Original Research Article

Evaluation of Awareness about Electronic Waste in Tayma Governorate, Tabuk region, Saudi Arabia

ABSTRACT

This study was carried out to evaluate the people's awareness level about electronic waste (e-waste) disposal and management practices as well as their impact on environment, also provides recommendations for moving forward on this problem in Tayma governorate, KSA. The data for this work were collected during the distribution of 96 questionnaires on householders and governmental organizations (municipality and health sector). Likert Scale was used for the analysis of the participants. The results of householders exhibited that awareness are low or medium various degrees for e-waste disposal and management practices as well as their impact on environment and there is no formal or informal e-waste sector in Tayma governorate. The participants reported that they use all electronic home appliances, computers, laptops and Mobile phone and more than double the equipment was disposed of as e-waste during the past 10 years, which increases e-waste. The received answers from municipality and health sector of Tayma governorate showed that the large proportion of respondents were ranged from 68% to 88% not know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, they not know of any electronic waste management policies currently implemented in Tayma , very low perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals and the people are not aware of the hazardous chemicals found in e-waste. Also, there are hazards to the growing amount of e-waste in Tayma and they must be support the unorganized sector's role in waste management (while providing for safer practices). They added, no companies and the general population complied with electronic waste management policies and not found priority of government and individual levels for e-waste problem now. Finally, they said the vision 2030 for Kingdom of Saudi Arabia is gives full attention to the e-waste problem. The participants needs to more information on government rules and regulation for e-waste management. Therefore, government bodies must invest more in awareness rising not only in society but also on legislation and institutional levels in Tayma governorate.

Keywords: Awareness, householders, governmental organizations, e-waste, Tayma, KSA.

INTRODUCTION

Electronic Waste (e-waste) is a term used to include all electrical and electronic equipment that has been has reached its end-of-life (EoL) and regarded by its user as waste and without the intent of reuse. Another popular term is Waste Electrical and Electronic Equipment (WEEE). However, there is no standard definition of E-waste or WEEE. E-waste includes a huge

range of products that include circuitry or electric components and is powered by electricity or a battery. These can be categorized as the followings: cooling and freezing equipments, screens and monitors, toys and lighting equipment, leisure and sports equipment, large electrical equipment, medical devices, small electrical equipment, and small information technology (IT) and telecommunication equipment. In Northern America the term e-waste is limited to information and communication technology (ICT) products and televisions. In Japan e-waste refers to four product categories including TVs, air conditioners, refrigerators, and washing machines (**Khatib, 2011; Allam and Inauen, 2009 and Seitz, 2014**).

In general, e-waste contains more than 1000 different substances, which can be classified into "hazardous" and "non-hazardous" categories. E-waste contains ferrous and non-ferrous metals, plastic, glass, wood and plywood, printed circuit boards, concrete and ceramics, and rubber and other items. In terms of percentages, iron steel consists of 50% of e-waste, 21% of plastic and 13% non-ferrous metals such as copper, aluminum and precious metals; such as silver, gold, platinum, palladium and others. **Smith *et al.*, (2006)** mentioned that, large household appliances represent the largest proportion (about 50%) of e-waste, followed by information and communications technology equipment (about 30%) and consumer electronics (about 10%). Increasing quantities of e-waste and its mismanagement represent a major concern across the world due to the presence of hazardous substances such as heavy metals and hazardous chemical elements (lead, cadmium, chromium, mercury, copper, manganese, nickel, arsenic, zinc, iron, and aluminum [**Khatib, 2011 and Lundgren, 2012**]), as well as persistent organic pollutants (**Sankhla *et al.*, 2016**) and poly cyclic aromatic hydrocarbons (**Liu *et al.*, 2008**). On the other hand, e-waste contains valuable materials such as gold, silver, copper, platinum, palladium, iron, aluminum, indium, gallium and rare earth metals that may be recovered thus contributing to sustainable resource management (**Seitz, 2014**). Since e-waste is a diverse combination of various type of toxic elements, which are capable of creating an irreversible impact to the environment and human health if not handled properly (**Sankhla *et al.*, 2016**).

Saudi Arabia is considered to be the biggest producer of E-waste in Middle East. In 2016, five million ton of electronic waste are produced by the Kingdom annually, an increase of 25 percent per annum, which highlights the need to redouble efforts and initiatives to recycle hardware (**Alghazo and Ouda, 2016**). The per capita waste generation is estimated at 1.4 kg/person/day. Waste is collected from individual or community bins and disposed of in landfills (**Nizami *et al.*, 2017 and Ouda *et al.*, 2016**). The per capita e-waste generation in Saudi Arabia is estimated at 12.5 kg per year with a total country wide annual generation of about 378 thousand tons (**Blade *et al.*, 2015**). Vision 2030 of the Kingdom of Saudi Arabia states "By preserving our environment and natural resources, we fulfill our Islamic, human and moral duties. Preservation is also our responsibility to future generations and essential to the quality of our daily lives. We will seek to safeguard our environment by increasing the efficiency of waste management, establishing comprehensive recycling projects, reducing all types of pollution and fighting desertification" (**Saudi vision, 2016**).

The objective of this study is collect relevant data to identify the background of people with e-waste, their awareness of the dangers inherent in improper handling and disposal of wastes, e-waste generation quantities, disposal and reuse/recycle practices and to knowledge of health hazards and environmental impacts associated with electronic waste. It will take a systems analysis approach to the problem, explore solutions and suggest possible pathways for e-waste in Tayma governorate, Kingdom of Saudi Arabia.

MATERIALS AND METHODS

Participants and Questionnaires:

Data were taken from the Voice of the householders, municipality and health sector of Tayma governorate survey during 2017, a voluntary and confidential based survey offered to all participants. The overall allocation scheme was aimed toward equalizing the number of questionnaires at participants. In this study the questionnaires were used to evaluation of public awareness regarding e-waste hazards during identify the current status of e-waste management practices, the effect of e-waste on environment and disposal of e-waste in Tayma governorate. The questionnaires with a short description of the current study and intended use of collected data were also distributed on householders, municipality and health Sector of Tayma governorate by hand which created room for one on one interaction with the respondents. The questionnaires were developed in English and then translated in the Arabic. Participants were asked to complete a self-administered structured questionnaire.

The data had collected through the distribution of 96 well-structured questionnaires distributed among different respondents with numbers of 63, 25 and 8 on householders, municipality and health Sector of Tayma governorate, respectively. The questionnaire for householders was divided into four sections i.e., personal data, involvement in e-waste generation, generation and management of e-waste and impact on the environment. Generally, the questionnaires focus on use of household electronics, waste disposal, waste hazards on environment, e-waste management policies government role and role of the informal sector. The Questionnaires for householders, municipality and health sector of Tayma governorate were listed in Appendix A, B and C, respectively.

Statistical Analysis:

Statistical approach adopted for the analysis of the respondents was **Likert Scale Analysis (1932)** in which responses was coded using figures to quantify the responses. Means of coding values were used as critical region and mean responses were compared with the critical region to determine the hypothesis to accept. To calculate the critical region and mean response rates for surveys in this study, we used the following equations:

$$Critical\ region\ = \frac{Summation\ of\ coding\ values}{Number\ of\ coding\ values}$$

$$Mean\ response\ = \frac{Number\ of\ responses\ to\ your\ survey}{Number\ of\ people\ you\ sent\ the\ survey}$$

Accept the null hypothesis if the value of mean response was lower than the values of critical region. While, reject the null hypothesis if the value of mean response was higher than the values of critical region. Charts were used for better understanding of available data, as well as, the demographic information of respondents.

