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Parasitic Infection Among Farmers Dealing With Treated Wastewater In Al-Zaitoun Area, Gaza City

MSc. Thesis By

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master in Public Health - Epidemiology

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Thesis Approval

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Jerusalem – Palestine

1438 / 2017

Dedication

I would like to dedicate my thesis and everything I do

To ***my father and my mother*** for their endless love, support and continuous encouragement. Without their love and support I will not be who I am today.

To my brothers and sisters ***Nour, Ramy, Fatima, Hanan, Reem, Wafaa , Mohammed, Ahmed, and Belal***.

To the soul of my first teacher ***Eng. Jamal Al-Dadah***, who guide me for treated wastewater reuse science.

To my close friends ***Alaa' and Rasha.***

To every person who give others without waiting their acknowledgement.

To all those who encouraged and helped me to complete this work.

To all of them I dedicate this work.

Haneen Nabil Al-Sbaihi

Declaration

I certify that this thesis submitted for the degree of Master, is the result of my own research, except where otherwise acknowledged, and that this study (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed:

Haneen Nabil Al-Sbaihi

Date: 27/05/2017

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Abstract

Treated wastewater irrigation is associated with several benefits but can also lead to significant health risks. The main objective of this study is to investigate the parasitic infection (PI) among farmers dealing with treated wastewater (TWW) in Al-Zaitoun area, Gaza City. This study included two farmer groups: farmers who dealing with TWW (Mixed water users (MWUs)), and farmers who irrigate by using groundwater (GW) (Ground water users (GWUs)). Each participant was asked to provide stool samples. Soil, irrigation water, and hand washing water samples were taken from each participant in addition to interview structured questionnaire was filled with all of them. Prevalence of PI was 30.9% and increased to be 47.3% in the 2nd phase which was after using TWW for 3 months. Positive association statically significant was found between PI and TWWR in the 2nd phase (OR=1.37, CI 0.448-4.21). Six parasites species were identified among participants: Entamoeba "histolytica/dispar and coil", Cryptosporidium, Microsporidia, Giardia lamblia, Strongyloides stercoralis, and Ascaris lumbricoides. Prevalence of soil parasitic contamination was 54.5% and increased statically significant to be 61.5% in the 2nd phase. Negative association not statically significant was found between irrigation water type and parasitic soil contamination (OR 1st=0.813, CI 0.265-2.495) and (OR2nd =0.897, CI 0.28-2.876). The highest PI was found between females, participants age ≤ 18 year, participants who had the least Academic qualification, who work in agriculture for period of ≤10 years, and who work ≤ 6 hours per day in the farm. Participants who had less family size and who previously had ant-parasitic drugs had less PI with SSR. High PI was found between participants who had bad financially status, who had landless areas inside their homes, who work in farm far away from their homes, who is a new user for TWW and irrigate more agricultural dunums by it, who didn't work mainly in agriculture, who use fertilizers with TWW, who hadn't toilet in their farm, who disposed from their home and farm toilet into the farm and cesspits respectively, who breed animals/birds in places non- closed inside or beside their farms, who previously diagnosed for intestinal parasites, and who had less HB mean. Non-drinking water consumption per person per day was least at parasitic infected participants. Generally MWUs HB was better than GWUs HB inside home and through harvesting process, but it was less through working in the farm. It was found the HB for MWUs through using TWW periods had increased to be the best.

In spite of, increasing MWUs HB with using TWW, MWUs were working in soils less parasitic contaminated, and they also use localized irrigation technique, it was found a positive not statically significant relationship between PI and using TWW in irrigation, may this attributed for increasing the infection opportunity between MWUs as a result of increasing soil microorganisms activity in their soils by increasing soil organic matter from using TWW, in addition to 80% of participants who within age group ≤ 18 year " who hosting more parasites" were from MWUs.

Key words: *Wastewater, Groundwater, Treated wastewater, Hygiene behavior, Parasitic infection*

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List of abbreviations

BOD	Biochemical oxygen demand
CDC	Centers for Disease Control and Prevention
CMWU	Costal Municipality Water Utility
CSO-G	The Comparative Study of Options for an Additional Supply of Water for the Gaza Strip
EC	Electrical conductivity
FAO	Food and Agriculture Organization
FG	Farmer's group
GS	Gaza strip
GW	Groundwater
GWIP	Groundwater irrigation periods
GWUs	Groundwater users
GWWTP	Gaza wastewater treatment plant
HB	Hygiene behavior
hr.	Hour
JCP	Job Creation Program
Km	Kilometer
M^3/d	Cubic meter per day
MCM/y	Million cubic meter per year
Mg/l	Milligram per liter
MID	Minimal infective dose
Min	Minute
Ml	Millimeter
Mm^3	Million cubic meter
MOA	Ministry of Agriculture
MOH	Ministry of Health
MW	Mixed water
MWUs	Mixed water user
OR	Odds ratio
PCBS	Palestinian Central Bureau of Statistics
pH	Power of hydrogen
PHG	Palestinian Hydrology Group
PHIC	Palestinian Health Information Center
PI	Parasitic infection

PWA	Palestinian Water Authority
RII	Relative importance index
SAT	soil-aquifer treatment system
Sec/s	Second
SSR	Statistically significant relationship
TSS	Total suspended solids
TWW	Treated wastewater
TWWIP	Treated wastewater irrigation periods
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNRWA	The United Nations Relief and Works Agency
US EPA	United States Environmental Protection Agency
USAID	United States Agency for International Development
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization
WW	wastewater
WWR	Wastewater reuse
WWTP	Wastewater treatment plant

Chapter I

Introduction

1.1 Background

Gaza strip (GS) is located in a semi-arid region, with a tight area of $365km^2$; population of the Gaza strip is more than 1.8 inhabitant and will reach more than 2.6 Million inhabitant by year 2025 (CMWU, 2016; Dudeen, 2001). Groundwater aquifer is considered the main water supply source for all kind of human usage in the Gaza Strip (domestic, agricultural and industrial). This source has been faced a deterioration in both quality and quantity for many reasons such as the low rainfall, increasing the urban areas which led to a decrease the recharge quantity of the aquifer, also increasing the population number which depletes the groundwater aquifer and lead to seawater intrusion in some areas as a result of pressure differences between the groundwater elevation and sea water level (CMWU, 2016). Recent reports showed that the groundwater aquifer in the GS will become unusable by 2020 as the deterioration will become irreversible (United Nations Country Team in the occupied Palestinian territory, 2012).

The present net aquifer balance is negative; the net deficit is about 85 MCM/y and will increase if there is no management actions taken (PWA, 2016). In the same time food security levels in 2012 year has collapsed in Gaza, and became only one in ten households are food secured (PCBS et al., 2012).

Water resource planners therefore, proposed to use non-conventional alternate sources of water to bridge the deficits (Al-Agha & Mortaja, 2005). Possible management options include the use of treated wastewater (TWW) and desalination are at the forefront of water management plans (Al-Juaidi et al., 2011; Mimi et al., 2007).

There is a high potential for wastewater reuse (WWR) due to the increased generated wastewater quantities, about $92Mm^3$ of wastewater were estimated to be generated in GS by year 2020 (Afifi, 2006). This amount if properly used can provide adequate amount for the agricultural sector and save the aquifer from further deterioration. WWR not only can reduce the water deficit in the GS, but it also can minimize the environmental deterioration which is one of the main aspects considered by the policy makers in the GS (Al- Juaidi et al., 2010).

1.2 Problem Statement

Wastewater (WW) incresingly used for agriculture in both developing and industrilized countries as a result of (a) Increasing water scarsity, stress and degrgation of fresh water resources resulting from improper disposal of wastewater. (b) Population increase and related increasing demand for food. (c) Agrowing recognition of the resource value of wastewater and the nutrients it contains. (d) Ensuring environmental sustainability and elmination poverty and hunger (WHO, 2006). WW contains a varity of different pathogens, may of which are capable of survival in the environment (in the wastewater, on the crops, or in the soil) long enough to be transmitted to human. In places where wastewater is used without adequate treatment, the greatest heath risks are usually associated with intestinal helminths (WHO, 2006). The health hazards associated with wastewater use in irrigation are of three kinds: (a) The rural health and safety problem for those working on the land where the wastewater is being used (farmers workers and their families), (b) Population groups consuming crops irrigated by treated wastewater, and (c) Health effects among population residing near wastewater-irrigated fields (Shuval, 1990). Health risk associated with wastewater reuse may differ in different subgroups of the population. The most important subgroup to consider are agricultral workers exposed occupationaally (occupational risk) and persons consuming crops irrigated with the wastewater (consumer risk) (WHO, 1989). Many studies reported the parasitic risk from WWR between farmers. In Pakistan it was reported that farmers who using wastewater in irrigation were five times more likely to be infected with hookworms than others using canal water (Ensink et al., 2005). In Senegal where only WW is available 60% of farmers were infected with intestinal helminths (Faruqui et al., 2006). Uganda farmers who exposed to WW were more likely to be infected with helminths than slum dwellers and workers involved in sludge collection (Fuhrimann et al., 2016).

As we see, parasitic infection between farmers who use TWW in agriculture is a known public health issue in the world, but not studied yet in GS. This study is a Pioneer study will investigate the parasitic infection among farmers dealing with TWW in Al-Zaitoun area, Gaza City in order to submit suitable recommendations that could be helpful for decision makers to take the necessary measures in order to reduce the possible infection and protect the health of farmers and their families who involved or will be involved in future in WWR projects.

1.3 Problem Justification

The agricultural sector represents a key source of income for Gaza at the present time. However, it suffers from inefficiencies and from the profligate and uncontrolled use of the precious water supplies; approximately half of the current fresh water use in Gaza is allocated to the agricultural sector. Strategic studies that completed by the Palestinian water Authority (PWA) and assessments by both the World Bank (WB) and United Nations Environment Programme (UNEP) have all shown that the water supply situation in Gaza is in an extreme concern at present, and will become much worse over time, in the absence of major interventions. Reuse of treated wastewater was a very important component of water strategy as revealed by the comparative study of options for an additional supply of water for the Gaza Strip (CSO-G), in part because approximately half of the current fresh water use in Gaza is allocated to the agricultural sector (Phillips Robinson & Associates, 2011).

PWA strategic planning study in 2000 sets out strategy to increase the wastewater reuse over the next 20 years. According to PWA plans, 60% of the available TWW will be reused for agricultural purpose in the west Bank and Gaza (39 MCM and 51MCM respectively) and 15% will be recharged to aquifer (10 MCM and 13MCM respectively) (World Bank, 2004).

