towards the intense utilization of non-conventional sources of water. Among these sources is wastewater reuse that can provide alternative water supply for several activities that do not require potable water quality.

Wastewater reuse can have various domestic uses (toilet flushing, bathing and showering, floor cleaning, toilet flushing) industrial, and recreational uses (landscape and golf course irrigation). In addition, it protects existing sources of valuable fresh water, and if managed properly, it is a superior source for agriculture. For instance, wastewater has the advantage of providing both water and nutrients to crops, thus reducing the cost of fertilizer use(Choukr-Allah, Ragab, & Rodriguez-Clemente, 2012). Despite of restrictions regarding public acceptance, benefits of agricultural reuse of wastewater are of importance when agricultural production is maintained while water sources and environmental quality are preserved (Haruvy, 1998).

However, if not treated properly, wastewater may contain pathogens, hazardous material and chemical toxins that may be carcinogenic or cause gastrointestinal infections in human beings. Furthermore, it may lead to environmental degradation such as soil structure

deterioration (soil clogging), eutrophication, hypoxia and salinization (Bdoura, Hamdib, & Tarawneha, 2009).

Among the non-conventional water resources and according to the level of treatment (primary, secondary, tertiary) wastewater reclamation has the lowest marginal cost (cost of additional treatment, storage, and distribution)(Ammary, 2007). Treated wastewater effluent that has been treated to levels suitable for domestic, industrial or recreational reuse – can provide a safe and reliable source for both non-potable and direct/indirect potable urban water supply.

Perceived health risks, confidence and trust, **w**ater culture, environmental concerns, public knowledge and education are considered to be the major social drivers that may affect the perceptions of the community(Mankad & Tapsuwan, 2010).People generally favor reuse that promotes water conservation, provides environmental protection benefits, and protects human health(Hartley, 2006). On the other hand, several reasons cause lack of enthusiasm when it comes to using treated wastewater. These range from the disgust factors (sometimes known as the "Yuck" factor), perceptions of risk, lack of trust, insufficient knowledge, socio demographic factors, and the cost of treatment. Generally, public opposition for wastewater reuse decreases when the level of contact with the reusable water increases (Jefferson, 2004). For example, public opposition for potable water reuse is expected to be higher as compared to landscape irrigation. Positive perceptions of, and knowledge about using treating wastewater are key drivers for likelihood of usage and awareness of water scarcity, as well as prior experience with using water from alternative sources increases the likelihood of use (Dolnicar, Hurlimann, & Grüna, 2011). Thus, positive public perceptions and acceptance of water reuse are considered fundamental factors for the successful introduction of water reuse projects.

The problem of water shortage in Lebanon is primarily a result of mismanagement of water resources thathas been aggravated due to high population growth followed by recent influx of refugees, modernization and higher living standards. According ESCWA projections, the population growth rate in Lebanon was 3.04% during the period 2010-2015 (ESCWA) in addition to the approximate 1.3 million refugees who resided in Lebanon (UNHCR Global Appeal Update, 2015). Meanwhile, fresh water availability per capita per year in Lebanon is projected to decrease from 1,818 m^3 in 1991 to 800 m^3 in 2050.(Musa, 2008).

The agricultural sector accounts for 85% of the total water resources in the country while the industrial and domestic sectors constitute around 4% and 11% respectively (Musa, 2008). Water demand is increasing annually, mandating the necessity of adopting long term, sustainable water management plans, including the use of non-conventional water resources.

Wastewater management is a major challenge in Lebanon. It is estimated that the ratio of reused wastewater to withdrawn fresh water in the country is 0.2% (El-Fadel, Ghanimeh, Maroun, & Alameddine, 2012). The unsafe disposal of wastewater is contaminating surface andgroundwater resources and coastal waters. Many coastline cities are losing their recreational value because of the high quantities of industrial and municipal wastewater (Bdour, 2009). Wastewater treatment and reuse are covered by a legislation that goes back to 1930(Angelakis, Monte, Bontoux, & Asano, 1998). In most of the Mediterranean countries, wastewater is reusedtodifferent extents within planned or unplanned schemes (Brissaud, 2008). The practice of re-using untreated wastewater for irrigation might be an important incentive towards treatment. Wastewateris regarded to be a very important and valuable resource, if treated properly and rendered fit for human use without inducing negative impacts on the human health or the environment. The type and extent of treatment used

highly depends on the type and extent of impurities present in the water and the ultimate use of this water. Pathogenic bacteria, parasites, enteric viruses and chemicals in the treated wastewater can be controlled, reduced and eliminated by using appropriate wastewater treatment technologies.Water reuse would provide a viable and sustainable option in water demand management.

Research Objectives

1. Estimate the level of support for various water reuse options.
2. Assess the socioeconomic characteristics influencing the acceptance/rejection of water reuse at household level.
3. Explore the willingness to consume products irrigated with treated wastewater.
4. Investigate willingness to use (WTU) and willingness to pay (WTP) for recycled water.

CHAPTER II

LITERATURE REVIEW

A. The Need for Water Reuse

As the worldwide population increases and water resources become more coveted, water emerges as one of the driving componentsimpacting sustainability of global economy.It is estimated that by 2025, nearly 1,800 million people will be living in regions with absolute water scarcity (UN-Water, 2006). Currently, according to the UN projections, more than 80% of wastewater resulting from human activities is being discharged into rivers or seas without any treatment. Approximately 70% of all water abstracted from these "polluted" sources is used for irrigation(UN, 2015).Human water consumption is increasing beyond sustainable levels primarily because of economic development, population growth, climate change and high levels of industrialization and urbanization. Subsequently, this overconsumption is resulting in depletion of environmental flows in natural water systems and the decrease in the quality of drinking water reservoirs, including groundwater systems (Dolnicar & Schafer, 2009). Thus, the utilization of unconventional sources of water is becoming vital.

B. Water Reuse in Developed Versus Developing Countries

Successful direct and indirect water reuse projects have been implemented in both developed and developing countries. The development of these projects has been driven by the need to overcome water shortage problems. Yet, several challenges have faced the implementation of these projects. In addition to the technical challenges of water quality control, the most difficult challenge has always been to break down consumers' psychological

barriers to the principle of direct reuse for potable purposes. Table 1 presents a summary of some of the successful projects in some countries.

Table 1: Some of the successful projects in developing countries

Project	Place	Year	Treatment	Comments	Uses	Source
Goreangab Water Recalamtion Plant	Windhoek , Namibia	1968–2002 Upgrade 2002–now	Sand filtration, pre-ozonation, ozonation, ultrafiltration, chlorination, etc	• The upgraded reclamation plant meets the newest technological standards and potable water demand.	Sometimes used for direct potable purposes.	(Lempert, 2007), (Koncagül, 2015)
The Sulaibiya Wastewater Treatment and Reclamation Plant	Kuwait	2004	The largest facility of its kind in the world to use reverse osmosis (RO) and ultrafiltration (UF); depends on membrane-based water purification systems	• Capable of contributing to up to 26% of Kuwait's overall water demand. • Water quality treats wastewater to World Health Organization (WHO) potable quality standards for non-potable use in agriculture, industry and aquifer recharge.	Non-potable uses	(Alhumoud & Madzikanda, 2010)
Soukra irrigation scheme	Tunisia	1965		Irrigation of citrus orchards and olive trees	Non-potable uses	(Choukr-Allah, 2008)
	Tunisia	2008	secondary treatment	• 61 wastewater treatment plants (2008) • Cultivators pay subsidized charges for the treated wastewater used for irrigating their lands • Social constraint is a major inhibiting factor. • Only 20-30% of WW is reused.	Non-potable uses Agricultural and golf course irrigation	(Bahri, 2008) (Guardiola-Claramonte, Sato, Choukr-Allah, & Qadir, 2012) (JMWI, 2009)

	Jordan	For several decades	Stabilization ponds (natural aeration, facultative, anaerobic lagoons), Screen, grit removal, primary sedimentation, biological process, secondary sedimentation, disinfections, ...	• 21 domestic wastewater treatment plants (2008) • A top leader in WW policy framework and institutional support in the Middle East in the region. • Water authorities in Jordan set a plan in 2009 to support wastewater reuse in irrigation. • Jordan is encouraging the reuse of treated WW at the household level; particularly to irrigate plants in home gardens.	Non-potable uses; Mainly for irrigation	(Guardiola-Claramonte, Sato, Choukr-Allah, & Qadir, 2012) (Choukr-Allah, 2008) (Al-Zboon & Al-Ananzeh, 2008)

C. Factors Influencing the Acceptance of Water Reuse

A noteworthy amount of experimental work has been conducted in both developed and developing countries to study the level public acceptance to use treated wastewater (UNWater, n.d.). However, literature on public perception towards the reuse of treated wastewater is controversial and there have always been disagreements in studies examining the factors affecting the acceptance of reusing treated wastewater. Among these factors are the risk perception, type of use, trust in authorities, awareness and knowledge, cost of treated wastewater and socio demographic factors (age, gender, education, income...).