RESULTS AND DISCUSSION

It might be mentioned that, results will be presented according to questionnaires are used in this work as follows:

A. Householders.

B. Municipality of Tayma governorate.

C. Health Sector - Ministry of Health, Tayma governorate.

A- Householders:

1- Personal data:

The personal data i.e., sex, age, are you currently, marital status, qualification and annual income were common demographic questions asked in surveys. Most likely answer the questions were differently by the respondents, due to that the respondents were various in these personal data. The data in Table (1) results displayed that, reject of the null hypothesis for sex and educational qualification, therefore there are significant differences. However, accept of null hypothesis for other studied personal data in this study.

Table (1): The mean response, critical region and null hypothesis of personal data for householders.

Personal data	Mean response	Critical region	Null hypothesis
Sex	1.89	1.50	Reject
Age	1.75	2.50	Accept
Are you currently	3.00	3.00	Accept
Marital status	1.67	2.50	Accept
Qualification	4.42	4.00	Reject
Annual income	1.62	2.50	Accept

The descriptive characteristics of households are presented in Table (2). Out of the number of participants (63), female (56), 20 - 29 year (32), student (28), married (30), University (42) and Under SR 50,000 (37) were recorded the highest values of frequency for sex, age, are you currently, marital status, qualification and annual income, respectively.

Table (2): Number of blanks and valid responses from personal data for householders.

Personal Data	Frequency						
	Blanks	No. of valid responses according to Likert scale coding					
		1	2	3	4	5	Total
Sex	0	7 (Male)	56 (Female)				63
Age	2	32 (20 – 29)	14 (30 – 39)	13 (40 – 49)	2 (50 and above)		61
Are you	0	3	22	10	28	0	63

currently		(Retired)	(Employed)	(Unemployed)	(Student)	(Other)	
Marital status	0	28 (Single)	30 (Married)	3 (Divorced)	2 (Widowed)		63
Qualification	1	3 (Uneducated)	3 (Primary)	1 (Preparatory)	13 (Secondary)	42 (University)	62
Annual income (SR)	2	37 (Under 50,000)	12 (50,000-99,999)	10 (100,000-149,999)	2 (Over 150,000)		61

In Figure (1), the valid percentages of the respondents in sex were 89% at female and 11% at male, indicating most of the respondents are female. As for age, 52%, 23%, 21% and 3% of the participants are 20 - 29, 30 - 39, 40 - 49 and 50 and above years, respectively, this indicates that the majority of young people were used in this study. 44%, 35%, 16%, 5% and 0% of the participants are student, employed, unemployed, retired and other, respectively, indicating that the largest proportion of respondents in this voting are workers in Tayma governorate. On the other hand, the highest percentage of the participants in case marital status were registered by married (48%) followed by single (44%), divorced (5%) and Widowed (5%). In relation to educational qualification, the represented 68% of the total participants collected was found for university qualification, however, the remaining 32% was collected mainly from uneducated (5%), primary (5%), preparatory (2%) and secondary (20) qualifications, this meaning most of the participants in this study are graduates and learners in different stages. Finally, under SR 50,000 (61%) of annual income was gave the largest valid percentage of participants followed by SR 50,000-SR 99,999 (20%), SR 100,000- SR 149,999 (16%) and Over SR 150,000 (3%), indicating most of participants are low annual income. **Okoye and Odoh (2014)** studied demographic information of respondents for assessment of the level of awareness of e-waste management and concern for the environment amongst the householders; they mentioned that most of the respondents were female, 30 to 39 years, married and holders certificates.

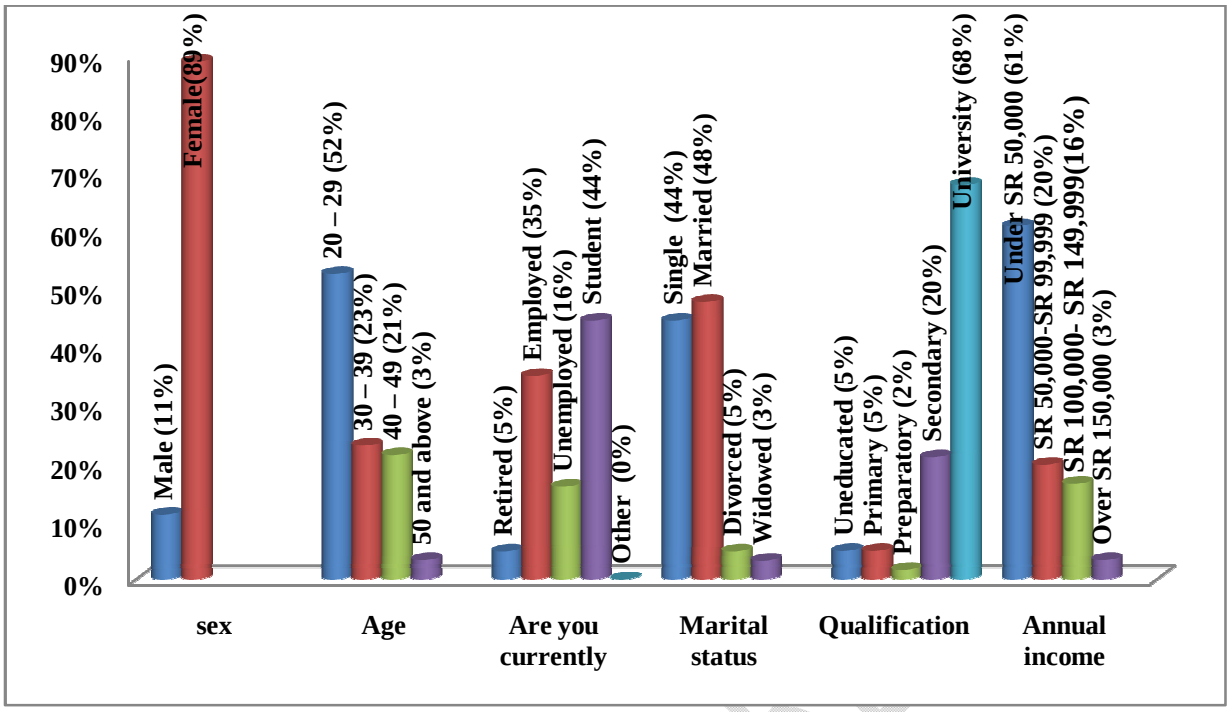


Figure (1): The data collected through the demographic questions for householder's.

2- Involvement in Electrical/Electronic Waste Generation:

The participants were asked "what are the namely of used electronics in the house?" (First question), the participants reported that they use all electronic home appliances, computers, laptops and mobile phone in house. As for the second and third questions "How many household electronics have you purchased/replaced in the past 10 years? and How many household electronics do you still used of the ones you have purchased in the past 10 years?", the participants mentioned that, during the past 10 years purchased and still used on average, 22.8 and 10.6 household electronics, respectively. These results indicate that more than double the equipment was disposed of as e-waste. **Shah *et al.*, (2014**) reported that, 94% of questionnaire respondents reported that they use household electronics (again, defined in this study as mobile phones and personal computers), while 85% indicated that they use both mobile phones and computers frequently. Over the past 10 years, respondents purchased, on average, 4.3 mobile phones and 2.5 personal computers.