As recommend in CSO-G; the reuse of treated wastewater should be introduced immediately on a pilot scale, with the intention to prove the value of this to the farming community; the pilot reuse projects should be followed as soon as possible by large-volume reuse of treated wastewater, as this intervention is especially important in reducing groundwater abstraction and hence in protecting the aquifer in the long term. A number of wastewater reuse demonstration or pilot projects have been established in Gaza, and numerous studies related to WW treatment and reuse also have been conducted; these were vary from guidelines to preferred technology and social acceptability reports, and it may be considered that Gaza has long ago passed the ‘trial’ stage and is ready for much larger-scale WWR than currently exists (Phillips Robinson & Associates, 2011). However there is no studies to investigate the epidemiological link between this practice and parasitic infection among farmers. In this regard this study aimed to determine the association between using TWW in agriculture and the parasitic infection in the second pilot project at Al-Zaitoun area, Gaza.

1.4 Objectives

1.4.1. Main objective:

The main objective of this study is to investigate the parasitic infection among farmers dealing with treated wastewater in Al-Zaitoun area, Gaza City.

1.4.2. Specific objectives:

1. To compare the parasitic infection prevalence between farmers dealing with treated wastewater after using TWW in irrigation for three months and farmers dealing with groundwater (as a benchmark for comparing).
2. To examine the parasitic status for treated wastewater, groundwater, soil, and farmers hand washing water.
3. To identify the risk factors associated with parasitic infection especially the hygiene behavior among the farmers.

1.5 Context of Study

This study conducted at two agricultural areas in Gaza city where influenced by many demographic, socioeconomic, environmental, and health factors.

1.5.1. Demographic and Socio- economic Context

Gaza Strip is a coastal region located in the southern part of Palestine. GS divided into five governorates: North, Gaza City, Middle area, Khanyouins area, and Rafah area. At mid of 2016 the estimated population of Gaza Strip totaled 1.88 million of which 956 thousand males and 925 thousand females (PCBS, 2017).

The Gazan economy has come to a near standstill due to a combination of unemployment, closures, and restrictions placed on workers, industries, goods and services. With unemployment in Gaza reaching alarmingly high levels, the military operations have further paralyzed economic development, destroying much of the remaining productive resources, capital stock, and employment opportunities. The Gazan economy is largely dependent on agriculture, however due to closures and land razing, this sector has been greatly affected. In addition to the military operations have been increased food insecurity and loss of livelihoods, demolition of greenhouses and agricultural infrastructure, uprooting of trees, contamination of agricultural land, loses in livestock, and widespread damage to crops (UNDP, 2012).

1.5.2. Environmental and health factors

Water quality monitoring has revealed very high chloride and nitrate pollution in coastal aquifer. High nitrate levels are primarily caused by the infiltration of sewage into water resources, as well as by over application of N-Fertilizers. High chloride concentration are primarily caused by the sea water intrusion. Although environmental conditions are difficult in GS as a result of the very high population density, sanitary conditions have much improved over the last few decades. As a result of this improving life expectancy has risen, infant mortality has decreased and most health indicators are become among the best in the region. An important achievement of the health sector in Palestine was the serious drop in child mortality due to poor quality water and poor sanitation (PWA, 2013).

1.6 Operational Definitions (MED WWR WG, 2007)

Groundwater

Water contained in rocks and sub soils.

Irrigation water

Appropriate quality of water suitable for irrigation application not result in any significant risk to health of user or consumer.

Reclaimed water

Municipal wastewater that has been treated to a specific water quality criteria, normally a higher quality than secondary treatment, so it can be beneficially reused.

Restricted irrigation

The use of treated wastewater to irrigate all crops except salad crops and vegetables that may be eaten uncooked.

Unrestricted irrigation

The use of treated wastewater to irrigate crops that are normally eaten raw.

Treated wastewater

Primary treated wastewater, secondary treated wastewater, tertiary treated wastewater, or to a higher standard.

Treated wastewater reuse

Beneficial use of appropriately treated wastewater.

Wastewater

Liquid waste discharged from homes, commercial premises, and similar sources to individual disposal systems or to municipal sewer pipes, which contains mainly human excreta and used water. When wastewater produced mainly from household and commercial activities, it is called domestic, municipal wastewater, or domestic sewage.

Soil aquifer treatment

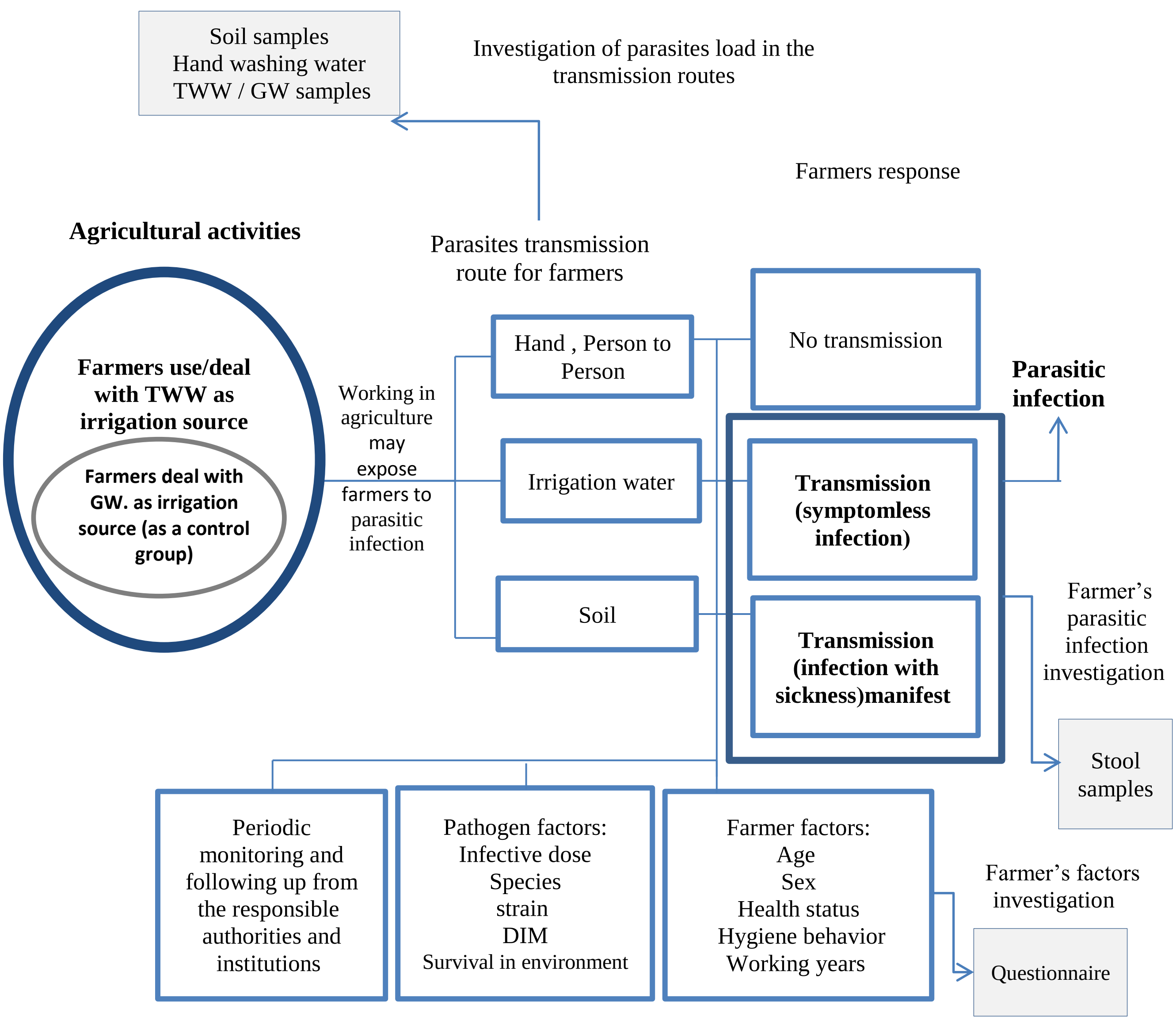
An infiltration of the sewage effluent into the aquifer, and the natural movement of the effluent within the groundwater acts as a natural filter to treat wastewater (Austrian Development Cooperation & Palestinian Water Authority, 2011).

Chapter II

Literature Review

This chapter illustrates the study conceptual framework and describes background information about water, wastewater status in Gaza strip and agricultural sector; in addition it describes the interest and effect of wastewater reuse, previous experience of treated wastewater reuse in Gaza Strip, health risks associated with treated wastewater irrigation, microbial contaminants in wastewater, chain of infection, major parasites that causing waterborne parasitic diseases, health protection measures for reducing health risks associated with wastewater irrigation, and the treated wastewater reuse guidelines.

2.1 Conceptual Framework



Human enteric disease are caused by many types of pathogenic microorganisms including bacteria, viruses, protozoa, and helminths. These diseases are transmitted when the pathogenic microorganisms are excreted to the environment by an infected person "host", transported by a suitable vector; such as water or food, and ingested by another susceptible human "host". Large numbers of the disease-causing pathogens are excreted in the urine and feces of infected individuals; thereafter these pathogens contaminate the wastewater which dumped into the environment or agricultural lands when farmers use TWW in irrigation. The number of pathogenic microorganisms per gram feces of infected person usually ranges from 1 million to 100 million (10^6-10^8) of bacteria or viruses, from 10 to 100 thousand (10-10^5) of protozoa, and 100 to 10,000 (10^2-10^4) of encysted helminths. Wastewater from communities carries the pathogenic microorganisms excreted by the diseased and infected people who live in that communities. The calculated amount of pathogenic microorganisms in the wastewater stream is many millions per liter for bacteria, thousands per liter for viruses, and a few hundred per liter for some of the helminth eggs (Shuval, 1990).

Based on the epidemiological studies the using TWW in agriculture exposes farmers to the pathogenic microorganisms still exist in the WW after treatment; the pathogenic microorganisms can transmit to farmers either from the TWW itself, soil, contaminated plants, or from other infected farmer/person.

Many factors play significant role in determining farmers response, some of these factors are related to farmer as age, sex, health status, hygiene behavior, working years in agriculture or related to the pathogenic microorganisms itself as species, infective dose, survival in environment.

The periodic monitoring and following up TWWR projects by the responsible authorities/institutions such as Ministry of Health (MOH), PWA, or Coastal Municipality Water Utility (CMWU) should ensure farmers commitment in using protection tools and the provided TWW quality is according to TWWR standards.