1. Risk Perception

Disgust or "Yuck" factor, as a hurdle to treated wastewater reuse has been mentioned in the literature since the early 1970s at the beginning of public perception studies towards reuse. A disgust reaction in using recycled water is likely to be generated from people's perceived 'dirtiness' of the water and their fear of personal contamination from using the water(Po, Kaercher, & Nancarrow, 2003). People perceive treated wastewater as filthy and unclean, thus a disgust reaction is generated that motivates people to stay away from using recycled water in order to prevent illness and disease. They believe that products can be contaminated because of the wastewater and both drinking and/or using treated wastewater will pose health risks to the user(s)(Fielding & Roiko, 2014). Communities perceive that concerns about water quality continue to stall the uptake of treated wastewater reuse, although many groundwater and surface water supplies are not free of contaminants today. A review of studies suggests that community acceptance is higher when:

- Protection of public health is clear.
- Reuse is regarded safe for intended uses.

- People are aware of water supply problems.
- Confidence in the local management of public utilities and technologies is high.
- Positive economic impacts of reuse are communicated.
- Successful implementation of projects in other countries is communicated (Khan & Gerrard, 2006).

Perceptions regarding the treated wastewater reuse are related to water quality issues, adequacy of water resources, awareness of reuse applications and possible health risks posed by reusing. People are afraid of potential pathogens and toxic substances present in the treated wastewater.

In addition, risk perception is associated with a community's norms, traditions and religion. For example, the primary reasons for opposition in Bahrain were health risks, followed by psychological repugnance and religion; as some Muslims believe that treated wastewater cannot be used because of its "unclean" origin (Madany, Al-Shiryan, Lori, & Heyan, 1992).Meanwhile, in other studies, no evidence was found to support the proposition that adherents to Islam reject potable reuse on religious grounds (Wilson & Pfaff, 2008).

2. Type of Use

It is anticipated that accepting the idea of treated wastewater reuse depends upon three main factors: the particular intended use, correlated with the levels of closeness to the person, and the degree of treatment (Baumann, 1983; Madany, Al-Shiryan, Lori, & Heyan, 1992; Toze, 2006; Jefferson, 2004). In other words, most people, are less favorable towards reused water in the household or as it physically comes closer to them or when the likelihood of personal physical contact of the treated wastewater of an individual is high. For example, public opposition for potable water reuse is expected to be higher as compared to landscape irrigation. Thus, when usage involves direct body contact such as drinking and cooking,

acceptance rates are expected to be at their lowest (Baumann, 1983; Dolnicar & Schafer, 2009; Madany, Al-Shiryan, Lori, & Heyan, 1992). On the other hand, when usage is perceived as most distant from persons such as for golf course irrigation and industrial use, public support is at its maximum(Dolnicar & Schafer, 2009). In other words, they are more supportive of the irrigation of public parks but baulk at the use of reused water in the household or when the chance of personal physical contact increases (Toze, 2006) .

3. Trust in Authorities and Awareness/knowledge

The success of any reuse project is directly related to the public knowledge and awareness; hence it is always essential to understand if community members are aware of possible reuse applications (Buyukkamaci & Alkan, 2013). Awareness about current or future water scarcity problems have been found to be important in shaping people's willingness to use treated wastewater, with acceptance being associated with water shortages and experiences of water restrictions (Bakopoulou &Kungolos, 2009; Bakopoulou, Polyzos, &Kungolos, 2010; Dolnicar, Hurlimann, &Grun, 2011). Moreover, people who drink tapwater have a higher probability of using treated wastewater. In other words, drinking tap water (as opposed to bottled water) has been regarded as an important factor for foreseeing an intention to drink treated wastewater (Gibson & Burton, 2013). Often, although controversial, peoples' knowledge is shaped by age, gender, education and income and is bounded by the risks and benefits of wastewater reuse. Thus, raising public awareness and striving to change communities' attitudes on wastewater reuse are worldwide objectives, although it is foreseen that there is no direct relationship between awareness and attitude change (Abu-Madi, Al-Sa’ed, Braadbaart, & Alaerts, 2008). People’s trust in authorities who are responsible for managing treated wastewater influence their attitudes. The availability of skilled labor and

efficient management is a concern among people (Nijhawan, Labhasetwar, Jain, & Rahate, 2013).

Most often, individuals do not trust local municipalities or governmental officials and their ability to handle and operate wastewater treatment correctly and supervise the application process adequately (Fielding & Roiko, 2014). Attitudes of consumers however, are subject to change. Awareness and knowledge can be extremely effective if correctly implemented. Media (TV, radio, newspaper) is the most dominant way of raising public awareness (Buyukkamaci & Alkan, 2013). Consumers are also responsive to community leaders and environmental specialists (Abu-Madi, Al-Sa'ed, Braadbaart, & Alaerts, 2008).

4. Cost of treated wastewater

Contradictory evidence exists in the literature regarding the correlation between the price of treated wastewater and willingness to use it. Different studies showed that people who accepted to buy or consume treated wastewater were willing to pay less than the amount they paid for fresh water (Menegaki, Hanley, & Tsagarakis, 2007). Increasing the price of conventional water resources in order to favor the reuse of treated wastewater has not significantly affected respondents' willingness to use recycled wastewater (Baumann, 1983). Regardless of the price, community members in the mentioned study were not willing to accept reusing treated wastewater. Thus, public campaigns emphasizing the potential economic benefits of a water reuse project to the city in general and to the individual end user in particular are essential (Friedler, Lahav, Jizhaki, & Lahav, 2006).

5. Socio Demographic Factors

a. Age

According to the literature, socio demographic factors such as age, for example, seem to play an important role in accepting/rejecting wastewater reuse practices. Studies have shown that younger people are more likely to consume products irrigated with treated wastewater than the elderly (McKay & Hurlimann, 2003; Tsagarakis, 2005; Menegaki, Hanley, & Tsagarakis, 2007).The acceptance has been possibly shaped by the effects of lower education, knowledge and income. For example, respondents aged 50 and above are more reluctant to consume treated wastewater than those under 50(Baumann, 1983). Previous studies have pointed out that women, the elderly, and persons with less education are inclined to view risks associated with treated wastewater reuse as greater than others, though these results are inconsistent across the literature (Mankad &Tapsuwan, 2011; Po et al., 2003; Robinson, Robinson, & Hawkins, 2005).

b. Education

The single personal characteristic found consistently over several years in the literature to be related to the acceptance of treated wastewater reuse is education (Dolnicar & Schafer, 2009).It is perceived that an individual with a higher education is more likely to support the wastewater reuse practices and is more willing to participate in projects and pay to consume products irrigated with treated wastewater. According to studies, people who attend or graduate from college are more favorable to wastewater reuse than those with secondary education or less. The level of education is directly related to the general knowledge of the individual, his/her perception that treated wastewater is not disgusting or irritating and awareness about the importance of conserving water. Better educated persons are more likely to express greater faith in science and technology, hence are more likely to accept the reuse of treated wastewater (Baumann, 1983). Similarly, the single factor that had been most frequently found to be associated with the acceptance levels of treated wastewater

in a study conducted in Kuwait was the education of the individuals expressing their opinion, followed by age and knowledge about reuse, income and gender having been identified as associated in one third of the studies(Alhumoud & Madzikanda, 2010).