The results in Table (3) show reject of the null hypothesis for the sixth, eighth and ninth questions, indicating that awareness of these questions are high (reason of purchasing the new household electronics, aware of government regulation on e-waste management in in Saudi Arabia and they have rules guiding activities in the association, respectively). On the other hand, accept of null hypothesis for the questions 4, 5 and 7 and therefore low awareness of these questions (knowledge of electronic wastes, use these household electronics frequently and the model of disposal of e-waste adopted in the house, respectively).

Table (3): The mean response, critical region and null hypothesis of involvement in e-waste generation for householders.

No.	Questions	Mean response	Critical region	Null hypothesis
Q_4	Do you know what electronic wastes are?	1.34	1.50	Accept
Q_5	Do you use these household electronics frequently?	1.13	1.50	Accept
Q_6	What was your reason for purchasing the new household electronics?	3.40	3.00	Reject
Q_7	Which of the following is the model of disposal of e-waste adopted in the house?	2.13	2.50	Accept
Q_8	Are you aware of any government regulation on e-waste management in Saudi Arabia?	1.84	1.50	Reject
Q_9	Do you have rules guiding your activities in the association?	1.80	1.50	Reject

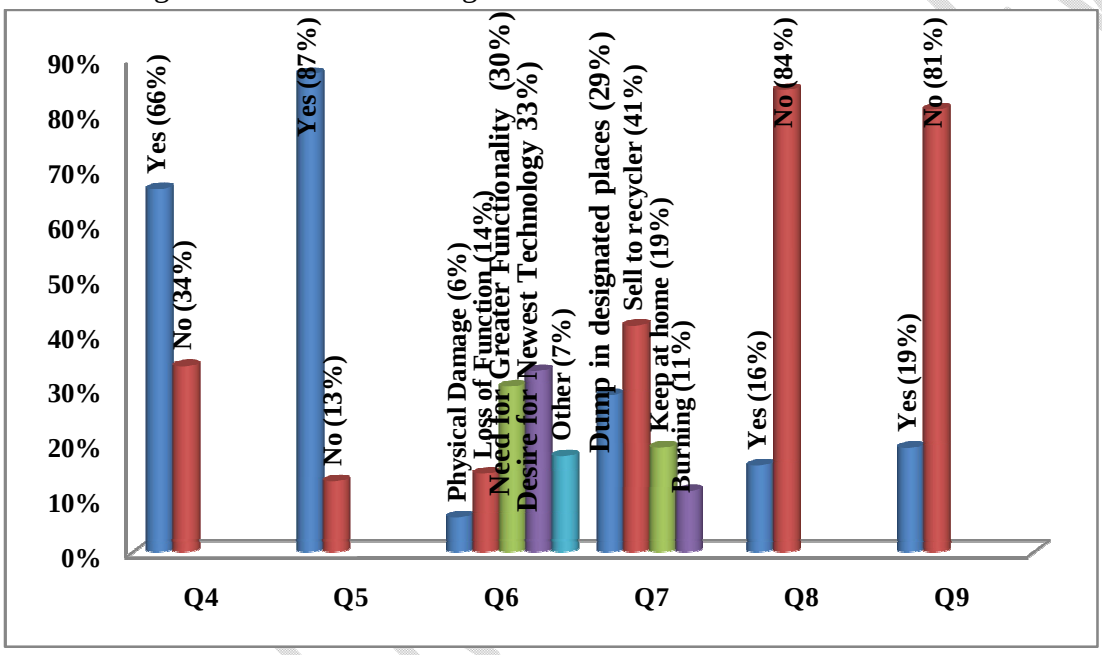
Data collected for number of valid responses according to Likert Scale Coding as Table (4) were showed that most of the participants chose yes (41 and 54) for the questions 4 and 5, respectively, desire for newest technology (20) for the Question 6, sell to recycler (26) for the Question 7 as well as no (48 and 51) for the two questions 8 and 9, respectively. Responses on the Questions 4 and 5 shows that 66% and 87% of respondents are said "yes", respectively, but, remaining respondents are said "no". These results indicating that, most respondents on complete knowledge with electronic wastes and they use these household electronics frequently.

Table (4): Number of blanks and valid responses from involvement in e-waste generation for householders.

Questions	Frequency						
	Blanks	No. of valid responses according to Likert scale Coding					
		1	2	3	4	5	Total
Q_4	1	21 (No)	41 (Yes)				62
Q_5	1	8 (No)	54 (Yes)				62
Q_6	0	4 (Physical Damage)	9 (Loss of Function)	19 (Need for Greater Functionality)	20 (Desire for Newest Technology)	11 (Other)	63
Q_7	0	18 (Dump in designated places)	26 (Sell to recycler)	12 (Keep at home)	7 (Burning)		63
Q_8	6	48 (No)	9 (Yes)				57
Q_9	1	51 (No)	11 (Yes)				62

The Figure (2) depicts data collected from the questions about involvement in e-waste generation. Data collected from the Question 6 exhibited the respondents say that reason for purchasing the new household electronics, 6% of physical damage, 14% of loss of function, 30% of need for greater functionality, 33% of desire for newest technology and 7% of others reasons, this indicate 66% of participants want to replace old electronics with modern electronics, which increases e-waste. The survey results of the Question 7 confirm that 29%, 41%, 19% and 11% of participants disposal of e-waste adopted in the house by dump in designated places/refuse dump, sell to recycler, keep at home and burning/incineration, respectively, this result means that a very

large proportion of participants (89%) deal with e-waste in a good ways, while a small proportion (11%) of them are harmful of the environment and human. People were asked to comment on the eighth and ninth Questions, 84% and 81% of participants showed no are not aware of any government regulation on e-waste management in Saudi Arabia and no do not have rules guiding your activities in the association, respectively. When participants were chose yes for the Question 9, 65% of participants are chose yes, this indicating the participants correspond the rules with government regulation for waste management, but the remaining respondents are chose no. As for How effectively are the rules enforced?, 18%, 54% and 28 % of participants were mentioned that the rules enforce strongly , fairly and not enforced, respectively. These results indicating that the participants in this study needs to more information on government rules and regulation for waste management.



The Figure (2): The data collected through the questions of Involvement in e-waste generation for householders.

The data obtained from householders involvement in e-waste generation **Okoye and Odoh (2014)** reported that most of the respondents possessed phone than other appliances. 54.54% of the householders keep their e-wastes at home whereas 36.36 dump theirs at the designated refuse dumps. The remaining 9% sell theirs to the recyclers. This calls for an urgent need for enlightenment campaign on the need and benefits of re-cycling e-waste and the implication of mixing e-waste with other municipal wastes. Also they added, the awareness for government regulation of e-waste management is low among the selected householders. **Shah *et al.*, (2014)** mentioned that most respondents, approximately 61% purchase new electronic items due to a desire for the latest technology.

3- E-Waste Management:

In this study we are require from the participants answer on the first question "What volume of electrical/electronic waste do you handle per day?" the participants were reported that the average of volume of electrical/electronic waste do you handle per day was 7.34 and ranged between electronic home appliances, computers, laptops, mobile phone, battery and circuit board. In response to Question 2 "Indicate the volume of reusable, recyclable and residue from your work", the participants were say the average of the volume of reusable, recyclable and residue from your work was 4.0 and varied among washer, mobile phone, TV, fan, stereos, batteries and computer.