In this study stool samples were taken in order to investigate the parasitic prevalence, while to investigate the parasitic load in the surrounding environmental mediums irrigation water, soil, and hand washing samples were taken, finally to find the relationship between risk factors and parasitic infection interview questionnaire was conducted.

2.2 Water Status in Gaza Strip

The population of the Gaza Strip is more than 1.8 inhabitant and will reach more than 2.6 Million inhabitant by year 2025. Groundwater is considered the main water source that supply Gaza Strip population by domestic, agricultural, and industrial water needs. Gaza coastal aquifer is limited where its thickness is between120-150 meter in some areas of the western part to few meters in the east and southern part of the coastal aquifer. It has been faced deterioration in both quality and quantity for many reasons such as the low rainfall rate, increasing the urban areas which led to a decrease in the recharge quantity, increasing the population who depletes the groundwater and lead to seawater intrusion in some areas, and existing incorrectly designed sewage system (CMWU, 2016).

According to PWA reports the total abstraction of GW is a proximately 190.5 MCM/y, from which 95.202 MCM/y for domestic use through 260 water wells, Mekorot, and 154 desalination plants. The total water supplied for agriculture use including the livestock are about 95.3 MCM/y (92.7 for agriculture and 2.64 for livestock). The present net aquifer balance is negative, the net deficit was about 85 MCM/y and will increase if there is no management actions taken (PWA, 2016).

In Gaza strip, the direct consequences of over pumping of the coastal aquifer are seawater intrusion and uplift of the deep brine water; consequently, the water quality became fall below the accepted international guidelines for potable water resources. Currently, several agricultural wells are also showing high salinity levels. In addition to salinity problem Gaza is experiencing a serious wastewater-driven problems, it is characterized by high levels of nitrates in the GW. The chloride concentration of the pumped water is in the range of 100-1000 mg/l, while the nitrate is in the range of 50-300 mg/l. As a result there is only less than 5% of the delivered domestic water matching prevailing drinking water Standards (PWA, 2012).

Regarding microbiological water quality, El-Mahallawi (1999) and Melad (2002) (as cited in (Yassin et al., 2006)) reported that despite of there are few studies have addressed microbiological water quality problem, it has deteriorated in the Gaza strip. The bacteriological quality of the tap water and the roof tanks in Deir El-Balah - Gaza strip are not hygienically safe. Various levels of total and fecal coliforms have also been found in water samples from 20 groundwater wells located around the wastewater treatment pond of Beith Lahia - Gaza strip. Another study found a total of 8 out of 420 samples (1.9%) of various drinking water sources which collected during one year period in Gaza strip are contaminated by *Cryptosporidium* oocysts (Ghuneim & Al-Hindi, 2016). In addition to it was found the total and fecal coliform contamination in both water wells and networks generally exceeded the WHO limit in Gaza Governorate. A strong correlation (r = 0.7) was found for giardiasis with fecal coliform contamination in drinking water networks, whereas correlation with diarrheal diseases and hepatitis A were relatively weak (r = 0.3 and 0.1, respectively). Diarrheal diseases were the most self-reported diseases in Gaza city; such diseases were more prevalent among people who used municipal water than people who used desalinated water and home filtered for drinking (OR=1.6) (Yassin, et al., 2006).

2.3 Wastewater Status in Gaza Strip

2.3.1. Wastewater networks in the Gaza strip:

Sanitation sector in GS over the previous years was, to some extent, neglected and this is due to the frequent closures of Gaza crossing in addition to the limited funding for sanitation sector. The expansion of wastewater networks is linked to the treatment plants where the dumped water is treated. Treatment plants have barely obtained some funds for expansion, developing and improving their efficiency. Thus, the network coverage of this sector has reached 72% distributed amongst the Gaza strip governorates (CMWU, 2016) as shown in the Annex (1).

2.3.2. Wastewater treatment plants in Gaza strip:

In Gaza strip there are three main wastewater treatment plants (Beit Lahiya treatment plant, Sheikh Ajleen "Gaza" treatment plant, and Rafah treatment plant) and two temporary plants (Khanyounis temporary treatment plant and Wadi Gaza intermediate treatment plant) for collecting and treating wastewater to the level allowed to be dumped to the sea and to not pollute the aquifer in case of infiltration. The locations of these treatment plants were chosen during the times of the Israeli occupation of the Gaza strip; however, the regional contour of Ministry of Planning suggests establishing three central treatment plants near the eastern armistice line. The current treatment plants still do not meet the standards of treating wastewater in Gaza and this is due to the frequent closure of Gaza crossings that hinder the required periodical maintenance. Moreover, the population growth without a proper expansion of the treatment plants has caused a problem since the wastewater production rate is increasingly (CMWU, 2016)**.**

2.3.3.1. Gaza wastewater treatment plant (GWTP):

GWTP was established in 1979 with an infiltration basin next to it. By the year 1986 UNDP established another two infiltration basin to develop the plant. The plant also was developed in 1996 by the Municipality of Gaza and The United Nations Relief and Works Agency (UNRWA) in order to recharge 12,000 cubic meters per day. United States Agency for International Development (USAID) in collaboration with PWA in 1998 rehabilitated the plant and enlarge its capacity to recharge 35,000 cubic meters per day in order to accommodate population growth till the year 2005, then a part of the treated WW was pumped to the infiltration basins and another part was pumped to the sea. After the year 2005 many people seized the plant infiltration basins and turned them into agricultural lands. In 2009 the water pumped to the plant increased to 60,000 cubic meters per day and this exceeds the plant capacity (CMWU, 2016).

2.4 Agriculture

2.4.1. Irrigation water quantity in Gaza strip:

Irrigated agriculture is a vital component of total agriculture and supplies many of the food needs for human beings and animals. There are about 2600 agricultural legal wells and more than 7765 illegal agricultural wells distributed allover Gaza Strip (Al-Daddah, 2013). Approximately half of the current fresh water use in Gaza is allocated to agricultural sector (Phillips Robinson & Associates, 2011). The amount of fresh water allocated for agriculture should be reduced radically to meet the increasing demand for the municipal purposes. So it is becoming clear that developing new water sources will not be enough to meet these challenges; it must be coupled with wiser use of existing sources of water through water demand management measures, water reuse, and maintenance of water quality. Adequate water demand management in the agricultural sector needs establishment of incentives, regulations and restrictions help, guide, and coordinate the farmers' behavior for the efficient use of water in irrigation while encouraging water saving technologies (Al-Daddah, 2011).

2.4.2. Irrigation water quality in Gaza strip

The main water source for irrigation in GS is the coastal aquifer who has many water quality problems; approximately two-thirds of the total cultivated area in Gaza were irrigated. Moreover the rainfall is insufficient for the cultivation of most crops and supplementary irrigation is needed in order to meet the crop water requirements. In spite of the over extraction from aquifer has resulted in draw down the groundwater with resulting intrusion of seawater and up-coning the underlying saline water. The irrigation process can degrade water quality by increasing salt concentration and adding toxic materials through the over application of fertilizers and mismanagement of pesticides (Al-Daddah, 2011).

2.4.3. Future water resources development for agriculture in the Gaza strip

In light of the expected climate change in the region, and upon the fact that the entire existing agricultural demand is taken from the groundwater aquifer, which a large proportion of this is brackish. PWA has reported that by 2020 the utilization of wastewater is planned to provide 50 % of the total required by agriculture, with the remainder being provided by the freshwater aquifer in order to maintain the balance of salts in the soil and provide the quality necessary for certain crops (PWA, 2010).

2.5 Interest in Wastewater Reuse in the World

Wastewater treatment and disposal through land application gained increasing attention after 1945 provided almost the only feasible, relatively low-cost method for sanitary disposal of municipal wastewater as a mean of preventing surface water pollution and increasing water resources in arid and semiarid areas. These factors coupled with rapid urban growth and the need to increase agricultural production made sewage farms attractive to the agricultural community and municipal planners. The regulations developed by the state of California helped to re-establish the feasibility of wastewater reuse in agriculture in the western part of the United States. Soon thereafter a similar trend began in many of the rapidly developing countries faced water shortages and insufficient waterways to properly dilute and dispose of municipal wastewater (Shuval, 1990).

A survey of current wastewater reuse practices in developing countries carried out by the WB and UNDP has estimated that approximately 80 percent of the wastewater flow from urban areas in developing countries is currently used for permanent or seasonal irrigation (Gunnerson 1985). Although wastewater reuse has been practiced more widely in developing countries over the past thirty years, much of it is unplanned and uncontrolled and poses a threat to public health. These risks must be fully understood and appropriate measures must be taken to provide technically feasible and economically attractive solutions so that the public can reap the full benefits of wastewater reuse without suffering harmful effects (Shuval, 1990).

2.6 Previous Experiences of Treated Wastewater Reuse in Gaza Strip

Responding to the short-term strategy of PWA in 2000, many small wastewater reuse pilot projects carried out in Gaza strip. These experiments aimed principally to demonstrate the practical feasibility of treated wastewater for agricultural purposes in a sustainable development and to increase farmers and the public awareness that the agricultural reuse of treated wastewater is acceptable and feasible in terms of good production, minimum health risks, and good economic results (Austrian Development Cooperation & Palestinian Water Authority, 2011).

There are four reuse pilot projects in GS demonstrated to use treated wastewater for irrigation fodder and fruit orchards. Some pilot projects used the soil-aquifer technique to treat the sewage water before being used for irrigation, and another pilot projects used sand filters.

2.6.1. Bedouin village pilot project:

The first pilot location for TWWR was at Beit Lahia by Italian fund; the effluent of the Beit Lahia Lake water treatment was used to irrigate the fodder crops (alfalfa, Sudan grass, and ray grass). The fodder crops were used for feeding the small animals. The total area that cultivated by Alfalfa is extended to 45 dunums and later on enlarged to 140 dunums. A comprehensive monitoring system is carried out to examine crops, soil, ground water, and the effluent from Beit Lahia Lake water treatment. Short training courses for farmers as well the agricultural engineers to qualify the target groups in addition to public awareness sessions for the interested farmers and agricultural associations was lunched (Austrian Development Cooperation & Palestinian Water Authority, 2011).

2.6.2. Zaitoun area pilot project:

The second pilot location for TWWR was in 2004. The Job Creation Program (JCP) in cooperation with Palestinian Hydrologists Group (PHG) had proposed a project to use treated wastewater from (GWWTP) for irrigating 100 dunums of citrus and olive trees at A-Zaitoun area. The project had been established under French fund and the supervision of PWA and Municipality of Gaza with coordination with Ministry of Health (MOH) and Ministry of Agriculture (MOA). This project was successful, thereafter, extension has made till the last Israeli invasion that led to the destruction of some of infrastructure of the project. However, rehabilitation was currently done under the French and Spanish funds and the project was operated again on November 2010 covering 186 dunums (Al-Dadah, 2013) .