c. Gender

A person's gender is weakly related to the willingness to reuse and/or the attitude towards reusing treated wastewater (Baumann, 1983). Gender has not appeared to be among the main drivers that influenced peoples' attitudes. Men are somewhat more willing to consume/ accept to use treated wastewater than women (Baumann, 1983). Examples from literature show that usually both genders feel unfavorable toward using treated wastewater for groundwater recharge and less favorable towards laundry use as compared to golf irrigation, car washing and agricultural irrigation(Robinson, Robinson, & Hawkins, 2005; Dolnicar & Saunders, 2006). However, women particularly, tend to be significantly less favorable to treated wastewater reuse for potable purposes. This is because women are the principal users of water in homes, especially in patriarchal communities, thus are more critical of their households' water (Madany, Al-Shiryan, Lori, & Heyan, 1992).

d. Income

More studies have been conducted examining the influence of farmers' income on reuse of water as compared to consumers. No significant differences in attitude on wastewater reuse among people with different income levels have been observed (Robinson, Robinson, & Hawkins, 2005). One of the exceptions was the study conducted in Crete, Greece, where poor people were more willing to consume olives irrigated by treated wastewater. Because olive oil is a product used daily in large quantities in Greek cuisine,

poorer people's budgets would be relieved by cheaper olive oil (Menegaki, Hanley, & Tsagarakis, 2007).

CHAPTER III

METHODOLOGY

A. Instruments

1. Survey questionnaire

For the acquisition of primary data, a survey questionnaire was administered (refer to Appendix 1 for the questionnaire). The questionnaire consists of six sections to be filled by participants. Section one elicited information on potable and non-potable water use patterns like source, distance, availability, cost, problems encountered in non-drinking water and perceived risk. Section two aimed to provide useful insights regarding the level of opposition to and support for various water reuse options. The options were divided into three categories namely low, medium and high contact. Participants were asked to mark each of the reuse options (agricultural and urban irrigation, industrial use, toilet flushing, laundry, bathing, cooking, none) on a scale from 1 to 5 (1: strongly opposed; 2: opposed; 3: indifferent; 4: supportive, 5: strongly supportive). Section three assessed participants' perception/knowledge regarding water reuse and aimed to find out the underlying reasons why they would support reusing treated wastewater. Participants were asked for their opinion regarding a list of statements that identifies their perceptions towards reuse. Section four elicited information with regards to public trust and who the participants trust and to what degree. Participants were representatives of households in the administrative Beirut area. Section five assessed participants' willingness to use and willingness to pay for treated wastewater and the last section aimed to extract information on socio-demographic variables including gender, education, marital status and income level. The questionnaire was not self-administered but rather completed by the researcher herself. Thus, illiterate/visually impaired subjects did not need to be excluded. The questionnaire was pre-tested to check for ambiguity,

misunderstanding and confusion over terms and questions and to ensure that the exact meaning of the questions was captured in the English-to-Arabic translation. A cover letter was attached to the questionnaire to explain the background and purpose of the study. In order to protect participant privacy and data confidentiality, certain measures were taken. For instance, names, addresses, date of birth and other identifiers were removed from the survey document. Study data is properly and securely stored within locked locations at the faculty of health sciences at the university.

B. Population and Sampling

The study area of the public survey encompasses Administrative Beirut which extends over an area of 19.6 km^2. This area is divided into 13 different zones. Three zones were excluded since they are non-residential. Therefore, the study includes the remaining ten zones. To compute the sample size needed, equation 1 was used within 5 % error and with 95% confidence interval. p-values were assumed to be 50% and Z value is 1.96 for 95% confidence level.

$$n = \frac{\left[(z)^2 \times p \times q\right]}{d^2}$$

Where:

n: Household sample size
z: Confidence interval
p: Probability of success
q: Probability of failure
d: Margin of error

The population of Administrative Beirut is approximately 400,000. Accordingly, the sample size is estimated at 300 which will be divided among the 10 zones chosen from Administrative Beirut, proportional to the distribution of population in those zones.

The unit of analysis of the study is the head of the household (i.e. age greater than 18 years old) (interviewee). The sampling units that make up the study sample are the residential households in Administrative Beirut Area. Random samples of digitized and geo-referenced residential buildings were taken from each zone to choose the buildings to be targeted. Household units, within each randomly chosen residential building, were then randomly selected. In the event of a non-response, rejection, and inaccessibility, an adjacent left-side building or household unit was selected.

C. Data Management

1. Data Entry

The collected data from the public survey was numerically coded to facilitate the use of latest version of the statistical program (v.20.0.0), namely the Statistical Package for Social Sciences (SPSS) software.

2. Data Analysis

Following the coding process, the data was subjected to statistical analysis. Frequencies of the various responses were worked out, interpreted, and explained in terms of the general trends that emerged from the analysis. Descriptive statistics of the study sample were carried out using SPSS to present the frequency distribution of the socio economic characteristics of the respondents, their general knowledge/awareness, behavior and perceptions regarding treated wastewater as well as their current water practices. Continuous variables, such as age, were reported in terms of mean and standard deviation. Relationships between the variables were explored. After identifying the major outcomes to be explored by this study,2 models

were developed to meet the objectives of this study and an analysis was carried out to investigate possible associations between predictor variables (independent variables) and the main outcome variables (dependent variables). Model 1, consisting of a set of potentially-significant independent variables to be associated with the main outcome: “variables affecting the willingness to use treated wastewater" (outcome 1). Possible associations between independent variables and outcome 1 are tested using this model will be helpful for developing future policies.

- Model 2, consisting of a set of potentially-significant independent variables to be associated with the main outcome: "variables affecting the willingness to use treated wastewater for non-potable purposes" (outcome 2). Possible associations between independent variables and outcome 2 are tested using this model will be helpful for developing future policies.

a. Models 1 and 2: Multivariate Regression Analysis

Binary logistic regression for univariate analysis was initially performed to test for any significant association between the predictor variables and the respondent variable. A cut-off point for statistical significance was obtained at 95% confidence interval, where P-value less than 0.05 indicates a statistically significant association. Following univariate regression analysis, multivariate logistic regression was carried out to identify the best combination of predictor variables for each outcome of interest for each model. Unadjusted Odds ratio (OR) for each significant predictor variable was obtained at 95% confidence interval.

The multivariate logistic regression models containing more than one predictor variables were calculated using the below mentioned formula:

$$\log\left(\frac{p_i}{1-p_i}\right) = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip}$$

P: probability of the event of the dependent variable Y,

Alpha: Y- intercept parameter,

Beta: slope parameters,

X_i: predictor independent variables

D. Ethical Considerations

The study was conducted in the Administrative Beirut Area, where survey questionnaires were administered to randomly selected participants/respondents in accordance to the guidelines on human subjects for Social and Behavioral Sciences as set by the International Review Board at the American University of Beirut. All information provided by respondents were anonymous. No identifying questions that could directly or indirectly disclose a respondent's identity or personal information were asked. Results and findings of this study were solely used for the purpose of this Project Subject participation was strictly voluntary. An IRB signed written informed consent, including the research objectives, was provided to the participants prior the start of administering the questionnaire.

CHAPTER IV

RESULTS AND DISCUSSION

A. Respondents Demographic and Socio-Economic Characteristics

A total number of 300 questionnaires were collected from the Administrative Beirut Area between the months of February and March of 2016. The sample somehow showed gender bias; it consisted of 58.6% females (N= 174) and 41.1% males (N= 122). Mean age of the interviewers was around 46 years old (minimum age = 18; maximum age = 85) with the majority of the respondents falling in the range of 35-49 years old (30%). About 71% of the interviewers were married and 29% were single. The average number of persons per household was around 4 persons (mean= 3.64). About 54% of the respondents have attained university degrees, while 27.8% have reached intermediate education, 9.2 % elementary and 7.8% have held technical degrees (Table 2). It is worth mentioning that the high educational level is not reflective of Lebanon, but only the Administrative Beirut Area. About 60% of the interviewers were employed at the time when this survey was conducted. The majority of those who were unemployed were either housemakers or retirees (people aged 64 and more). Nearly a quarter of the respondents reported that they had a monthly income between 1,000 and 3,000 $US and almost a quarter did not report their monthly income (in $US). A possible explanation for the high percentage of non-response rates regarding the monthly household income could be privacy reasons. No conclusion can be drawn regarding the monthly income of the interviewees versus the national minimum monthly wage which is currently set up at LBP 675,000, or the equivalence of US$ 450(Dar-el-Handesah, 2014).