Reject of the null hypothesis for the Questions 4 and 5 (Table, 5), this indicates awareness of recover any of the electrical/electronic equipment/components from waste and they do with the recovered equipment/components are high. While, accept of null hypothesis for the question 3, this indicating awareness of the electronics appliances that you no longer use is low.

Table (5): The mean response, critical region and null hypothesis of e-waste management for householders.

No.	Questions	Mean response	Critical region	Null hypothesis
Q_3	What have you done with the electronics that you no longer use?	2.21	3.00	Accept
Q_4	Do you recover any of the electrical/electronic equipment/components from waste?	1.79	1.50	Reject
Q_5	What do you do with the recovered equipment/components?	2.00	2.00	Reject

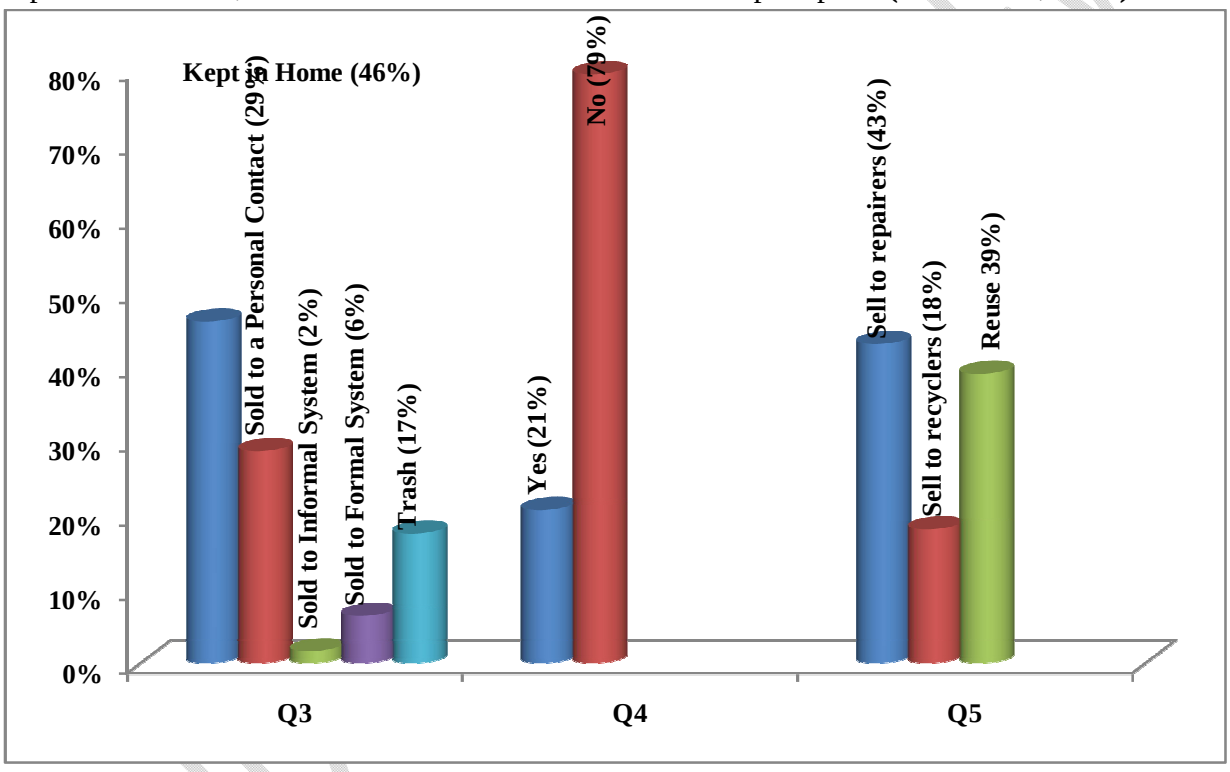
The number of valid responses to the Questions 3, 4 and 5 about “generation and management of e-waste” revealed that, 29, 50 and 26 of participants were chose kept in home, no and sell to repairers when answer on this questions, respectively as Table (6).

Table (6): Number of blanks and valid responses from e-waste management for householders.

Questions	Frequency						
	Blanks	No. of valid responses according to Likert scale Coding					
		1	2	3	4	5	Total
Q_3	0	29 (Kept in Home)	18 (Sold to a Personal Contact)	1 (Sold to Informal System)	4 (Sold to Formal System)	11 (Trash)	63
Q_4	0	50 (No)	13 (Yes)				63
Q_5	2	26 (Sell to repairers)	11 (Sell to recyclers)	24 (Reuse)			61

The data for the questions about management of e-waste are illustrated in Figure (3). In relative to the Question 3, 46%, 29%, 2%, 6% and 17% of respondents were chose kept in home, given/sold to a personal contact, sold to informal system, sold to formal system and trash, respectively, this implies a large proportion of the participants (83%) benefit from e-waste unused at home by different used methods. The data in the Figure (1) based on the Question 4 were showed that, 21% and 79% of participants are chose yes and no, respectively. Unrecovered any of the electrical/electronic equipment/components from waste had general direction for most participants. When participants were chose yes (21%) for the Question 4,we asked "Which

equipment?", 19%, 22%, 17% and 42% of participants are say computer, laptop, TV and mobile phone, respectively. Also, we asked "Which component do you recycle/recover?" the answers were circuit board (14%) battery (50%) plastics (22%) iron (8%) copper (6%), aluminum (0%) and others (0%). The participants sell to repairers (43%) or sell to recyclers (18%) and reuse (39%) when we asked the question 5 "What do you do with the recovered equipment/components? " this suggests that the participants benefit from e-waste unused at home. **Okoye and Odoh (2014)** revealed that the items mainly sort after are cathode ray tube (54%), mobile phones (30%), laptops (6%) and other (10%). Many people tend to sell or give unused electronic items to a personal contact (35%), or keep these electronics in the home (26%). Most respondents (61%) do not consider unused electronics to be waste, and can either be repaired or reused, or can be a source of raw materials or spare parts **(Shah *et al.*, 2014)**.



The Figure (3): The data collected through the questions of e-waste management for householders.

4- Impact of E-Waste on Environment:

From the data in Table (7), accept null hypothesis were found for the Questions 1 and from 4 to 8, this suggesting that awareness are low for known health risks associated with electronic wastes, information about the environmental issues in your local area, concerned about your environment, knowledge some components of electronic devices contain toxic/hazardous materials, know toxic/hazardous materials require special treatment for environmentally sound disposal and disposal/treatment method in use for electronic waste have any impact on the environment. On the other hand, the null hypothesis for the remaining other Questions were

reject, this indicating that the highest awareness were found for known local programs, projects or activities pertaining to electronic waste management and aware of recycling/trading fairs for electronic wastes.

Table (7): The mean response, critical region and null hypothesis for impact of e-waste on environment and human in householders.