2.6.3. Al-Mawasi (SAT):

JCP in close cooperation with PWA and CMWU with a fund of the Catalan Government launched the third pilot location for TWWR with soil-aquifer treatment system (SAT). The project started with 60 dunums in 2008 and expanded to 90 dunums in 2010 cultivated with Jawaffa and Palm trees (Al-Dadah, 2013).

2.6.4 European hospital in Khanyounis project:

The fourth pilot location for TWWR was funded by the European Commission, and was installed in the European hospital in Khanyounis. The effluent from the plant is irrigating (by sprinkler) 90 dunum of olive, and other trees. The main partners involved are MOA and PWA (Austrian Development Cooperation & Palestinian Water Authority, 2011).

2.7 Effects of Wastewater Reuse in Agriculture

2.7.1. Positive effects of treated wastewater use in agriculture:

2.7.1.1. Environmental benefits:

Wastewater reuse schemes if managed well can have several environmental benefits as a) Avoidance of surface water pollution, which would occur if the wastewater were not used but discharged into surface water, b) Avoidance major environmental pollution problems, such as dissolved oxygen depletion, eutrophication, foaming, and fish killing, c) Conservation or more rational use of freshwater resources, especially in arid and semi-arid areas, d) Reduced requirements for artificial fertilizers, with a concomitant reduction in energy expenditure and industrial pollution elsewhere, and e) Soil conservation through humus build-up and through the prevention of land erosion, desertification control and desert reclamation through irrigation and fertilization of tree belts (D Mara & S Cairncross, 1989).

2.7.1.2. Agricultural benefits:

Wastewater reuse schemes if managed well can have several agricultural benefits as reliable and possibly less costly irrigation water supply, a) Increased crop yields, often with larger increases than with freshwater due to the wastewater's nutrient content, b) Ensuring more secure and higher urban agricultural production, c) Contribution to food security, income and employment generation in urban areas, and d) Improving livelihoods for urban agriculturalists, many of whom are poor subsistence farmers, including a large share of women (Scheierling et al., 2010). Wastewater can often contain significant concentrations of organic and inorganic nutrients for example nitrogen and phosphate. There is potential for these nutrients present in recycled water to be used as a fertilizer source when WW is recycled as an irrigation source for agriculture, in addition to soil microorganisms have been observed to have increased metabolic activity when sewage effluent is used for irrigation (Ramirez-Fuetes et al. 2002, Meli et al. 2002).

2.7.1.3 Water resources management benefits:

In terms of water resources management, the benefits may include supplying: a) An additional drought-proof water, often with lower cost than expanding supplies through storage, transfers, or desalinization; b) More local sourcing of water; inclusion of wastewater in the broader water resources management context; and c) More integrated urban water resources management (Scheierling, et al., 2010).

2.7.2 Negative effects of treated wastewater use in agriculture:

2.7.2.1 Environmental impacts:

Sewage effluents from municipal origin are rich in organic matter and also contain appreciable amounts of major and micronutrients (Brar et al., 2000; Pescod, 1992). However, these chemical constituents may affect public health and/or environmental integrity (Assadian et al., 2005). The wastewater may also contain significant quantities of toxic metals (Som et al., 1994; Yadav et al., 2002) and therefore its long-term use may result in toxic accumulation of heavy metals with unfavorable effects on plant growth (Rattan et al., 2005). In addition to reuse of wastewater may be seasonal in nature, this will resulting in the overloading of treatment and disposal facilities during the rainy season. In some cases, reuse of wastewater is not economically feasible because of the requirement for an additional distribution system. Also the application of improper treated wastewater as irrigation water or as injected recharge water may result in groundwater contamination (Austrian Development Cooperation & Palestinian Water Authority, 2011).

2.7.2.2 Agricultural impacts:

The practice of wastewater reuse could result in soil damage. Although the organic matter in wastewater can help improve soil texture and water-holding capacity, wastewater also has harmful effects by causing soil salinization, blocking soil interstices with oil and grease, and accumulating heavy metals (Faruqui et al., 2004) There is a concern about a possible increase in soil-borne diseases in human populations (Santamaria & Toranzos, 2003).

Many of the diseases associated with soils have been well characterized and studied, enteric diseases and their link to soil contamination have been understudied and possibly underestimated (Solaymani-Mohammadi et al., 2010).

2.8 Health Risks Associated with Treated Wastewater Irrigation

Wastewater use in agriculture has risk especially when untreated wastewater is used for crop irrigation, it poses substantial risks not only to the farmers, but also the surrounding communities and the consumers of the crops. The microbial risk is the biggest risk to health which arises as a result of existence pathogens that are usually present in untreated or partially treated (and to some level also in treated) wastewater (Asano, 1998). People who directly or indirectly work by using WW have potentially greater risk for parasitic infection than the general population (Zimmerman, 2005).

The detection of pathogens in soil, wastewater used for irrigation and on crops indicates potential environmental and health risks to occupationally exposed farmers and consumers of the contaminated crops. As there are soil-borne diseases caused by enteric pathogens which get into soil by means of human or animal excreta (Weissman et al., 1976).

2.8.1 Risks to agricultural workers and their families:

Direct contact with untreated wastewater in irrigation at particularly in the dry season causes diarrhoeal disease; the risk of diarrhoeal disease reduced when the wastewater is stored in storage reservoirs before use (Blumenthal et al., 2001; Cifuentes, 1998). There is also evidence to suggest that direct contact with untreated wastewater can lead to increased helminth infection mainly *Ascaris* and hookworm infection and that this effect is more pronounced in children than in adult farm workers (Blumenthal, et al., 2001; Bouhoum & Schwartzbrod, 1998; Habbari et al., 2000; Peasey, 2000).

Study in Mexico revealed that the irrigation with untreated or partially treated wastewater was directly responsible for 80% of all Ascaris infections and 30% of diarrhoeal disease in farm workers and their families (Cifuentes et al., 2000). The hookworm infection effect of exposure to untreated wastewater among farm workers varies from attributable risks of between 37% in children and 14% in adults (Krishnamoorthi et al., 1973). The major threat to farmers and their families is from intestinal parasites most often worms (Faruqui, et al., 2004). Bacterial and viral infections are other health threats which can occur after the consumption of raw vegetables contaminated with fecal matter. Cholera epidemic in Jerusalem and typhoid epidemics in Santiago and Dakar are all isolated to urban and peri-urban agriculture (UPA) (Faruqui, et al., 2004). Study conducted in Phnom Penh, Cambodia indicated that there may be an association between exposure to wastewater and skin problems such as contact dermatitis (eczema) (Van der Hoek et al., 2005).

2.9 Wastewater Microbial Contamination

The principal categories of pathogenic organisms found in wastewater are bacteria, viruses, protozoa, and helminths (Pescod, 1992). The numbers and types of pathogens found in wastewater vary both spatially and temporally depending on season, water use, economic status of the population, disease incidence in the population producing the wastewater, awareness of personal hygiene, and quality of water or food consumed (WHO, 2006). Examples of Microbial Pathogen levels and diseases associated with untreated wastewater are shown in Annex (2).

2.9.1 Wastewater pathogenic parasites:

A parasites is an organism that lives on or in another species which constitute the host. The parasites normally doesn't kill its host, because the life of the parasites also would be terminated (Zimmerman, 2005). Parasites are two types:

2.9.1.1 Helminthes parasites:

There are two groups of helminths. These groups are the flatworms and roundworms. Flatworms consist of tapeworms (cestodes) and flukes (trematodes). Roundworms also are known as nematodes. Helminths exist in two forms. The first form is an actively growing larva or worm. The larva is found inside the definitive host and produces eggs or ova. The egg or ovum is the second form and leaves the host in fecal waste. The ovum develops a protective structure that is resistant to adverse conditions and has the ability to infect a new host (Zimmerman, 2005). Helminths can be present as the adult organism, larvae, eggs, or ova. The eggs and larvae, which range in size from about 10 µm to more than 100 µm, are resistant to environmental stresses (EPA, 2012). Intestinal nematodes are the greatest health risk involved in the use of untreated wastewater in agriculture (Mitchell, 1992), the helminths that are of significant health risk, include round worm (*Ascaris lumbricoides*), the hook worm (*Ancylostoma duodenale or Necator americanus*), the causative agent of strongyloidiasis (*Strongyloides stercoralis*), and the whip worm (*Trichuris trichiura*) (Ottoson, 2005; Toze, 1997).

2.9.1.2 Protozoan parasites:

The term "protozoan" is a common name of single-celled, eukaryotic organisms that are either animal-like, fungus-like, or plant-like. Protozoans also can be distinguished or grouped by their inability or ability to move with cilia (ciliates), flagella (flagellates), or pseudopodia (amoebae). Protozoans that have no direct locomotive ability are coccidians. The form of a protozoan parasite that lives inside the host is called the trophozoite stage (Zimmerman, 2005). Most of the protozoan parasites produce cysts or oocysts, which are quite resistant to environmental stress and to disinfection which are able to survive outside their host under adverse environmental conditions. A new trophozoite is released from the cyst. This process is called excystment (Bitton, 2005).

Although most protozoans are free living in soil or water, some protozoans can be parasitic. Parasitic protozoans are small in size (2–200mm). The animal-like protozoans contain several parasites of concern to wastewater personnel including Cryptosporidium (Zimmerman, 2005).

Erdogrul and Sener 2005 as cited in (Kwashie, 2011) reported that the protozoa parasites commonly detected in wastewater and wastewater irrigated fields are the *Giardia lamblia, Enterobius vermicularis, Entamoeba histolytica, and Cryptosporidium parvum*.

2.9.2 Survival of parasites in environment:

The persistence or survival of pathogenic microorganisms, and their resistance to treatment processes is an important wastewater reuse issue (Toze, 1997).

Pathogenic microorganisms remain a health risk as long as they persist in environments such as wastewater. The longer they survive in an environment the greater the potential they have of becoming mobilized if the chemical, physical or hydraulic conditions are suitable. Therefore, the longer pathogens persist in wastewater, the chance that they could come into contact with workers and the general public increase (Kwashie, 2011).

Knowledge of the survival of pathogens in soil and on the crop allows an initial assessment of

the risk of transmitting disease via produced foodstuff or through worker exposure (Westcot, 1997). Annex (3) shows the survival times of the pathogens in water are different from soil and crops.