The sample in this study was calculated based on the total population density in the Administrative Beirut Area. This means that, although this sample is representative of the

Administrative Beirut Area, it cannot represent the national profile of the country because of differences in socio economic and demographic characteristics prevailing in the country.

Table2: Demographic and socio economic background of respondents

Characteristics	Frequency (%)
Gender (N=297)	
Male	122(41.1)
Female	174(58.6)
Age, Mean (±SD) (N=272)	46.14 (±16.272)
Education (N=295)	
Elementary	27 (9.2)
Intermediate	82 (27.8)
University	160 (54.2)
Technical	23 (7.8)
Household Size, (±SD) (N=292)	3.64 (±1.594)
Currently Employed (N=284)	
No	116 (40.6)
Yes	168 (58.7)
Monthly Household Income (in USD) (N=294)	
Less than 500	14 (4.8)
Between 500 and 1000	55 (18.7)
Between 1000 and 3000	86 (29.3)
Between 3000 and 5000	32 (10.9)
Between 5000 and 10000	23 (7.8)
Greater than 10000	2 (0.7)
No answer	82 (27.9)

B. Most commonly used sources of water

Awareness of water supply problems is high in the Administrative Beirut Area. About seventy percent (70%; N=207) of the respondents reported that they personally suffer from water scarcity problems (Table 3).Public water supply is mainly used for domestic purposes. Around a quarter (32%) of the surveyed population who used network water for various purposes reported to have water supply four times per week while 25% mentioned they receive network water three times a week. Moreover, more than half (nearly 64%) of the network water users were not satisfied by the quality they are receiving.

To meet their domestic potable and non-potable needs, households in Beirut not only rely on governmental water network alone, but also they use well water, water tankers and bottled water. Respondents use well water for all types of domestic purposes except drinking and cooking. Nearly 87% of the interviewees who used well water declared that their wells were shared by apartments of the same building. It is estimated that the annual yield of public wells operated and maintained by public establishments in Beirut and Mount Lebanon are 138 wells and yield nearly 76 mm^3/year (El Hassan, 2010). Water from tankers is used especially for non-potable domestic uses. About 86% of the household members interviewed who reported using water from tankers mentioned that they use it upon need. Nearly 83% of these persons do not know the source of the received water tanker. The majority (77%) of the households use water bottles for drinking.

When interviewers asked the households' representatives whether or not they are satisfied by the quality of the water reaching their houses from different sources, nearly 11%of the well water users reported their satisfaction, 11% of the tanker users reported their satisfaction from this source, while 75% of the bottled water users were pleased by the quality of bottled water they are using. Some of the individuals claimed that the water they are receiving is turbid and not clean, has odor and is contaminated and others mentioned that they don't know the source of water they are buying from tank owners (Table 3). The low satisfaction levels can be explained by the additional cost (minimum of LBP 25,000 per 2 cubic meter tank) and jeopardized quality especially that households are not aware of the sources of the water tankers. Poor water quality encourages individuals to purchase more bottled water than they would normally consume had they had access to high-quality drinking water.

Table 3: Most commonly used sources of water

Characteristics	Frequency (%)
Suffering from water scarcity problems (N=295)	
Yes	70.2
Other[1]	29.8
Sources of household water (N=300)	
Network Water	93.33
Well Water	20.33
Water Tanker	28.67
Bottled Water	71.33
Satisfied by the quality of	
Network Water	33.4
Well Water	10.7
Water Tanker	10.7
Bottled Water	75

Other includes No(not personally suffering from water shortage problems= 27.8%) and No clue (2.0%).

C. Respondents perception and knowledge on wastewater reuse

Knowledge is important when it comes to evaluating the perception of the community towards the use of treated wastewater (Table 4). The results showed that 34% of those sampled had not heard about the term wastewater reuse, while nearly 19% reported they had heard the term and are aware of its uses but do not know its significance. In other words, they are aware of reuse initiatives in the region or in developed countries but lack information about how/why water is reused. Finally, 47% reported they had heard and knew the meaning of treated wastewater reuse. No link was found between the level of education and those who reported that they know the meaning of treated wastewater reuse (Table 4). In a similar study conducted in Kuwait, about 38% of the respondents had no knowledge, while 47% had some knowledge and only 14% had knowledge when they were asked about the reuse of treated wastewater (Alhumoud & Madzikanda, 2010). When asked about their willingness to use,

approximately 51% of the interviewers had accepted the use of treated wastewater for non-potable uses, while only 15% had shown willingness to use treated wastewater for potable purposes. This high percentage, as mentioned earlier, can be a result of the inaccurate responses provided by the respondents in order to impress the interviewers.

Table 4: General Knowledge about Wastewater

Characteristics	Frequency (%)
Awareness of the term treated wastewater	
Have not heard about it	34.3
Have heard and know what it means	46.8
Have heard but don't know what it means	18.9
Do you accept to use treated wastewater for non-potable purposes?	
Yes	50.7
No	38.3
No Clue	11.0
Acceptance to reuse treated wastewater for:	
Agriculture/landscaping	80.8
Industrial Use	72.0
Toilet Flushing	75.6
Clothes Washing	55.3
Showering/Bathing	43.7
Cooking	23.7
Do you accept to use treated wastewater for potable purposes?	
Yes	15.1
No	79.5
No Clue	5.4

Although there are some wastewater treatment plants operating in the country, almost all the respondents have no prior experience with reusing treated wastewater. Thus, questions about the likelihood to use this alternative source of water are hypothetical and reflect the perception of the residents in the Administrative Beirut Area. Around 60% of the participants think it is risky to use treated wastewater (Table 5). Interviewers were asked a list of questions through which their general knowledge about wastewater was deduced (Table 5).Many people trust their own impressions of water quality (often based on the turbidity of

the water) more than they trust scientific evidence. Their impressions might be due to their lack of confidence in local management of public utilities, and the lack of people's public health and environmental awareness. In addition to religious beliefs, it is psychologically very difficult for people to accept that water being previously in contact with contaminants is purified and clean. From this perspective, they consider treated wastewater of inferior quality that might pose health risks.

Less than a quarter (21%) of the total respondents considered treated wastewater reuse as religiously unacceptable ("Strongly Agree"=10.4%; "Agree"=10.4%) while 63.7% of the interviewers believed that it is disgusting to reuse water that once was contaminated with waste. The majority of the respondents (58%) believe that treated wastewater is of inferior quality (Table 5). Nearly 47% trust there is plenty of freshwater to use, thus using treated wastewater is not needed. A large percentage of the household members interviewed (42 %) believe that the incidence of disease outbreak would increase with the treated wastewater reuse. Table 5 represents the perception of residents in the ABA to diarrhea, Typhoid Ascariasis, Hepatitis A, cholera, salmonella.