No.	Questions	Mean response	Critical region	Null hypothesis
Q_1	Are you aware of any health risk/s associated with electronic wastes?	1.27	1.50	Accept
Q_2	Are you aware of local programs, projects or activities pertaining to electronic waste management?	1.55	1.50	Reject
Q_3	Are you aware of recycling/trading fairs for electronic wastes?	1.67	1.50	Reject
Q_4	How informed are you about the environmental issues in your local area?	2.25	2.50	Accept
Q_5	Are you concerned about your environment?	2.13	2.50	Accept
Q_6	Do you know that some components of electronic devices contain toxic/hazardous materials?	1.33	1.50	Accept
Q_7	Are you aware that these toxic/hazardous materials require special treatment for environmentally sound disposal?	1.41	1.50	Accept
Q_8	Does the disposal/treatment method in use for electronic waste have any impact on the environment?	1.38	2.00	Accept

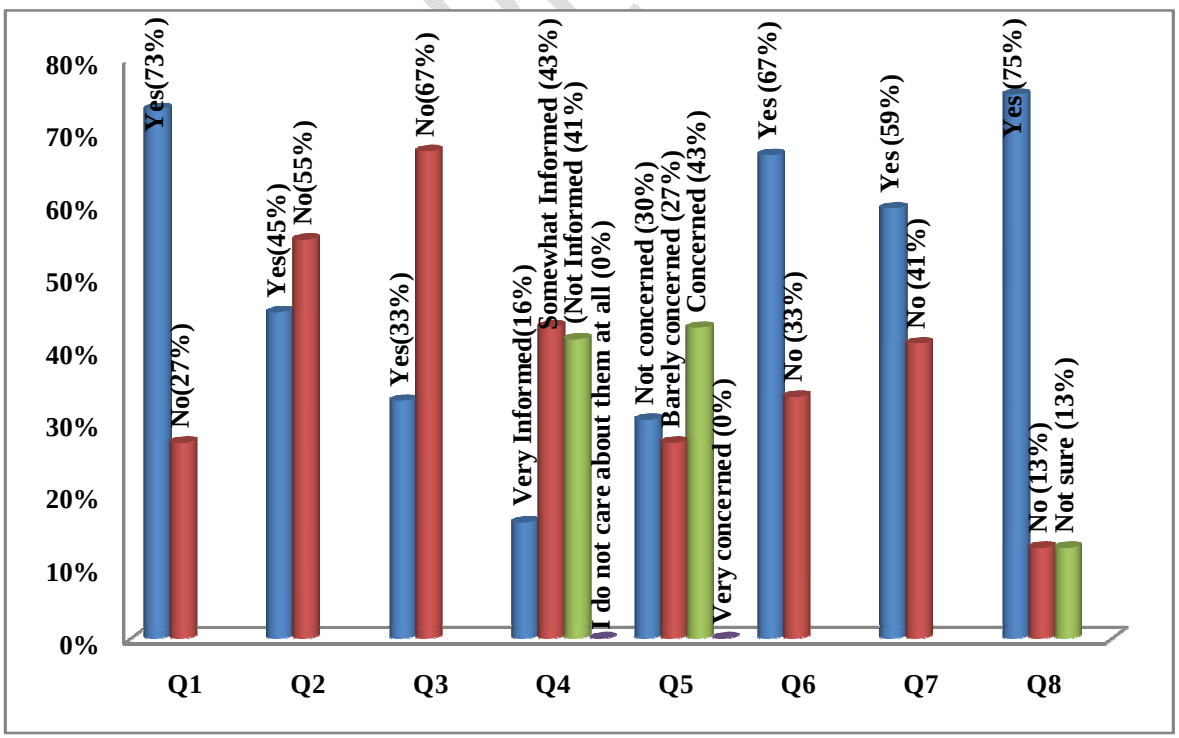
According to Likert Scale Coding for the questions in the Table (8), the highest number of valid responses with values 46, 42, 35 and 42 of participants are chose yes during the Questions 1, 6, 7 and 8, respectively, with values 33 and 41 of participants are chose no during the Questions 2 and 3, with value 27 of participants is chose somewhat informed and concerned through the Questions 4 and 5. The effect of e-waste on environment is presented in Figure (4). Regarding the questions 1, 6, 7 and 8 the respondents are chose yes, they are demonstrated a good understanding of health risks associated with electronic wastes (73%), know that some components of electronic devices contain toxic/hazardous materials (67%), toxic/hazardous materials require special treatment for environmentally sound disposal (59%) and disposal/treatment method in use for electronic waste have any impact on the environment (74%), while, with 21%, 33%, 41% and 26% replying "no". On the other hand, the respondents are chose no, therefore they do not aware of local programs, projects or activities pertaining to electronic waste management (55%) and not know recycling/trading fairs for electronic wastes (67%), while, 45% and 33% replying "yes" during the questions 2 and 3.

Table (8): Number of blanks and valid responses from impact of e-waste on environment and human for householders.

Questions	Frequency					
	Blanks	No. of valid responses according to Likert scale Coding				
		1	2	3	4	Total
Q_1	0	17 (No)	46 (Yes)			63
Q_2	3	33	27			60

		(No)	(Yes)			
Q_3	2	41 (No)	20 (Yes)			61
Q_4	0	10 (Very Informed)	27 (Somewhat Informed)	26 (Not Informed)	0 (I do not care about them at all)	63
Q_5	0	19 (Not concerned)	17 (Barely concerned)	27 (Concerned)	0 (Very concerned)	63
Q_6	0	21 (No)	42 (Yes)			63
Q_7	4	24 (No)	35 (Yes)			59
Q_8	7	7 (No)	7 (Not sure)	42 (Yes)		56

As for the Question 4, 16%, 43% and 41% of the participants were very informed, somewhat informed and not informed with environmental issues in local area. The participants were asked "Are you concerned about your environment?", they replying not concerned (30%) barely concerned, (27%), concerned, (43%) and very concerned (0%), this implies that a large proportion of the participants not interested environmental issues in local area and concerned about environment. **Okoye and Odoh (2014)** from the data on effect of e-waste on environment and human, they stated that most householders are concerned with environmental conditions, where, 96% of the householders are concerned about their environment. The awareness of the harmful content of e-waste was also tested for the respondents. The result shows that the householders (78%) are not aware of the hazardous nature of e-waste.



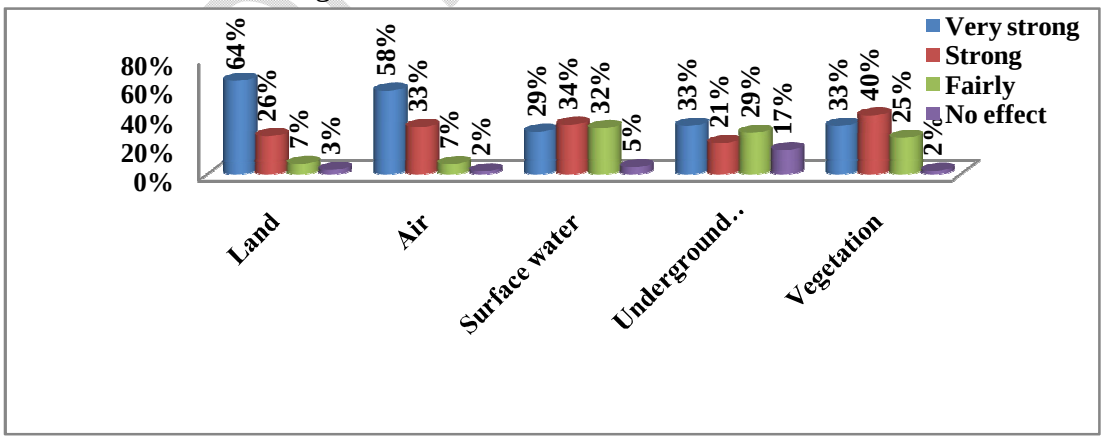
The Figure (4): The data collected through the questions from impact of e-waste on environment and human for householders.