2.10 Chain of Infection

The potential for a biological agent to cause infection in a susceptible host depends on the following factors:

2.10.1. Type of infectious agent:

Several infectious organisms may cause diseases in humans. These agents include bacteria, fungi, protozoa, helminths, and viruses. The potential for causing illness depends on infectious agents virulence and the stability of the infectious agent in the environment (soil, crops, and water), and the minimal infective dose (MID). MID varies widely with the type of pathogen or parasite (Bitton, 2005). As it illustrated in table (2.1) a few protozoan cysts or helminthes eggs may be sufficient to establish infection; moreover, helminths are the most infectious agent have a long persistence in environment.

Table 2.1: Epidemiological characteristics of enteric pathogens against their effectiveness in causing infections through wastewater irrigation, source (Bitton, 2005).

Pathogen	Persistence in environment	Minimum infective dose	Immunity	Concurrent routes of infection	Latency/soil development stage
Viruses	Medium	Low	Long	Mainly home contact, food and water	No
Bacteria	Short/medium	Medium/high	Short/medium	Mainly home contact, food and water	No
Protozoa	Short	Low/medium	None/little	Mainly home contact, food and water	No
Helminthes	Long	Low	None/little	Mainly soil contact outside home and food	Yes

In addition to the above factors minimal concurrent transmission through other routes such as food, water, poor personal or domestic hygiene, and the need for a soil development stage represent a main factors that contribute to the effective transmission of pathogens particularly by wastewater irrigation. As shown in table (2.1) helminths (worms) diseases are the most effectively transmitted by irrigation with raw wastewater because they persist in the environment for relatively long periods; their minimum infective dose is small; there is little or no immunity against them; concurrent infection in the home is often limited; they latency is long, and a soil development stage is required for transmission. In contrast, the enteric viral diseases should be least effectively transmitted by irrigation with raw wastewater, despite their small minimum infective doses and ability to survive for long periods in the environment. Due to poor hygiene in the home, and the prevalence of concurrent routes of infection in some areas, most of the population has been exposed to and acquired immunity to the enteric viral diseases as infants. Most enteric viral diseases impart immunity for life or at least for very long periods, so that they are not likely to re-infect individuals exposed to them again, for example, through wastewater irrigation, while the transmission of bacterial and protozoan diseases through wastewater irrigation lies between these two extremes.

Shuval (1990) demonstrated that pathogens can be theoretically ranked in the following descending order of risk:

1. High: Helminths infections,
2. Lower: Bacterial infections and Protozoan infections,
3. Least: Viral infections.

2.10.2. Reservoir of the infectious agent:

A reservoir is a living or nonliving source of the infectious agent allows the pathogen to survive and multiply. The human body is the reservoir for numerous pathogens; person-to-person contact is necessary for maintaining the disease cycle. Domestic and wild animals also may serve as reservoirs for several diseases called zoonoses, that can be transmitted from animals to humans. Nonliving reservoirs such as water, wastewater, food, or soils can also harbor infectious agents (Bitton, 2005). Farmers are having more than one probably reservoir for the infectious agents as they in direct contact with nonliving reservoirs elements in addition to almost of them used to breed birds and animals in their farms which may serve as a nonliving source of the infectious agent.

2.10.3. Mode of transmission:

Transmission involves transport an infectious agent from the reservoir to the host. As this is the most important link in the chain of infection. Pathogens can be transmitted from the reservoir to a susceptible host by various routes.

2.10.3.1. Person-to-Person transmission:

The most common route of transmission of infectious agents is from person to person.

2.10.3.2. Waterborne transmission:

Waterborne route is not, however, as important as the person-to-person contact route for the transmission of fecally transmitted diseases. World Health Organization (WHO) reported that diarrheal diseases contracted worldwide mainly by contaminated water or food, killed 3.1 million people, most of them children (WHO, 1996).

2.10.3.3. Foodborne transmission:

Food may serve as a vehicle for the transmission of numerous infectious diseases caused by bacteria, viruses, protozoa, and helminthes parasites. WHO estimated that the accidental food poisoning kills up to 1.5 million people per year. Food contamination results from unsanitary practices during production or preparation. Vegetables contaminated with wastewater effluents are also responsible for disease outbreaks (e.g., typhoid fever, salmonellosis, amebiasis, ascariasis, viral hepatitis, and gastroenteritis). Raw vegetables and fruit become contaminated as a result of being handled by an infected person during processing, storage, distribution or final preparation, or following irrigation with fecally contaminated water (Bitton, 2005).

2.10.3.4. Airborne, Vector-Borne and Fomites transmission:

Some diseases can be spread by airborne transmission. This route is important in the transmission of biological aerosols generated by wastewater treatment plants or spray irrigation with wastewater effluents. The most common vectors for disease transmission by vector- born are arthropods (e.g., fleas, insects) or vertebrates (e.g., rodents, dogs, and cats). The pathogen may or may not multiply inside the arthropod vector. In addition to some pathogens may be transmitted by nonliving objects or fomites (e.g., clothes, utensils, toys, environmental surfaces) (Bitton, 2005).

2.10.4. Portal of entry

Pathogenic microorganisms can gain access to the host mainly through the gastrointestinal tract (e.g., enteric viruses and bacteria), the respiratory tract, or the skin. Although the skin is a formidable barrier against pathogens, wounds or abrasions may facilitate their penetration into the host (Bitton, 2005).

2.10.5. Host Susceptibility

Both the immune system and nonspecific factors play a role in the resistance of the host to infectious agents. Immunity to an infectious agent may be natural or acquired (Bitton, 2005). Significant host immunity occurs only with the viral diseases and some bacterial diseases (David; Mara & Sandy Cairncross, 1989) Its hypothesized that many farmers who use TWW or the treatments plant workers acquired relatively high levels of permanent immunity to the most of the common enteric viruses that endemic in their communities from their childhood (Shuval, 1990).

2.11 Common Parasites Causing Waterborne Parasitic Diseases

2.11.1. *Strongyloides stercoralis*:

Strongyloides stercoralis is a nematode or a roundworm, in the genus *Strongyloides*. The larvae are small; the longest reach about 1.5mm in length (CDC, 2017e).

2.11.1.1 *S. stercoralis* transmission:

S. stercoralis larvae found in contaminated soil and transmitted to the host when penetrate their skin. Person-to-person transmission is rare but documented (CDC, 2016).

2.11.1.2. Strongyloidiasis symptoms:

For those who have the infection a local rash can occur immediately; the cough usually occurs several days later; abdominal symptoms typically occur approximately 2 weeks later. Larvae can be found in the stool about 3 to 4 weeks later. Most people infected with *Strongyloides* do not know they're infected (CDC, 2017e). The infection may be severe and life-threatening in cases of immunodeficiency (hematological diseases, immunosuppressive therapies), for this reason it is extremely important to suspect, diagnose and treat the infection (WHO, 2017c).

2.11.1.3. *S. stercoralis* disease:

Strongyloidiasis is the disease that caused by the *S. stercoralis*. Most people do not know when their exposure occurred. Where it is often associated with agricultural activities. Therefore, activities that increase contact with the soil increase the risk of becoming infected, such as: walking with bare feet, contact with human waste or sewage, and occupations that increase contact with contaminated soil such as farming and coal mining (CDC, 2017e).

2.11.1.4. *S. stercoralis* diagnosis:

Strongyloidiasis is difficult to diagnose because the parasite load is low and the larval output is irregular (Ericsson et al., 2001). Stool examination is currently the primary technique for the detection of *S. stercoralis* infection. If the diagnosis is strongly suspected and special techniques are not available, several specimens collected on different days should be examined (Muennig et al., 1999).

2.11.1.5. Strongyloidiasis treatment:

Treatment of strongyloidiasis is recommended for all persons found to be infected, whether symptomatic or not, due to the risk of developing hyper infection syndrome and/or disseminated strongyloidiasis (CDC, 2017e). Ivermectin, thiabendazole and albendazole are the most effective medicines for treating the *S. stercoralis* infection (WHO, 2017c).

2.11.1.6. Prevention and control of *S. stercoralis*:

The best way to prevent *Strongyloides* infection is to wear shoes through walking on soil and avoiding contact with fecal matter or sewage. Proper sewage disposal and fecal management are keys to prevention (CDC, 2017e).

2.11.1.7. *S. stercoralis* life cycle:

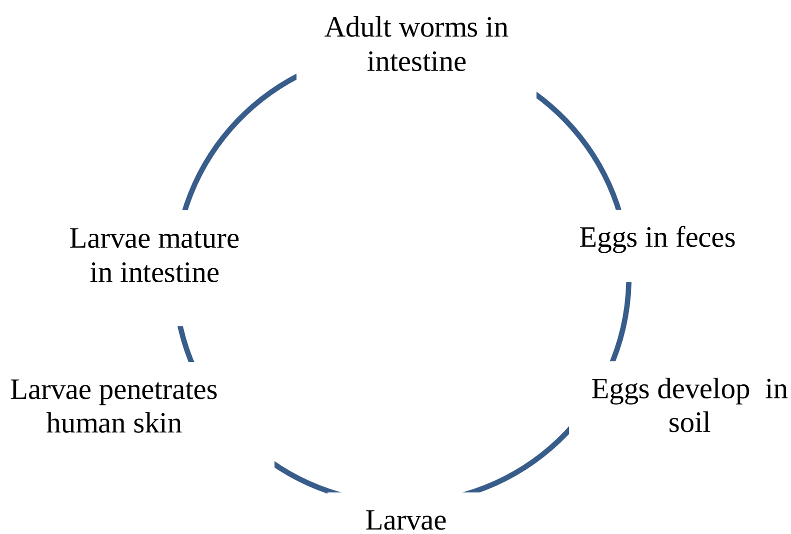


Figure (2.1): *S. stercoralis* life cycle

2.11.*2 Ascaris lumbricoides*:

A. lumbricoides is known as round worm. *A. lumbricoides* infection is one of the most common intestinal worm infections (Hossain, 2009).

2.11.2.1. *A. lumbricoides* transmission:

It is found an association between poor personal hygiene, poor sanitation, and places where human feces are used as fertilizer and Ascariasis. Ascariasis is caused by ingesting eggs. This can happen when hands or fingers that have contaminated dirt on them are put in the mouth or by consuming vegetables or fruits that have not been carefully cooked, washed or peeled (CDC, 2017b).

2.11.2.2. Ascariasis symptoms:

Most people infected with *A. lumbricoides* have no symptoms. If symptoms do occur they can be light and include abdominal discomfort. Heavy infections can cause intestinal blockage and impair growth in children. Other symptoms such as cough are due to migration of the worms through the body (CDC, 2017b).