Table 5: General Knowledge about Wastewater

Characteristics	**Frequency (%)**
Treated wastewater reuse is risky	
Yes	58.2
No	41.8
Treated wastewater is of inferior quality	
Strongly Agree	14.7
Agree	43.2
Other[1]	42.0
No need to reuse treated wastewater; there is plenty of freshwater	
Strongly Agree	20.4
Agree	25.9
Other[2]	53.4
Incidence of disease outbreak increases with treated wastewater reuse	
Yes	42.3
No	57.3
Treated wastewater reuse leads to diarrhea	

Strongly Agree	20.9
Agree	26.7
Other[1]	52.4
Treated wastewater reuse leads to typhoid ascariasis	
Strongly Agree	21.4
Agree	21.0
Other[1]	57.6
Treated wastewater reuse leads to hepatitis A	
Strongly Agree	17.0
Agree	25.9
Other[1]	57.1
Treated wastewater reuse leads to cholera	
Strongly Agree	20.5
Agree	24.2
Other[1]	55.3
Treated wastewater reuse leads to salmonella	
Strongly Agree	18.6
Agree	23.0
Other[1]	58.5

[1]*Other includes "neutral", "disagree" and "strongly disagree".*

[2]*Other includes "disagree" and "strongly disagree".*

Uses involving closer human contact with treated wastewater but minimal likelihood of ingestion (such as toilet flushing) seemed to have a higher acceptance rate as compared to direct contact uses such as drinking, cooking and bathing. Out of the total who accepted to use treated wastewater for non-potable uses, 76% for toilet flushing and 72% for industrial use (Table 4). In addition, nearly 81% reported their willingness to use treated wastewater for agriculture/landscaping. The high percentage of acceptance of wastewater reuse for car washing is because the level of direct contact with the reusable water (particularly ingestion) is minimal. On the other hand, the high levels of acceptance for agricultural purposes can be due to the fact that consumers are already aware that some farmers use untreated sewage water to irrigate fruits and vegetables. The acceptance rates decreased to 55% for clothes washing, 44% for showering/bathing and 24% for cooking. It is thus clear from our results that the level of human contact with the treated wastewater is crucial in determining the

acceptance of treated wastewater reuse because generally, public opposition for wastewater reuse decreases when the level of contact with the reusable water decreases (Jefferson, 2004). These results are in accordance with regional studies; for example, people in Kuwait refused to use advanced treated wastewater for drinking, cooking, showering/bathing and clothes washing (Alhumoud & Madzikanda, 2010). Similar results were observed in a study conducted in Bahrain, where 96.4% and 94.2% of the individuals surveyed were opposed to using reclaimed water for drinking and cooking purposes, respectively, whereas this opposition decreased as the proposed use of treated wastewater was not associated closely with personal contact (Madany, Al-Shiryan, Lori, & Al-Khalifa, 1992).

About 60% of the interviewers were aware that treated wastewater reuse conserves potable water ("Strongly Agree"=23.8%; "Agree"=34.9%). Furthermore, 60.7% were aware that reuse improves soil productivity ("Strongly Agree"=21.8%; "Agree"=38.9%). In addition, 60% were alert that reuse saves money ("Strongly Agree"=26.8%; "Agree"=33.2%) (Table 6). Awareness regarding the advantages of treated wastewater of the household members interviewed is minimal. Although the link between awareness and acceptance to use treated wastewater is controversial in the literature, as mentioned earlier, the data in our study suggests that there is an immediate need in promoting public awareness and knowledge regarding wastewater through different media including TV, newspapers, university professors, NGOs etc.

Table 6: General Knowledge about Wastewater

Characteristics	**Frequency (%)**
Perception treated wastewater is disgusting	
Strongly Agree	35.0
Agree	28.7
Other[1]	36.3
Perception wastewater reuse is not religiously accepted	
Strongly Agree	10.4
Agree	10.4

Other[1]	79.2
Do you think treated wastewater reuse will conserve potable water?	
Strongly Agree	23.8
Agree	34.9
Other[1]	41.3
Do you think treated wastewater reuse will improve soil productivity?	
Strongly Agree	21.8
Agree	38.9
Do you think treated wastewater reuse will help us save money?	
Strongly Agree	26.8
Agree	33.2
Other[1]	39.9
Trust in authorities	
Members of the Parliament	12.6
Municipalities	16.4
Public Health and environmental NGOs	53.1
University professors	72.8
Media	20.3
Internet articles	22.3

[1]*Other includes "neutral", "disagree" and "strongly disagree".*

The success of water reuse projects depends on the credibility of information provider. From our results, the sample population of our study showed low levels of trust to authorities and media. This might be because throughout the years, the residents of Beirut have not witnessed any type of commitment from members of the parliament (MPs) or their municipal councils that promoted their welfare. The study showed that 87.4% and 83.6% of the respondents did not trust the parliament or municipalities respectively (Table 6) when it comes to the operation of the treatment plant properly or supervise the application process adequately. It was found that interviewers believed that water authorities will fail to manage and supervise the water treatment plant adequately and to deliver safe and high quality water. When asked whether or not they trust the public health sanitation/environmental NGOs and academicians, 47% and 27% of the respondents reported mistrust towards them respectively. Furthermore, 80% of the surveyed Administrative Beirut Area residents have no trust in

information communicated through social media (newspapers, TV stations and radios) and 77.7% in the articles accessible on the internet (Table 6). This might be because media institutions are operated by subjective porters, who are affected by the socio-political context of Lebanon; making it impossible for these media institutions to be completely accurate and objective in their reporting.

D. Respondents Willingness to pay for wastewater reuse

About 34% of the respondents in the administrative Beirut area are not willing to participate in programs that support the use of treated wastewater or are willing to use treated wastewater. Nearly half of the respondents (51%) showed willingness, 16% had no clue regarding their support of such programs, while the remaining 33% was not willing to use treated wastewater (Table 7). It is worth noting that a number of studies have investigated the acceptance level of different forms of water reuse. For example, in the United States, the average opposition level for potable use among different studies was summarized to be equal to 54% (range 44-63%)(Dishman, Sherrard, & Rebhun, 1989). Moreover, 96% of respondents in a study conducted in Kuwait were strongly opposed against using treated water for domestic use. Opposition levels regarding willingness to use and pay for treated wastewater might be shaped by geographical differences, cultural norms and traditions and socio economic characteristics.

Furthermore, 45%of the interviewees were not willing to pay extra on their current water bills in order to build a new system for water reuse while 41% were willing to pay (Table 7). No significant association was found between the willingness to pay extra on the bill to build a plant and the awareness on the advantages that treated wastewater can bring, such as saving money, soil productivity and conservation. Moreover, no significant association was found between those willing to pay extra on their current water bills and their

level of education or their trust in NGOs. More than half of the interviewees reported their willingness to pay for treated wastewater, where 29% reported their willingness to pay the same amount, 17% less than, and 11% more than the amount they paid for regular water; meanwhile, 27% of the interviewers weren't willing to pay for treated wastewater (Table 7). Those who refused to pay for treated wastewater were the less educated and with no awareness about the term treated wastewater.

Table 7: Respondents' willingness to pay for wastewater reuse

Characteristics	Frequency (%)
Willingness to participate in programs that support the use of treated wastewater	
Yes	50.5
No	33.9
No clue	15.6
Willingness to pay extra on current water bills for the cost of building a system	
Yes	40.8
No	44.6
No clue	14.6
Amount paid for treated wastewater	
same amount as regular water	29.0
less than regular water	17.3
More than regular water	10.6
No pay	27.2
Other	15.9

E. Factors influencing Willingness to Use Treated Wastewater and Specifically for Non-Potable Purposes

Model 1 studies the correlation between predictor variables and willingness to use treated wastewater in general, while Model 2 studies specific correlations of predictor variables affecting the willingness to use treated wastewater for non-potable purposes only.

1. Model 1: Variables affecting the willingness to use treated wastewater

a. Logistic Regression- Univariate Analysis

Logistic regression was adopted in an effort to find the predictors affecting people's willingness to use treated wastewater. Significant variables at the 95% CI are discussed below:

- *"Disgust towards reuse of treated wastewater";* Strong significant predictor variable (OR=2.848, p-value<0.05); where those who believed it is disgusting to reuse treated wastewater are on average, three times less likely to be willing to use treated wastewater.
- *"Religion";* Strong significant association with respondents' willingness to use treated wastewater (OR=1.88, p-value<0.05). Interviewers who thought treated wastewater reuse is not religiously accepted are, on average, two times less likely to show willingness regarding the use of treated wastewater.
- Diseases such as *"Diarrhea"* (OR=2.525, p-value<0.05), *"Typhoid Ascariasis"* (OR=2.86, p-value<0.05), *"Hepatitis A"* (OR=2.586, p-value<0.05), *"Cholera"* (OR=2.277, p-value<0.05), *"Salmonella"*(OR=2.092, p-value<0.05) were found to be significant. Those who perceived that reusing treated wastewater would lead to diseases and affect the human health, were on average, two times less likely to accept the reuse (average of ORs for all types of diseases).

b. Logistic Regression- Multivariate Analysis

Significant univariate predictor variables for willingness to use treated wastewater were then subjected to multivariate logistic regression analysis. As expected, not all the predictor variables found to be significant at the univariate analysis level were also significant at the multivariate analysis level. The significant ones were: *Typhoid Ascariasis* (OR=1.876, p-value<0.05), *Disgust Factor* (OR=1.948, p-value<0.05), and *Religion* (OR=1.366, p-value<0.05) (Table 8). In general, those persons who believed treated

wastewater reuse would lead to Typhoid Ascariasis, also believed that it would cause other diseases such as diarrhea, hepatitis A, cholera and salmonella. Therefore, waterborne diseases in general, are highly correlated with willingness to use treated wastewater. Disgust factor alone does not explain the negative public response of the community members. A possible explanation can be that the level of knowledge about reuse within the inhabitants of Beirut is relatively low as compared to USA and other European countries. Have people had previous experience or have heard about successful implementation stories/examples, they were likely to know more about certain advantages such as water conservation, soil productivity and economic benefits and become less reluctant towards using treated wastewater.