When participants were chose yes for the Question 8 (74%) we asked "what is part of the environment affected and rate the impact?". During the data in Table (9), reject null hypothesis for all environments parts, this indicating the high effect of e- waste on environment.

Table (9): The mean response, critical region and null hypothesis for impact of e-Waste on environment parts.

Parts	Mean response	Critical region	Null hypothesis
Land	3.52	2.50	Reject
Air	3.45	2.50	Reject
Surface water	2.88	2.50	Reject
Underground water	2.71	2.50	Reject
Vegetation	3.05	2.50	Reject

In Figure (5), 90%, 90, 63%, 55% and 74% of respondents mentioned that the effect of e-waste on land, air, surface water, underground water and vegetation were strong or very strong, respectively, while the remaining percentages for fairly effect or not effect on environment's parts. The responses on negative impact of the waste on environment show that most of the respondents are not aware of the harmful effect of the products **(Okoye and Odoh, 2014)**. **Sankhla *et al*., (2016)** mentioned that, the e-wastes are considered dangerous, as certain components of some electronic products contain materials that are harmful, depending on their condition and density. The harmful content of these materials pose a threat to human health and environment. Its toxic emissions mixed with virgin soil and air and causing harmful effects to the entire biota either directly or indirectly. Direct impacts include release of acids, toxic compounds including heavy metals, carcinogenic chemicals and indirect effects such as bio magnification of heavy metals. Discarded computers, TV, DVD, stereos, copiers, fax machines, electric lamps, cell phones, audio equipment and batteries if improperly disposed can leach lead and other substances into soil and groundwater.



The Figure (5): The effect of e-waste on environment components.

B- Municipality of Tayma governorate:

The data in Table (10) revealed that, the participants were showed the low awareness of someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, they see any hazards or risks to the growing amount of e-waste in Tayma and do think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices), due to accepted of null hypothesis for the Questions 1, 2 and 7. In contrast, the participants were good aware for knowledge e-waste management policies currently implemented in Tayma , are there flaws to these policies, perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals and are people aware of the hazardous chemicals found in e-waste, due to rejected of null hypothesis for the Questions 3, 4, 5 and 6.

Table (10): The mean response, critical region and null hypothesis for the questions of municipality.

No.	Questions	Mean response	Critical region	Null hypothesis
Q_1	Do you know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling?	1.56	2.00	Accept
Q_2	Do you see any hazards or risks to the growing amount of e-waste in Tayma ?	2.17	2.50	Accept
Q_3	Do you know of any electronic waste management policies currently implemented in Tayma ?	1.88	1.50	Reject
Q_4	Are there flaws to these policies?	1.81	1.50	Reject
Q_5	What is your perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals?	1.79	1.50	Reject
Q_6	Are people aware of the hazardous chemicals found in e-waste?	1.72	1.50	Reject
Q_7	Do you think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices)?	1.20	1.50	Accept

During questionnaire of municipality of Tayma governorate, the Questions 1, 3, 4, 5 and 6 were demonstrated that, 68%, 88%, 81%, 79% and 72% of the participants were chose no as shown in Figure (7), respectively, this indicates the large of the participants not know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, they not know of any electronic waste management policies currently implemented in Tayma , not flaws to these policies, very low perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals and the people are not aware of the hazardous chemicals found in e-waste. On the other hand, 75% and 80% of participants are replied with yes, this result is meaning they see hazards or risks to the growing amount of e-waste in Tayma and they think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices).

Regarding Question 6, when the participants were replied yes (28%). we asked "who informs them?" the participants said "there is no one ignorant of the dangers of electronic waste" and "provide the guides and the mentors for that", while when the participants were choose no (72%), we asked them "what is the best way for creating mass awareness?" some participants replied through educational courses and social media.

During the Question 8, the participants were asked “How well have companies and the general population complied with electronic waste management policies", the participants said "unknown" or "there is no". As for the question 9 "How much of a priority is this issue at the government level? At the individual level", the participants mentioned that not found priority for government and individual levels. In relation to the Question 10 "How much should the public and government prioritize e-waste management, relative to other public issues", some participants are replied "this is the vision 2030 for Kingdom of Saudi Arabia where gives full attention to the e-waste with percentages ranging from 80% to100%", other participants are replied "unknown" or "there is no".

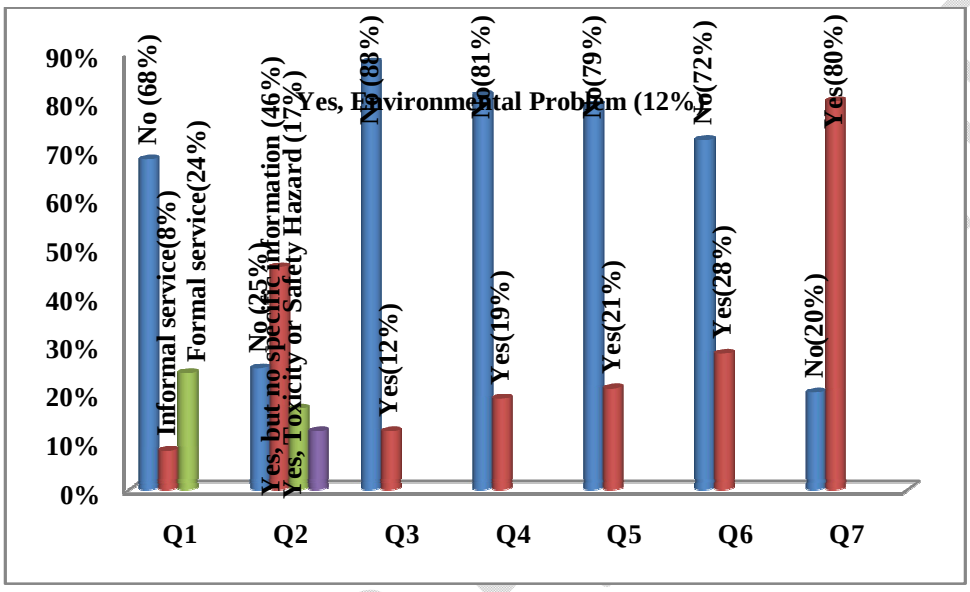


Figure (7): The data collected through the municipality questionnaire.

C- Health Sector - Ministry of Health, Tayma governorate:

During questionnaire of Health Sector - Health Ministry, Tayma governorate, null hypothesis was accepted for the Questions 1, 2, 4 and 7 as Table (11), this showed the awareness was low for knowledge on someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, for the hazards or risks to the growing amount of medical e-waste and others in Tayma , for the policies flaws and for they think would be viable to support the unorganized sector’s role in management of medical e-waste and others (while providing for safer practices). Otherwise, the null hypothesis for the other Questions were rejected, this indicates that the awareness was high for the medical e-waste and others management policies currently implemented in Tayma , for perception of public awareness of the regulations in place for medical e-waste and others, and for the control of exposure to hazardous chemicals and for the people aware of the hazardous chemicals found in medical e-waste and others.

Table (11): The mean response, critical regionand null hypothesis for the questions of health sector.