2.11.2.3. *A. lumbricoides* disease:

Ascariasis is the diseas that cased by ingested Ascaris eggs.

2.11.2.4. *A. lumbricoides* diagnosis:

The diagnosis of ascariasis depends on the identification of the adult worms passed through the rectum or from some other body orifice, or by identifying the eggs in the stool, vomitus, sputum, or small bowel aspirate. Diagnosis during the stage of larval migration is difficult, although occasionally larvae may be found in the sputum or gastric contents. Once the fertile females within the gut begin to release eggs, the diagnosis of ascariasis can usually be made by direct fecal smears. However, concentration techniques using centrifugation (e.g., formalin-ethyl acetate method) may facilitate diagnosis (Hossain, 2009).

2.11.2.5. Ascariasis treatment:

Roundworm is usually treated with antiparasitic drugs. Medications most commonly used for treatment include: albendazole (Albenza), ivermectin (Stromectol), or mebendazole. In advanced cases, other treatment may be needed. Surgery may be used to control a larger infestation (Health line, 2017)

2.11.2.6. Prevention and control of *A. lumbricoides*:

The best defense against ascariasis is practicing good hygiene before handling food by washing the hands with soap and water and washing fresh fruits and vegetables thoroughly (Mayo Clinic, 2017).

2.11.2.7. A. *lumbricoides* life cycle:

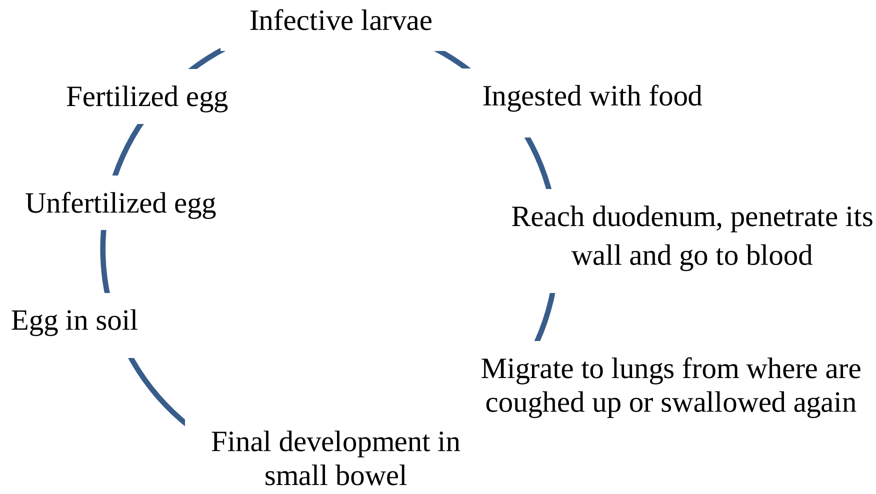


Figure (2.2): A. *lumbricoides* life cycle

2.11.3. *Cryptosporidium sp.*

Cryptosporidium is a microscopic parasite protected by an outer shell that allows it to survive outside the body for long periods of time and makes it very tolerant to chlorine disinfection (CDC, 2017c).

2.11.3.1 *Cryptosporidium* transmission:

Cryptosporidium can be transmitted directly via person to person, animal to human, animal to animal, or indirectly by water, food and possibly via air (Fayer et al., 2000). Animals were considered to be a reservoir of *Cryptosporidium* (Cama et al., 2003; Learmonth et al., 2004). Children infected with *Cryptosporidium hominis* shed higher levels of oocysts because they have underdeveloped immune system and oocysts can proliferate easier (Xiao et al., 2001).

2.11.3.2. Cryptosporidiosis symptoms:

Symptoms of cryptosporidiosis generally begin 2 to 10 days after becoming infected with the parasite which are watery diarrhea, stomach cramps or pain, dehydration, nausea, vomiting, fever, and weight loss. Some people with Crypto will have no symptoms at all. Symptoms usually last about 1 to 2 weeks in persons with healthy immune systems. While the small intestine is the site most commonly affected, in immunocompromised persons *Cryptosporidium* infections could possibly affect other areas of the digestive tract or the respiratory tract. The risk of developing severe disease may differ depending on each person's degree of immune suppression (CDC, 2017c).

2.11.3.3 Cryptosporidiosis:

Cryptosporidium causes the diarrheal disease cryptosporidiosis. Both the parasite and the disease are commonly known as "Crypto." *Cryptosporidium parvum* and *Cryptosporidium hominis* are the most prevalent species causing disease in humans (CDC, 2017c).

2.11.3.4. *Cryptosporidium* diagnosis:

Diagnosis of cryptosporidiosis is made by examination of stool samples. Most often, stool specimens are examined microscopically using different staining techniques, the staining methods of most commonly used are the modified Ziehl-Neelson acid-fast stain and modified Kinyoun's acid-fast stain (Zaglool et al., 2013). Molecular methods can be used to identify *Cryptosporidium* at the species level (CDC, 2017c).

2.11.3.5. Cryptosporidiosis treatment:

Most people who have healthy immune systems will recover without treatment. Diarrhea can be managed by drinking plenty of fluids to prevent dehydration (CDC, 2017c). Nitazoxanide is approved to treat cryptosporidiosis in immunocompetent people aged ≥1 year (CDC, 2016)

2.11.3.6. Prevention and control of Cryptosporidiosis:

To control cryptosporidiosis: a) Practicing good hygiene, b) avoiding water that might be contaminated, and c) avoiding touching farm animals are recommended (CDC, 2017c).

2.11.3.7. *Cryptosporidium* life cycle:

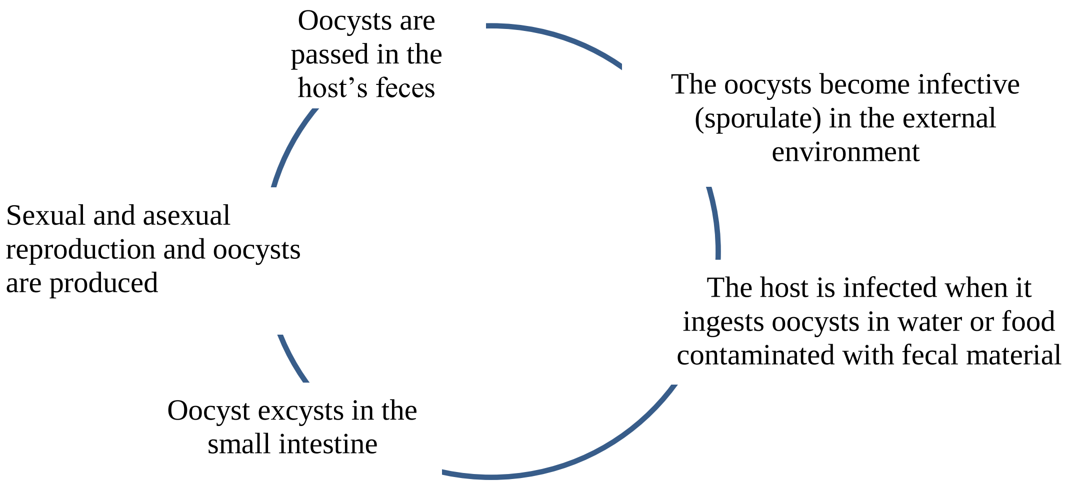


Figure (2.3): *Cryptosporidium* life cycle

2.11.4. *Entamoeba histolytica*:

Although several protozoan species in the genus *Entamoeba* colonize humans, not all of them are associated with disease. *E. histolytica* is well recognized as a pathogenic amoeba causing amebiasis. The other *Entamoeba* species are important because they may be confused with *E. histolytica* in diagnostic investigations (Pritt & Clark, 2008).

2.11.4.1. *E. histolytica* transmission

Transmission occurs via the fecal–oral route, either directly by person-to-person contact or indirectly by eating or drinking fecally contaminated food or water (WHO, 2017a).

2.11.3.2. E. histolytica *disease:*

Amebiasis *is the disease that caused by E. histolytica*.

2.11.4.3. Amebiasis symptoms:

Only about 10% to 20% of people who are infected with *E. histolytica* become sick from the infection. The symptoms are often quite mild and can include loose feces, stomach pain, and stomach cramping. Amebic dysentery is a severe form of amebiasis associated with stomach pain, bloody stools, and fever. Rarely, *E. histolytica* invades the liver and forms an abscess (a collection of pus). In a small number of instances, it has been shown to spread to other parts of the body, such as the lungs or brain, but this is very uncommon (CDC, 2017a).

2.11.4.4. Amebiasis treatment:

For symptomatic intestinal infection and extraintestinal disease, treatment with metronidazole or tinidazole should be followed by treatment with iodoquinol or paromomycin. Asymptomatic patients infected with *E. histolytica* should also can be treated with iodoquinol or paromomycin, because they can infect others and because 4%–10% develop disease within a year if left untreated (CDC, 2016).

2.11.4.5. E. histolytica *diagnoses:*

Microscopy does not distinguish between *E. histolytica* (known to be pathogenic), *E. bangladeshi*, *E. dispar*, and *E. moshkovskii*. *E. dispar* and *E. moshkovskii* have historically been considered non-pathogenic. More specific tests such as Enzyme immunoassay techniques or Polymerase chain reaction are needed to confirm the diagnosis of *E. histolytica*. Additionally, serologic tests can help diagnose extra-intestinal amebiasis (CDC, 2016).

2.11.4.6. Prevention and control of E. histolytica:

Good sanitary practice, as well as responsible sewage disposal or treatment are necessary for the prevention of *E. histolytica* infection on an endemic level. *E.histolytica* cysts are usually resistant to chlorination, therefore sedimentation and filtration of water supplies are necessary to reduce the incidence of infection (Madigan et al., 2010).