Table 8: The significant predictor variables tested for their association with willingness to use treated wastewater at multivariate logistic regression.

(B: regression coefficient, Wald: Wald statistic, tests statistical significance, df: degrees of freedom, Exp (B): odds ratio for each variable category).

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
Typhoid ascariasis	.629	.180	12.280	1	.000	1.876
Disgusting to reuse treated wastewater	.667	.177	14.149	1	.000	1.948
Treated wastewater reuse not religiously accepted	.312	.140	4.968	1	.026	1.366
Constant	-3.547	.590	36.142	1	.000	.029

Variable(s): typhoidascariasis, disgusting to reuse treated wastewater, treated wastewater reuse not religiously accepted.

2. Model 2: Variables affecting the willingness to use treated wastewater for non-potable purposes

a. Logistic Regression – Univariate Analysis

Similar to the analysis of Model 1, several predictor variables for willingness to use treated wastewater for non-potable purposes was subjected to univariate logistic regression analysis. Explanations for the significant variables are presented below (95% CI). Refer to Appendix 3 for the tables.

- *"Preferred responsible entity for communication";* strong significant association was found with peoples' willingness to use treated wastewater for non-potable purposes (OR=1.490, P-value=0.02 and OR=1.49, p-value<0.05), where those who had *"Trust in public health and environmental NGOs"* and *"Trust in academicians/professors"* were nearly 1.5 times more likely to reuse water for non-potable purposes, as compared to other entities such as municipalities, MPs, and media.
- *"Age";*(OR=0.647;p-value= 0.02) was found to be a significant predictor variable of willingness to use treated wastewater for non-potable purposes at 95% CI; elder people (age>64) in the population sample on average, were1.5 times less likely to consume or use treated wastewater for non-potable purposes.
- *"Level of education";* a significant parameter for predicting peoples' willingness to use treated wastewater for non-potable purposes (OR= 0.509; p-value=0.01); where those who have not attained a university education were 2 times less likely to accept then those who had obtained higher education.
- *"Awareness of the term treated wastewater";* a strong statistically significant predictor variable influencing the willingness to use treated wastewater for non-potable purposes (OR= 14.6; p-value<0.05). Those who have heard the term treated wastewater and know its meaning are 14 times more likely to be willing to use it for non-potable purposes as compared to those who haven't heard about it.

b. <u>Multivariate Logistic Regression Analysis</u>

Significant variables resulting from the univariate binary logistic regression analysis or willingness to use treated wastewater for non-potable purposes were then subjected to multivariate logistic regression (Model 2). The significant variables were the level of education, awareness of treated wastewater and trust in academicians (Refer to table with the respective OR and p-values).

University graduates appeared to be 6 times more willing to reuse treated wastewater for non-potable uses (significance level, alpha=0.05; p-value<0.05). The results are in accordance with the findings of various studies conducted in Trinidad, Bahrain and Kuwait, where people with high educational attainment showed greater willingness, compared to others, to use treated wastewater for different purposes(Peters & Goberdhan, 2016)(Madany, Al-Shiryan, Lori, & Al-Khalifa, 1992)(Alhumoud & Madzikanda, 2010). University graduates, usually younger individuals, utilize a broader array of information sources different from the traditional sources (newspapers, radio) for environmental news, thus are more familiar with success stories and advantages of possible uses of treated wastewater in various countries.

Age did not have any significant effect on the outcome in the multivariate regression model. This means that future campaigns and programs promoting the use of treated wastewater for non-potable purposes are not expected to be influenced by the age of the involved persons and hence such campaigns should target all age groups. Furthermore, because people's trust to academicians seemed to be very high, in addition to environmental and public health NGOs, these awareness campaigns should be communicated and promoted by academicians to find responsiveness among community members.

The findings are in agreement with a study on potential consumers' perception of treated wastewater reuse in Trinidad, in which no significant statistical differences between age groups and their willingness to use treated wastewater for non-potable purposes (Peters &

Goberdhan, 2016). Although attempts have been done to incorporate environmental educational activities and courses in the sciences program of Lebanese curriculum at schools, our findings imply that younger consumers are not necessarily more proactive with regards to environmental concerns.

Awareness of the term treated wastewater was another significant predictor variable at 95% CI (OR=1.54; p-value= 0.033, where those who have heard of the term and knew its meaning were nearly 1.8 times less likely to accept it. Furthermore, trust in academicians was significantly associated with the people's willingness to use treated wastewater for non-potable uses (OR=0.43p-value= 0.007).

Table 9: Table for the significant predictor variables tested for their association with willingness to use treated wastewater for non-potable purposes at multivariate binary analysis level.

(B: regression coefficient, Wald: Wald statistic, tests statistical significance, df: degrees of freedom, Exp (B): odds ratio for each variable category).

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
awareness of the term treated wastewater	.435	.204	4.533	1	.033	1.545
level of education	-1.752	.283	38.229	1	.000	.173
Trust in academicians	-.835	.311	7.228	1	.007	.434
Constant	5.759	1.091	27.850	1	.000	317.021

Variable(s) entered: Trust in academicians, level of education, awareness of the term treated wastewater

CHAPTER V

CONCLUSIONS AND RECCOMENDATIONS

This study revealed that peoples' perception of the treated wastewater reuse is affected by disgust factor, religious beliefs, and perceived health risks associated with the reuse. Socio demographic factors and existing water shortage problems did not appear to be significantly related to the perception of the respondents. Our results indicate that the degree of acceptance of water reuse in ABA is a function of:

1. Degree of human contact with a slightly greater inclination towards the reuse for purposes with minimal human contact such as landscaping and agriculture.
2. Knowledge and awareness of the citizens in the ABA regarding different aspects of wastewater.
3. Confidence in the authorities managing treatment plants and the adopted technologies.

In order to ensure the maximum social acceptability regarding treated wastewater reuse, awareness campaigns should be designed to promote the water reuse projects in the country. These campaigns should be transmitted by academicians in addition to environmental and public health NGOs and must highlight potential health risks and benefits of using treated wastewater through training workshops, media, and educational institutions. Furthermore, the government of Lebanon should develop relevant policies and abide by WHO standards to minimize the hazards of wastewater reuse and to ensure safe and good quality treated water in Lebanon. Ultimately, the involvement of all stakeholders in improving the social acceptability towards wastewater reuse is mandatory (MPs, Municipalities, academicians, media, NGOs).

Limitations of this study:

- It is widespread practice that respondents are likely to provide inaccurate yet best responses regarding their perceptions, attitudes, behavior and practices in order to impress the interviewers.
- Most of the respondents were not aware how many liters of bottled water they use for drinking/ week and how much money do they spend for bottled water. Similarly, the water tanker users did not know how much they pay/m3 of water they are receiving from the distributers.
- The high number of persons not answering the monthly household income question might have possibly affected the results. This means that, the high percentage of the unanswered results rendered the income an insignificant variable for willingness to use treated wastewater for non-potable purposes.

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APPENDIX I

CONSENT FORM AND QUESTIONNAIRE

Dear Sir/Madam;

We are asking you to participate in a research study. Please read the information below and feel free to ask any questions that you may have.