No.	Questions	Mean response	Critical region	Null hypothesis
Q_1	Do you know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling?	1.13	2.00	Accept
Q_2	Do you see any hazards or risks to the growing amount of medical e-waste and others in Tayma ?	1.88	3.00	Accept
Q_3	Do you know of any medical e-waste and others management policies currently implemented in Tayma ?	2.00	1.50	Reject
Q_4	Are there flaws to these policies?	1.00	1.50	Accept
Q_5	What is your perception of public awareness of the regulations in place for medical e-waste and others, and for the control of exposure to hazardous chemicals?	2.00	1.50	Reject
Q_6	Are people aware of the hazardous chemicals found in medical e-waste and others?	2.00	1.50	Reject
Q_7	Do you think it would be viable to support the unorganized sector's role in management of medical e-waste and others (while providing for safer practices)?	1.13	1.50	Accept

The chart in Figure (8) demonstrates that, 88%, 12%, 100%, 0%, 100%, 100% and 12% of participants were chose no for the Questions are presented in Table (1), while the remaining percentages are chose yes for same the Questions, respectively, these results indicate that they do not know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, also they do not know of any medical e-waste and others management policies currently implemented in Tayma , then they do not perception of public awareness of the regulations in place for medical e-waste and others, and for the control of exposure to hazardous chemicals and finally the people do not aware of the hazardous chemicals found in medical e-waste and others. But, they see hazards or risks from the growing amount of medical e-waste and others in Tayma , flaws to these policies and think it would be viable to support the unorganized sector's role in management of medical e-waste and others (while providing for safer practices).

During the Question 6 and when participants were chosen no (100%), we asked them "what is the best way for creating mass awareness?" they replied through educational courses and social media. The participants were asked of the question 8 " How well have companies and the general population complied with medical e-waste and others management policies?" the participants were replied lack of knowledge of companies and the general population with the culture of these policies. In respect to the Question 9 "How much of a priority is this issue at the government level? At the individual level?" some participants said "ignoring of e-waste on government and individual levels" and others did not respond. As for the Question 10 "How much should the health sector prioritize for management of medical e-waste and others, relative to other public issues?" some of them answered that the health sector must be gives full attention to the medical e-waste and others in percentages ranging between 95% and 100%, while others are in percentages ranging between 0% and 30%.

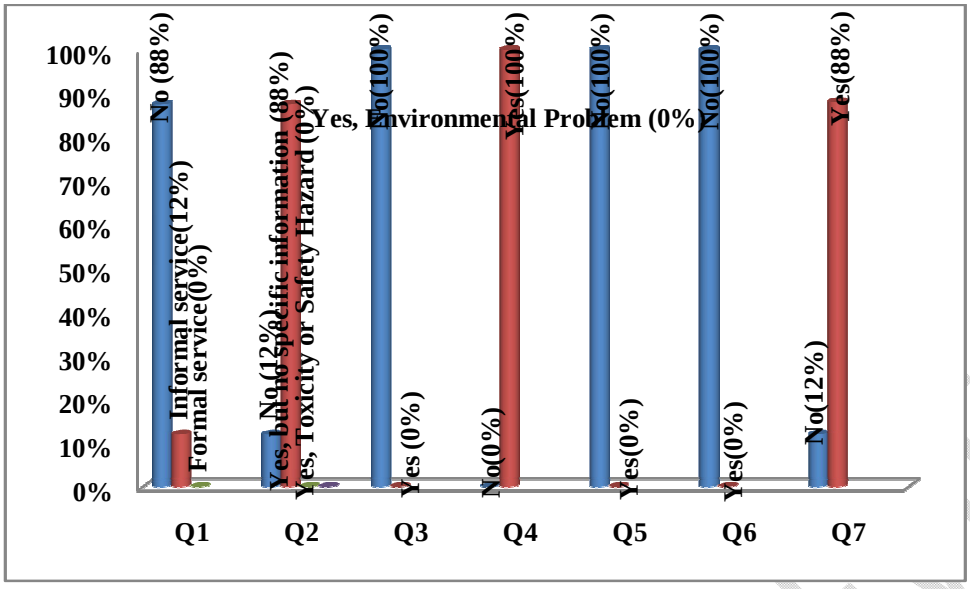


Figure (8): The data collected through the health sector questionnaire.

Generally, the pollution caused by their irregular management substantially degraded the environment mostly in poorer countries, receiving them for recycling and recovery of their valuable metals. As for the consequences on ecosystems, human health and environmental restoration of areas burdened by certain polluters generated by e-waste, there are no sufficiently documented scientific studies (**Gaidajis *et al*., 2010**). E-waste separation from the rest of solid waste and their recycling for the recovery of valuable raw materials and basic metals is essential **(Gaidajis *et al*., 2010).**

Shah *et al*., (2014) studied assessment of public awareness regarding e-waste hazards and management strategies, they showed that 63% of respondents either do not know of any unused electronics collection service or only know of informal services, while 37% of respondents know of formal collection services. While, 65% of respondents either do not perceive any health or environmental hazards to e-waste, or do not know of specific hazards. However, 89% of respondents either do not think there are any government policies in place to handle e-waste, or do not know of any pertinent policies or governing bodies. The age groups had similar percentages of respondents knowing of no hazards, respondents knowing of health hazards, and respondents acknowledging both health and environmental hazards.

There is very low and uncoordinated awareness among Arab countries on the hazards of WEEE and ways to dispose of end-of-life ICT products (**Allam & Inauen, 2009**). Since most of the countries are still in the absorption stage of ICT products, there has been little or no incentive to implement a national policy on proper e-waste management as distinct from waste management in general. However, private companies in individual countries and the regional context run collection and transportation systems to countries such as Switzerland that have a well-developed recycling culture (**Alameer, 2014**). Environmentally sound management of hazardous wastes or other wastes means taking all practicable steps to ensure that hazardous

wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes. This approach helps to protect the environment and human health while leading to economic benefit through resource recovery. Reuse is the best option and it extends the useful life of an asset, maximizing its overall value and delaying the consumption of raw materials and energy to produce new assets. Where component reuse is not possible, recycling a certified recycler is the next best option (**Alameer, 2014**).

Allam & Inauen (2009) revealed that most of the e-waste activities are collaboration projects between nongovernmental organizations, governmental and private institutions. All studies agree that little is being done by the Gulf Cooperation Council (GCC) countries and MENA countries to address the issue of e-waste. The countries lack many items of a comprehensive framework for e-waste treatment and management such as pilot projects for separation and collection. The lack of awareness about e-waste is mentioned in most studies. The GCC countries also lack any monitoring system for material flow (**Alghazo and Ouda, 2016**).

CONCLUSION

In this study, the results leads to the assumption that awareness on householders and governmental level is low or medium various degrees for e-waste disposal and management techniques as well as their impact on environment and there is no formal or informal e-waste sector in Tayma governorate. During the last decades, the increase in e-waste generation was due to the substantial increase in the standards of living. In the absence of any mechanism for the safe disposal of this equipment, there were growing signs that this electronic waste was ending up in landfills, creating a potential environmental hazard. e-waste management need to for developed regulatory and legal framework for e-waste management and it implemented, and more basic data collection, inventories and assessment studies. The answers of participants indicate that there is a need for raising E-waste awareness in the Tayma governorate.

RECOMMENDATIONS

The results of this study lead to several recommendations for the Tayma governorate, KSA:

1- The government bodies must invest more in awareness rising not only in society but also on legislation and institutional levels, where the raise of awareness is a key element of a starting e-waste management system, active participation in management systems and the ability to put pressure on producer compliance in Tayma governorate.