2.11.4.7. E. histolytica *Life cycle:*

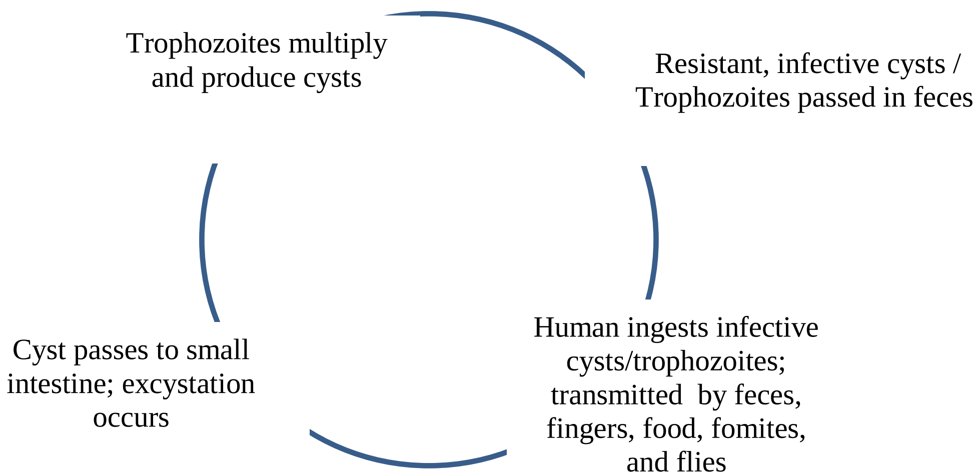


Figure (2.4): *E. histolytica* Life cycle

2.11.5. Giardia lamblia:

G. lamblia is a parasite protected by an outer shell that allows it to survive outside the body for long periods of time and makes it tolerant to chlorine disinfection (CDC, 2017d).

2.11.5.1. G. lamblia transmission:

G. lamblia is found on surfaces or in soil, food, or water that has been contaminated with feces from infected humans or animals. While the parasite can be spread in different ways, water (drinking water and recreational water) is the most common mode of transmission (CDC, 2017d). Infection usually occurs through ingestion of G. *lamblia* cysts in water (including both unfiltered drinking-water and recreational waters) or food contaminated by the feces of infected humans or animals (WHO, 2017b).

2.11.5.2. G. lamblia symptoms:

Symptoms of giardiasis may last 2 to 6 weeks. Occasionally, symptoms last longer (CDC, 2017d). Symptoms include abdominal pain, foul smelling diarrhea, foul smelling gas, and mechanical irritation of intestinal mucosa with shortening of villi and inflammatory foci. Malabsorption syndrome may occur in heavy infection (Leventhal & Cheadle, 2002).

2.11.5.3. G. lamblia disease:

Giardiasis is the disease that caused by *G. lamblia*.

2.11.5.4. Giardiasis treatment*:*

Several drugs can be used to treat Giardiasis. Effective treatments include metronidazole, tinidazole, and nitazoxanide (Letter, 2010) Alternatives to these medications include paromomycin, quinacrine, and furazolidone (Escobedo & Cimerman, 2007; Letter, 2010). Different factors may shape how effective a drug regimen will be, including medical history, nutritional status, and condition of the immune system (Solaymani-Mohammadi, et al., 2010; Upcroft & Upcroft, 1993).

2.11.5.5.Prevention and control of G. lamblia disease:

There is no vaccine to prevent Giardiasis in humans, nor any recommended chemoprophylaxis, a good hygiene practice, as well as consuming clean water are necessary to reduce the incidence of infection (Giardiaclub, 2017).

2.11.5.6. G. lamblia *life cycle:*

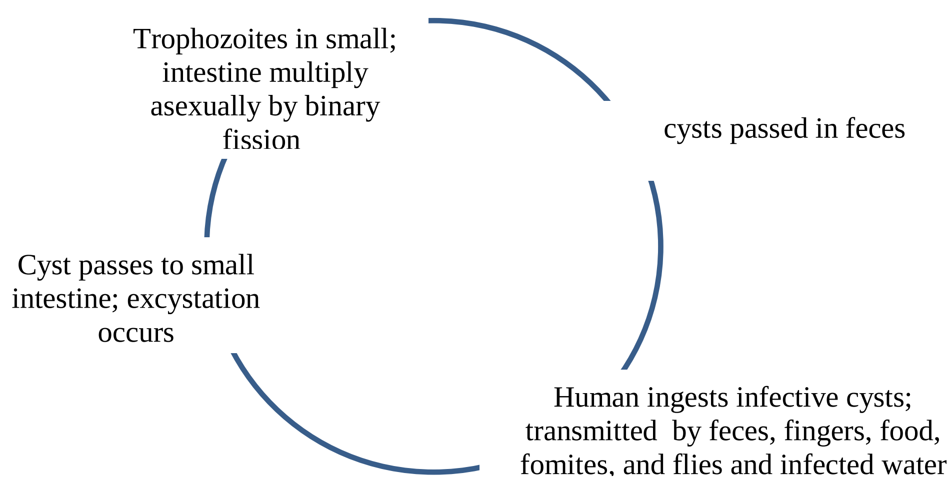


Figure (2.5): *G. lamblia* life cycle

2.11.6. Microsporidia

Microsporidia are eukaryotic parasites that must live within other host cells in which they can produce infective spores. Although there are over 1,200 species of microsporidia, there are 15 species that have been identified as causing disease in humans (Doerr, 2017).

2.11.6.1. *Microsporidia* symptoms:

Chronic diarrhea and wasting are the most common symptoms of microsporidiosis, the different *Microsporidia* species invade different sites including the cornea and muscles. Thus, the symptoms of microsporidiosis varies greatly depending on the site of infection (Smith, 2017).

2.11.6.2. *Microsporidia* disease*:*

Microsporidiosis is a disease caused by infection with *Microsporidia*. Microsporidiosis is primarily seen in individuals infected with human immunodeficiency virus (HIV), although it can rarely also cause disease in individuals with a normal immune system. Microsporidiosis can cause infection of the intestine, lung, kidney, brain, sinuses, muscles, and eyes (Doerr, 2017).

2.11.6.3. *Microsporidia* diagnosis:

Infecting organisms can be demonstrated in specimens of affected tissue obtained by biopsy or in stool, urine, Cerebrospinal fluid , sputum, or corneal scrapings. Microsporidia are best seen with special staining techniques as the modified Ziehl-Neelson acid-fast stain. Fluorescence brighteners (fluorochromes) are used to detect spores in tissues and smears. The quick-hot Gram chromotrope technique is the fastest. Immunoassay and PCR-based assays hold promise for the future. Transmission electron microscopy is currently the most sensitive test and is used for speciation (Pearson, 2017).

2.11.6.4. *Microsporidia* Treatment:

The treatment of microsporidiosis is generally achieved with medications and supportive care. Depending on the site of infection and the microsporidia species involved, different medications are utilized. The most commonly used medications for microsporidiosis include albendazole (Albenza) and fumagillin (Doerr, 2017).

2.11.6.5. *Microsporidia* life cycle:

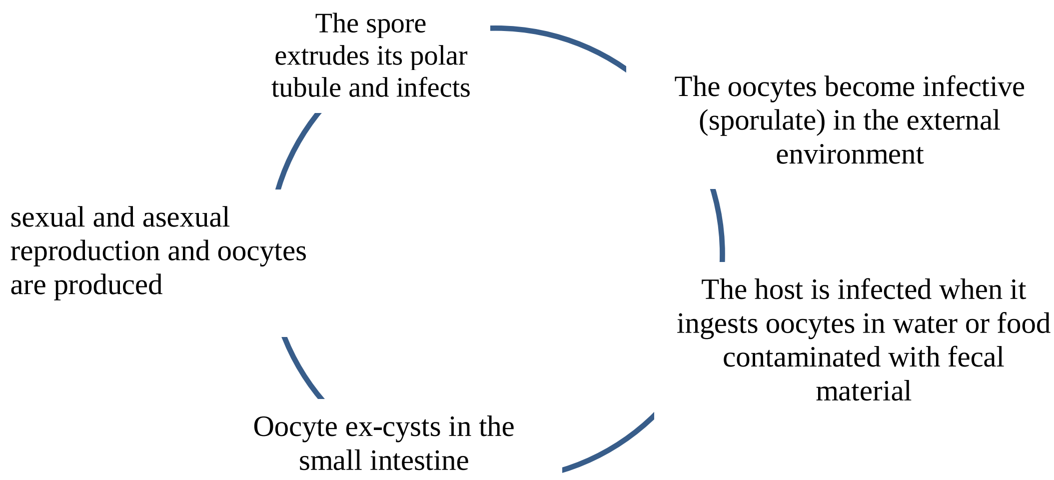


Figure (2.6): *Microsporidia life cycle*

2.12 Health Protection Measure for Reduction Health Risks Associated with TWWR in Agriculture

The groups potentially most at risk from wastewater reuse in agriculture are the farm workers, their families, crop handlers, consumers of crops, and those living near wastewater-irrigated areas. The approach required to minimize exposure depends on the target group. Farm workers and their families have higher potential risks of parasitic infections (Blumenthal et al., 2000).

2.12.1. Reducing health risks associated with wastewater irrigation approaches

2.12.1.2.Wastewater treatment:

When wastewater is treated with the intention of using the effluent for agricultural irrigation and not disposal in receiving water, the important quality criteria are those relevant to human health rather than environmental criteria should be considered. Therefore, fecal coliform removal and nematode egg removal are more important than BOD removal (Blumenthal, et al., 2000).

2.12.1.3.Wastewater application and human exposure control:

Irrigation water including treated wastewater can be applied to the land in the five following general ways (WHO, 1989):

1. Flooding (border irrigation): almost all the land surface is wetted;
2. By means of furrows: only parts of the ground surface is wetted;
3. By means of sprinklers: the soil and crops are wetted in much the same way as they are by rainfall;
4. By subsurface irrigation: the surface is only slightly wetted, if at all, but the subsoil is saturated,
5. By means of localized (trickle, drip, or bubbler) irrigation: water is applied to the root zone of each individual plant at adjustable rate.

Choosing a wastewater application method can impact on health protection of farm workers, consumers, and nearby communities. For example using sprinklers have the highest potential to spread contamination on crop surfaces and affect nearby communities. Farm workers and their families are at the highest risk when furrow or flood irrigation techniques are used. This is especially true when protective clothing is not worn and earth is moved by hand. Protection can be achieved by low-contaminating irrigation techniques (as subsurface and localized), together with wearing protective clothing (e.g. footwear for farmers and gloves for crop handlers) and improving levels of hygiene both occupationally and in the home can help to control human exposure. localized irrigation (drip, trickle and bubbler irrigation) can give the greatest degree of health protection by reducing the exposure of workers to the wastewater (Blumenthal, et al., 2000).

2.12.1.4. Crop restriction

Crop restriction can be used to protect the health of consumers. For example water of poorer quality can be used to irrigate non-vegetable crops such as cotton or crops that will be cooked before consumption (e.g., potatoes). However, crop restriction does not provide protection to the farm workers and their families where a low quality effluent is used in irrigation or where wastewater is used indirectly (i.e., through contaminated surface water) (Blumenthal, et al., 2000).