The main objectives of the study include estimating the level of opposition to and support for various water reuse options, assessing the socioeconomic characteristics influencing the acceptance/rejection of water reuse and exploring the willingness to consume products irrigated with treated wastewater.

The survey is intended for academic purposes only. Participants will be randomly-selected. To keep the information provided by respondents safe and anonymous, the trained researchers will refrain from using any identifying questions that might directly or indirectly disclose your identity or personal information. There are no direct or indirect risks or benefits from participation in this survey. Data will be aggregated and reported in total. Your name will not be attached to your answers so that your confidentiality can be maintained. Results and findings of this study might be published and used in academic presentations. The estimated time needed to complete this survey is approximately 20 minutes. Your participation is strictly voluntary and if you decide to participate now, you may change your mind and stop at any time. We would like to thank you in advance for your participation. Shall you have any questions or clarifications or comments regarding the study; do not hesitate to contact us on the following addresses:

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Interviewer Initials				**Questionnaire Serial #**		
Interviewer #						

HOUSEHOLD IDENTIFICATION INFORMATION			
	Area / Zone:		
	Street Name (if applicable)		
	Street Number		
	Remarks: _____ _____ _____ _____		

I. General Knowledge Questions:

II. Household Sources of Water:

Section	**Question**	**Answer**	**Code**
GN1	What are the sources of water reaching your house?	Network Water	1
		Well Water	2
		Water Tankers	3
		Bottled Water	4
		Other	5
GN2	Do you personally suffer from water scarcity problems?	Yes	1
		No	0
		No clue	2
GN3	If yes, during which months of the year do you face this problem? (Choose all that are applicable)	January	1
		February	2
		March	3
		April	4
		May	5
		June	6
		July	7
		August	8
		September	9
		October	10
		November	11
		December	12
GN4	Water shortage problem that you face is related to:	Governmental water network	1
		Well water	2
		Water tankers	3
		Bottled water	4
GN5	What problems did you encounter in non-drinking water? (mention all)		

Questions about the household sources of water:			
Section	**Question**	**Answer**	**Code**
If you receive water from network water(NW):			
NW1		(amount) in LBP	1
		NA	2

	How much do you pay for network water/m^3/year?	I don't know	3	
NW2A	What purposes do you use the water you receive from the network?	Drinking	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2B		Washing Hands	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2C		Bathing/Showering	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2D		Washing Fruits/Vegetables	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2E		Cooking	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2F		Dish Washing	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2G		Cleaning the floors	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2H		Laundry	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2I		Irrigating your plants at home	Yes	1
			No	0
			Sometimes	2
			I don't know	3
NW2J		Other		
NW3	How frequent do you have network water supply?	(times) per week	1	
		Always	2	
		NA	3	
		Don't know	4	
NW4	How long does the network water supply remain, when available?	(times) per week	1	
		Always	2	
		NA	3	
		Don't know	4	
NW5A	Are you satisfied by the quality of the network water you are receiving?	Yes	1	
		No	0	
		I don't know	2	

NW5B	(** if no) Why are you not satisfied?	The water is not pure; the water is turbid	1	
		There is the odor of chlorine in the water	2	
		The water has bad taste	3	
		The water is polluted	4	
		Other	5	
If you receive water from well water(WW):				
WW1	Type of the well	Personal; for your house only	1	
		Shared among different apartments of the same building	2	
		Shared among different buildings	3	
		I don't know	4	
WW2	How much do you pay for water from well/year?	(amount) in LBP	1	
		NA	2	
		I don't know	3	
WW3A	What purposes do you use the water you receive from the well?	Drinking	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WW3B		Washing Hands	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WW3C		Bathing/Showering	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WW3D		Washing Fruits/Vegetables	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WW3E		Cooking	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WW3F		Dish Washing	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WW3G		Cleaning the floors	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WW3G		Laundry	Yes	1
			No	0

			Sometimes	2
			I don't know	3
WW3H		Irrigating your plants at home	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WW3I		Other		
WW4A	Are you satisfied by the quality of the well water you are receiving?	Yes	1	
		No	0	
		I don't know	2	
WW4B	(** if no) Why are you not satisfied?	The water is not pure; the water is turbid	1	
		There is the odor of chlorine in the water	2	
		The water has bad taste	3	
		The water is polluted	4	
		Other	5	
If you receive water from water tankers(WT):				
WT1	During which month usually do you start buying water for the tanks?	Always	1	
		Upon Need	2	
		NA	3	
		I don't know	4	
WT2A	How much do you pay for water tanker/year/m^3?	(amount) in LBP	1	
		NA	2	
		I don't know	3	
WT2B	What is the source of the water tanker you are receiving?	River	1	
		Well	2	
		Company	3	
		I don't know	4	
WT3A	What purposes do you use the water you receive from the water tankers?	Drinking	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WT3B		Washing Hands	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WT3C		Bathing/Showering	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WT3D		Washing Fruits/Vegetables	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WT3E		Cooking	Yes	1
			No	0
			Sometimes	2
			I don't know	3

WT3F		Dish Washing	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WT3G		Cleaning the floors	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WT3G		Laundry	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WT3H		Irrigating your plants at home	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WT3I		Other		
WW4A	Are you satisfied by the quality of the water tanker you are receiving?	Yes	1	
		No	0	
		I don't know	2	
WW4B	(** if no) Why are you not satisfied?	The water is not pure; the water is turbid	1	
		There is the odor of chlorine in the water	2	
		The water has bad taste	3	
		The water is polluted	4	
		Other	5	
If you receive water from water bottles(WB):				
WB1A	What purposes do you use the water you receive from bottled water?	Drinking	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WB1B		Washing Hands	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WB1C		Bathing/Showering	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WB1D		Washing Fruits/Vegetables	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WB1E		Cooking	Yes	1
			No	0
			Sometimes	2
			I don't know	3

WB1F		Dish Washing	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WB1G		Cleaning the floors	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WB1H		Laundry	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WB1I		Irrigating your plants at home	Yes	1
			No	0
			Sometimes	2
			I don't know	3
WB1J		Other		
WB2	Are you satisfied by the quality of the bottled water you are receiving?	Yes	1	
		No	0	
		I don't know	2	
WB3	(** if no) Why are you not satisfied?	The water is not pure; the water is turbid	1	
		There is the odor of chlorine in the water	2	
		The water has bad taste	3	
		The water is polluted	4	
		Other	5	
WB4A	How many bottles do you use/week for:	Cooking	(insert number)	1
			I don't know	2
WB4B		Drinking	(insert number)	1
			I don't know	2
WB5	How many liters are these bottles?	(insert number)	1	
		I don't know	2	
WB6	How much do you pay for each bottle?	(insert number)	1	
		I don't know	2	

III. General Knowledge about Wastewater:

III. Willingness to Pay and final evaluation:

GNW1	Are you aware of the term "Treated Wastewater"		have not heard of it	1	
			have heard and know what it means	2	
			have heard but don't know what it means	13	
			No clue	21	
GNW2	Do you accept to use treated wastewater for non-potable uses?		Yes	1	
			No	0	
			No clue	2	
GNW3	If yes, I accept to use treated wastewater for:		Agriculture /landscaping (indirect contact)	Yes	
				No	
				No Clue	
			Car Washing (direct contact)	Yes	
				No	
				No Clue	
			Clothes washing (direct contact)	Yes	
				No	
				No Clue	
			Showering/bathing (direct contact)	Yes	
				No	
				No Clue	
			Cooking (direct contact)	Yes	
				No	
				No Clue	
Section	**Question**	**Answer**		**Code**	
WP1	Do you accept to participate in programs that support the use of treated wastewater? Or do you want to use treated wastewater?	Yes		1	
		No		0	
		No clue		2	
WP2	Assuming you accept buying or consuming treated wastewater products; how much are you willing to pay	Same as regularly treated		1	
		More than regularly treated		2	
		Less than regularly treated		3	
		No pay		4	
WP2	Would you pay an extra on your water bill for the cost of building a system for reusing water that will have an environmental benefit?	Yes		1	
		No		0	
		No clue		2	
FE1	Was the information provided to you during this survey adequate?	Yes		1	
		No		0	
		No clue		2	
FE2	How interesting was the research you have just participated in?	Yes		1	
		No		0	
		No clue		2	
GNW4	Do you accept to use treated wastewater for potable uses; i.e. drinking?		Yes	1	
			No	0	
			No clue	2	
GNW5	I think the use of treated wastewater will lead to diseases:		Diarrhea	St. Agree	1
				Agree	2
				Neutral	3
				Disagree	4
				St. Disagree	5
			Typhoid Ascariasis	St. Agree	1
				Agree	2
				Neutral	3
				Disagree	4
				St. Disagree	5
			Hepatitis A	St. Agree	1
				Agree	2
				Neutral	3
				Disagree	4