2- The public awareness can be reached during:
   - Educational courses in school, university and clubs.
   - Social media like Facebook and Twitter.
   - Education campaigns including information on occupational health and safety procedures.
   - Information posters and pamphlets containing information shall be printed and distributed amongst the citizens.

3- Work an annual conference on electronic waste to draw attention to this issue and alert the general public to the potential dangers of e-waste
4- Must be developed regulatory and legal framework for e-waste management and it implemented.
5- Basic data collection, inventories and assessment studies for e-waste management.
6- Establish a centralized collection point for electronic waste so they can be disposed of in an environmentally friendly way and benefit from it.
7- E-waste management pilot projects allowing the elaboration of regionalized practices and demonstrating the benefits of a sustainable e-waste management system.
8- Based on pilot projects a legal framework for the ICT and recycling sector has to be formulated and implemented.

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Appendix A: Questions for householders in Tayma Region.

Please let us know about your perceptions on the e-waste. Please read the following prior to answering questions.

Section (I): Personal Data:

1- Sex: Male ( ) Female ( )
2- Age: 20 – 29 ( ), 30 – 39 ( ), 40 – 49 ( ) , 50 and above
3- Are you currently: Retired ( ) Employed ( ) Unemployed ( ) Student ( ) Other ( )
4- Marital status: Single ( ) Married ( ) Divorced ( ) Widowed ( )
5- Qualification: Uneducated ( ) Primary ( ) Preparatory ( ) Secondary ( ) University.
6- What is range of your annual household income? Under SR 50,000 ( ) SR 50,000-SR 99,999 ( ) SR 100,000- SR 149,999 ( ) Over SR 150,000 ( )

Section (II): Involvement in Electronic Waste Generation:

1- What are the namely of used electronics in the house?.....
2- How many household electronics have you purchased/replaced in the past 10 years?
3- How many household electronics do you still used of the ones you have purchased in the past 10 years?
4- Do you know what electronic wastes are? Yes ( ) No ( ).
5- Do you use these household electronics frequently? Yes ( ) No ( )
6- What was your reason for purchasing the new household electronics?
Physical Damage ( ) Loss of Function ( ) Need for Greater Functionality ( )
Desire for Newest Technology ( ) Other ( )
7- Which of the following is the model of disposal of e-waste adopted in the house?
Dump in designated places/refuse dump ( ) Sell to recycler ( ) Keep at home ( )
Burning/incineration ( )
8- Are you aware of any government regulation on e-waste management in Saudi Arabia? Yes ( ) No ( )
9- Do you have rules guiding your activities in the association? Yes ( ) No ( )
If yes,
- Are the rules in compliance with government regulation for waste management? Yes ( ) No ( ) Others (please specify).....
- How effectively are the rules enforced? Strongly ( ) Fairly ( ) Not enforced ( )

Section (III): E-Waste Management:

1- What volume of electrical/electronic waste do you handle?.....
2- Indicate the volume of reusable, recyclable and residue from your work …… …….
3- What have you done with the electronics that you no longer use?
Kept in Home ( ) Given/Sold to a Personal Contact ( ) Sold to Informal System ( )
Sold to Formal System ( ) Trash ( )
4- Do you recover any of the electrical/electronic equipment/components from waste?
Yes ( ) No ( )
If yes,
- Which equipment? PC ( ) Laptop ( ) TV ( ) Mobile phone ( )

- Which component do you recycle/recover
  Circuit board ( ) Battery ( ) Plastics ( ) Iron ( ) Copper ( )
  Aluminium ( ) Others (please specify)……..

5- What do you do with the recovered equipment/components?
Sell to repairers ( ) Sell to recyclers ( ) Reuse ( )

Section (IV): Impact of E-Waste on Environment:

1- Are you aware of any health risks associated with electronic wastes? Yes ( ) No ( )
2- Are you aware of local programs, projects or activities pertaining to electronic waste management? Yes ( ) No ( )
3- Are you aware of recycling/trading fairs for electronic wastes? Yes ( ) No ( )
4- How informed are you about the environmental issues in your local area?
Very Informed ( ) Somewhat Informed ( ) Not Informed ( )
I do not care about them at all
5- Are you concerned about your environment?
Not concerned ( ) Barely concerned ( ) Concerned ( ) Very concerned ( )
6- Do you know that some components of electronic devices contain toxic/hazardous materials? Yes ( ) No ( ).
7- Are you aware that these toxic/hazardous materials require special treatment for environmentally sound disposal? Yes ( ) No ( ).
8- Does the disposal/treatment method in use for electronic waste have any impact on the environment? Yes ( ) No ( ) Not sure ( )
If yes, indicate the part(s) of the environment affected and rate the impact

Parts of environment affected	Impact			
	Very strong	Strong	Fairly	No effect
Land				
Air				
Surface water				
Underground water				
Vegetation				

Appendix B: Questions for Municipality of Taima Region.

Please let us know about your perceptions on the e-waste. Please read the following prior to answering questions.

1- Do you know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling?
   - No ( )
   - Informal Service ( )
   - Formal Service ( )

2- Do you see any hazards or risks to the growing amount of e-waste in Tayma ?
   - No ( )
   - Yes, but no specific information ( )
   - Yes, Toxicity or Safety Hazard ( )
   - Yes, Environmental Problem ( )

3- Do you know of any electronic waste management policies currently implemented in Tayma ? Yes ( ) No ( ).
   If yes, What are the current policies in place for e-waste management that span across KSA?

4- Are there flaws to these policies? Yes ( ) No ( ).

5- What is your perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals? Yes ( ) No ( ).

6- Are people aware of the hazardous chemicals found in e-waste? a. If yes, who informs them? b. If no, what is the best way for creating mass awareness?

7- Do you think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices)? Yes ( ) No ( ).

8- How well have companies and the general population complied with electronic waste management policies?

9- How much of a priority is this issue at the government level? At the individual level?

10- How much should the public and government prioritize e-waste management, relative to other public issues?

Appendix C: Questions for Health Sector, Ministry of Health,Taima Region.

Please let us know about your perceptions on the e-waste. Please read the following prior to answering questions.

11- Do you know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling?
- No ( )
- Informal Service ( )
- Formal Service ( )

12- Do you see any hazards or risks to the growing amount of medical e-waste and others in Tayma ?
- No ( )
- Yes, but no specific information ( )
- Yes, Toxicity or Safety Hazard ( )
- Yes, Environmental Problem ( )

13- Do you know of any medical e-waste and others management policies currently implemented in Tayma ? Yes ( ) No ( ).
If yes, What are the current policies in place for e-waste management that span across KSA?

14- Are there flaws to these policies? Yes ( ) No ( ).

15- What is your perception of public awareness of the regulations in place for medical e-waste and others, and for the control of exposure to hazardous chemicals? Yes ( ) No ( ).

16- Are people aware of the hazardous chemicals found in medical e-waste and others? a. If yes, who informs them? b. If no, what is the best way for creating mass awareness?

17- Do you think it would be viable to support the unorganized sector's role in management of medical e-waste and others (while providing for safer practices)? Yes ( ) No ( ).

18- How well have companies and the general population complied with medical e-waste and others management policies?

19- How much of a priority is this issue at the government level? At the individual level?

20- How much should the health sector prioritize for management of medical e-waste and others, relative to other public issues?