			St. Disagree	5
		Cholera	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
		Salmonella	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
GNW6	It is disgusting to reuse water that once contained waste		St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
GNW7	The use of treated wastewater is not religiously accepted		St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
GNW8	Assuming , the treated wastewater is of acceptable quality and safe: reclaimed wastewater reuse is acceptable for:	agricultural and urban irrigation,	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
		industrial use	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
		toilet flushing	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
		laundry	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
		bathing	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4

			St. Disagree	5
		cooking	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
		None	St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
GNW9	Do you think treated wastewater can bring the following advantages? (more than one may be applicable)			
	It conserves potable water		St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
	It improve soil productivity		St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
	We can save money by using treated wastewater		St. Agree	1
			Agree	2
			Neutral	3
			Disagree	4
			St. Disagree	5
GNW10	Do you think the incidence of Disease Outbreak increases due to the use of treated wastewater?	Yes	1	
		No	0	
GNW11	If the quality of the treated wastewater is proven to be satisfactory, not disgusting or irritating and safe. I accept and trust the results when communicated through*:*	MPs	Yes	1
			No	2
			No Clue	0
		Municipalities	Yes	1
			No	2
			No Clue	0
		Public health –sanitation-environmental NGOs	Yes	1
			No	2
			No Clue	0
		University Professors, researchers	Yes	1
			No	2
			No Clue	0
		Media (newspaper, TV, radio)	Yes	1
			No	2
			No Clue	0
		Internet Articles	Yes	1
			No	2

				No Clue	0
GNW12	Comment on the following sentences:				
	I have no trust in the municipality authorities that they will operate the treatment plant properly or that they will supervise the application process adequately	Strongly agree	Agree	Disagree	Strongly Disagree
	Products can be contaminated with treated wastewater	Strongly agree	Agree	Disagree	Strongly Disagree
	There is plenty of fresh water to use, so there is no need to use treated wastewater	Strongly agree	Agree	Disagree	Strongly Disagree
	Treated wastewater should be offered free of charge	Strongly agree	Agree	Disagree	Strongly Disagree
	Treated wastewater will be of inferior quality	Strongly agree	Agree	Disagree	Strongly Disagree
GNW12	How much do you trust authorities will handle wastewater treatment correctly? (Answers coded on a 5-points scale, with 1, not at all, and 5, very much				
GNW13	How repellent do you find the idea of recycled water? (Answers coded on a 5-points scale, with 1, not at all, and 5, very much				
GNW14	Do you think it is risky to use treated wastewater?				

IV. Socio Economic Information:

Section	Question	Answer	Code
SE1	Age (insert in format dd/mm/yyyy)		
SE2	Marital Status	Single	1
		Married	2
		Divorced	3
		Widowed	4
		Other	5
SE3	Gender	Male	0
SE4	Level of education	Female	1
		Elementary	1
		Intermediate	2
		University	3
		Technical	4
		Other	5
SE5	Are you currently employed? (if answer is No, immediately move to question SE)	Yes	1
		No	0
SE7	Number of persons at home (insert number)		
SE8	Relationship of persons living at the same place		
SE9	Monthly income in USD	Less than 500	1
		Between 500 and 1, 000	2
		Between 1,000 and 3,000	3
		Between 3,000 and 5,000	4

		Between 5,000 and 10,000	5
		More than 10,000	6
		No answer	0

APPENDIX II

Tables for predictor variables tested for their association with willingness to use treated wastewater at univariate binary analysis level.

(B: regression coefficient, Wald: Wald statistic, tests statistical significance, df: degrees of freedom, Exp (B): odds ratio for each variable category).

Variables in the Equation: treated wastewater reuse not religiously accepted

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	treated wastewater reuse not religiously accepted	.635	.124	26.368	1	**.000**	**1.888**
	Constant	-1.705	.430	15.740	1	.000	.182

a. Variable(s) entered on step 1: treated wastewater reuse not religiously accepted.

Variable in the Equation: disgusting to reuse treated wastewater

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	disgusting to reuse treated wastewater	1.047	.156	45.073	1	**.000**	**2.848**
	Constant	-1.786	.331	29.124	1	.000	.168

a. Variable(s) entered on step 1: disgusting to reuse treated wastewater.

Variables in the Equation: Perception that treated wastewater reuse leads to salmonella

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	salmonella	.738	.139	28.399	1	**.000**	**2.092**
	Constant	-1.441	.366	15.487	1	.000	.237

a. Variable(s) entered on step 1: Perception that treated wastewater reuse leads to salmonella.

Variables in the Equation: Perception that treated wastewater reuse leads to cholera

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	cholera	.823	.146	31.673	1	**.000**	**2.277**
	Constant	-1.602	.372	18.515	1	.000	.201

a. Variable(s) entered on step 1: Perception that treated wastewater reuse leads to cholera.

Variables in the Equation: Perception that treated wastewater reuse leads to hepatitis A

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	hepatitisA	.950	.156	37.285	1	**.000**	**2.586**
	Constant	-1.974	.405	23.776	1	.000	.139

a. Variable(s) entered on step 1: hepatitisA.

Variables in the Equation: Perception that treated wastewater reuse leads to typhoid ascariasis

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	typhoidascariasis	1.051	.157	44.918	1	**.000**	**2.860**
	Constant	-2.146	.398	29.150	1	.000	.117

a. Variable(s) entered on step 1: Perception that treated wastewater reuse leads to typhoid ascariasis.

Variables in the Equation: Perception that treated wastewater reuse leads to diarrhea

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	diarrhea	.926	.155	35.779	1	**.000**	**2.525**
	Constant	-1.780	.379	22.023	1	.000	.169

a. Variable(s) entered on step 1: Perception that treated wastewater reuse leads diarrhea.

APPENDIX III

Tables for predictor variables tested for their association with willingness to use treated wastewater for non-potable purposes at univariate binary analysis level.

(B: regression coefficient, Wald: Wald statistic, tests statistical significance, df: degrees of freedom, Exp (B): odds ratio for each variable category).

Variables in the Equation: Trust in public health and environmental NGOs

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	Trust in NGOs	.399	.129	9.516	1	**.002**	**1.490**

Variables in the Equation: Age

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Age	-.436	.139	9.831	1	**.002**	**.647**
	Constant	1.442	.360	16.043	1	.000	4.228

a. Variable(s) entered on step 1: Age.

Variables in the Equation: Education (University Level)

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	SE4New	-.676	.262	6.654	1	**.010**	**.509**
	Constant	2.756	.927	8.834	1	.003	15.735

a. Variable(s) entered on step 1: **Education (University Level)**.

Variables in the Equation: Awareness of the term treated wastewater

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	GNW2n	2.681	.332	65.347	1	.000	14.600
	Constant	-.995	.225	19.499	1	.000	.370

a. Variable(s) entered on step 1: **Awareness of the term treated wastewater**.

Variables in the Equation: Perception that disease outbreak will increase

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	GNW10	-2.252	.334	45.393	1	**.000**	**.105**
	Constant	1.866	.287	42.243	1	.000	6.464

a. Variable(s) entered on step 1: Perception that disease outbreak will increase

Variables in the Equation: Personally suffering from water shortage

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	GN2	.310	.270	1.319	1	**.251**	**1.364**
	Constant	.161	.240	.450	1	.502	1.175

a. Variable(s) entered on step 1: Personally suffering from water shortage.