2.12.1.5. Pathogen die-off before consumption:

The interval between final irrigation and consumption reduces pathogens (bacteria, protozoa and viruses) populations by approximately 1 log unit per day (Petterson & Ashbolt, 2003). The precise value depends upon climatic conditions, with more rapid pathogen die-off (approximately 2 log units per day) in hot, dry weather and less (approximately 0.5 log unit per day) in cool or wet weather without much direct sunlight (Amoah, 2008). A period of cessation of irrigation before harvest (1-2 weeks) can allow die-off of bacteria and viruses such that the quality of irrigated crops improves to levels seen in crops irrigated with fresh water (Vaz da Costa Vargas et al., 1996). However it must be stressed that helminth eggs can remain viable on crop surfaces for up to two months, although few survive beyond approximately 30 days (Strauss, 1996).

2.12.1.6. Chemotherapy and vaccination

Chemotherapy and immunization cannot normally be considered as an adequate strategy to protect farm workers and their families exposed to raw wastewater or excreta. Immunization against helminthic infections and most diarrhoeal diseases is currently not feasible. Chemotherapeutic control of intense nematode infections in children and control of anemia in both children and adults, especially women and post-menarche girls is important. Chemotherapy must be reapplied at regular intervals to be effective – as many as 2–3 times a year for children living in endemic areas (Montresor et al., 2002)

2.13 Treated Wastewater Reuse Guidelines

Wastewater reuse guidelines are put to protect the population from health risk and the environment from degradation and pollution. Most of the worldwide available guidelines are based on either the US EPA guidelines (US EPA, 2004) or the WHO guidelines (WHO, 1989). These guidelines are suitable for developed countries with anyway high wastewater treatment standards, but should be adjusted in developing countries and account for the end use (Choukr-Allah, 2010).

The guideline should include assessment of the irrigation method, exposure scenario and hygiene measures (Blumenthal & Peasey, 2002). The revised 1989 WHO guidelines and recommended guidelines for water reuse in the Mediterranean region in addition to Palestinian wastewater reuse standard are shown in Annex (4).

Chapter III

Methodology

This chapter presents all issues related to methodology that used to answer the study objectives, which are study design, population, setting, period, eligibility criteria, instruments, ethical and administrative consideration, sampling size and process, questionnaire formulation, piloting, laboratory procedures, data entry and analysis, and study limitation.

3.1 Study Design

The present study is a comparative study aimed to investigate the parasitic infection among farmers dealing with treated wastewater in Al-Zaitoun area, Gaza City. In order to understand the risk of dealing with TWW in agriculture; the parasitic infection between farmers who irrigate by groundwater was investigated as a benchmark " for comparison". The design of comparative research is simple; study objects are specimens or cases which are similar in some respects (otherwise, it would not be meaningful to compare them) but they differ in some respects. These differences become the focus of examination. The goal is to find out why the cases are different to reveal the general underlying structure which generates or allows such a variation (Routio, 2017).

3.2 Study Population

The present study included two farmer groups: farmers who dealing with TWW in agriculture through the summer season (Mixed water users (MWUs) Exposed group) and farmers who irrigate by using GW (agricultural/private/municipal wells) (Ground water users (GWUs) Non-exposed group).

3.3 Study Setting

3.3.1. Study areas

The present study carried out in Gaza strip at two different agricultural areas: The first agricultural area was approximately around 100 dunams at Al- Zaitoun area next to Gaza car shop (west of Salah El-Deen street) and away of 800 m from Gaza treatment plant.

In this agricultural area a pilot project called Sheikh Ejleen Pilot Project was initiated in 2004 when JCP in cooperation with PHG had proposed a project to use the TWW from GWWTP for irrigating 100 dunams of citrus and olive trees. This pilot project was funded from French program called "Strategy of agricultural water management in the Middle East", supervised from PWA and Municipality of Gaza with coordination with MOH and MOA. It aimed to demonstrate the interest of using TWW for the irrigation of citrus and olive orchards. This project was successful, thereafter, extension has made till the last Israeli invasion that led to the destruction of some of infrastructure of the project. However, rehabilitation was done under the French and Spanish funds to be operate again on November 2010 covering 186 dunum (Austrian Development Cooperation & Palestinian Water Authority, 2011). Finally this project temporarily was stopped as a result of the maintenance works in GWWTP from 2013 to 25.July 2016; the location of pilot project is shown in Annex (5). From 2010 to 2013 it is decided to install two parallel post wastewater treatment systems: sand filter and reed bed. The effluent of the pilot post-treatment plant was used for the growth of citrus and olives. This would require Class B water quality (BOD=20 mg/l, TSS=30mg/l, and Fecal coliform=1000 MPN per 100 ml), according to the Guidelines for wastewater reuse for irrigation in Palestine. The total capacity of the pilot post treatment system is 1,000 m3/d. This equals 62.5 m3/h. 50% of this flow to be treated in a sand filter and the remainder to be treated in a reed bed system. The treated effluent from both sand filter and reed bed is stored in a 600 m3 reservoir prior to be used as irrigation water (Austrian Development Cooperation and Palestinian National Authority, 2013), the post wastewater treatment system layout is shown in Annex (6).

The second agricultural area was approximately around 40 dunams at Joher Al-Deek area (east of Salah El-Deen street). This area was chosen to be as a control area based on the following conditions: a) Far away from the exposed area or the agricultural lands that irrigated by TWW, b) Irrigated by groundwater only.

3.3.2 Study period

The present study carried on two stages: the proposal writing with time period from September, 2015 till January, 2016 and the practical and experimental part which consumed period of one year from study proposal approval in February, 2016 till February, 2017, since the maintenance works in GWWTP delayed the TWW pumping process for exposed group for three months about the expected date on 01 April, 2016. According the actual TWW pumping for farmers was on 28 July,2016. The practical and experimental part was conducted on two phases: the first phase was in May and beginning of June 2016 in which each farmer groups were using the GW in irrigation. The second phase was in November and December 2016 after the exposed farmers' group used the TWW in irrigation for period of three months from 28.08.2016 – 27.11.2016.

3.4 Study Eligibility Criteria

3.4.1. Inclusion criteria:

The inclusion criteria for the exposed group were as follows:

1. Farmers who are dealing with TWW for at least two years
2. Farmers who are use the TWW in agriculture under PWA or any other association supervision.
3. Farmers will accept to provide researcher with stool samples, and will be ready to fill the questionnaire.

The Inclusion Criteria for the non-exposed group were as follows:

1. Farmers who irrigate by groundwater only and don't use previously TWW in their agricultural lands.
2. Farmers who live far away from the TWW fed agriculture lands
3. Farmers will accept to provide researcher with stool samples, and will be ready to fill the questionnaire.

3.4.2. Exclusion criteria

Any farmer hasn't the above inclusion criteria was excluded from study.

3.5 Study Instruments

Stool, Irrigation water, soil, and farmers hand washing water samples in addition to filling an interview structured questionnaire were used to fulfill study objectives.

3.5.1. Stool samples, Irrigation water, soil, and farmers hand washing water samples:

Each farmer was asked to provide stool samples in addition soil, irrigation water, and hand washing water samples were collected from each farmer at the two study phases. Stool samples in 1st phase aimed to ensure that all farmers are non-parasitic infected before the 2nd phase "in which the MWUs will use TWW in irrigation for three months in order to investigate its effect on parasitic infection"; otherwise, he/she will be excluded from the sample or treated before beginning the second phase.

Soil, irrigation water, and the hand washing water samples were asked in order to establish baseline data about parasitic load in the environmental mediums at each farmer.

The second phase was to compare the difference in parasitic infection prevalence between exposed farmers who irrigated their lands with TWW for three months and non-exposed farmers who still using GW and to compare the parasitic load in soil and irrigation water at each farmer according to the baseline data.

3.5.2. An interview structured questionnaire:

Interview structured questionnaire with eight sections was developed in February, 2016. The questionnaire was taken the final version as shown in Annex (7) by March 2016 after most of validation committee (Annex (8)) which was composed from 12 specialists comments were taken in consideration and pilot study was carried out. The questionnaire was used in a face-to-face interview conducted by researcher and assistant. The researcher accompanied the assistant in each time to supervised him/her and to make sure that the procedure was precisely followed. Each interview was taken approximately 20 minutes.

Questionnaire was administered to all cases and controls with the following sections: (a) General demographic and socio-economic information about farmer: Name, phone number, address, age, gender, educational level, family size, occupation, and economic and financial status, (b) Housing characteristics: home building materials, its land type, and type of the area that around it, (c) General information about participant agricultural activities: Farm address, area, daily spent time in the farm, cultivated pants, (d) Home water conditions; general water conditions was assessed by following indicators: Source of drinking water, type of non-drinking water used in the home, and total consumed non-drinking water, (e) Home sanitary conditions; general sanitary conditions was assessed by following indicators: Home sanitation disposal method, farm toilet, and its sanitation disposal method, (f) Bird and animal breeding; general bird and animal breeding was assessed by following indicators: Place of breeding the birds and animals, and types of the breeding birds and animals, (g) Farmer's hygiene behavior; hygiene behavior status was assessed by three models: Personal hygiene inside home, through harvesting process, and through working in the farm as (location of the home cooking place, soap consumption, wearing protection tools during field work (gloves, boots, etc.), hand washing, and eating habits), and (h) Farmer's health status: General health status was assessed by asking about the gastrointestinal symptoms as: Vomiting, abdominal pain, blood/mucus stools, etc.

3.5.2.1 Pilot study:

Before starting the actual data collection process, a pilot study was carried out with 6 farmers to examine farmers response to questionnaire questions, to identify how they will understand it, and to measure validity and reliability. Another studies revealed that the pilot study used to examine the clarity and ambiguity, length and suitability of questions before the data collection process starts (Polit & Beck, 2004). Moreover studies reveled the pilot phase is also practical for detecting major defects in questionnaire design. Pilot work can be costly but it will avoid a great deal of wasted effort on unintelligible questions producing unquantifiable responses and uninterruptable results (Oppenheim, 2000). After the pilot study slight amendments on questionnaire were done.

3.5.2.2 Reliability:

To ensure study reliability the following steps were done:

1. Standards methods were used for samples analysis as illustrated in section 3.9.
2. Each sample analyzed duplicated or/and many sequences analysis methods were used for more precise result.
3. When researcher seeked assistance, she was accompany the assistant to guide him and to ensure he did the work as required.
4. Data entry were done in the same day of data collection to allow any required possible corrections.
5. All data was re-entered after finishing data entry process to ensure correct entry procedure and decrease entry errors.

3.6 Ethical and Administrative Considerations

An approval from public health school at Al Quds University and ethical approval from Helsinki Committee were obtained; the ethical approval is shown in Annex (9). In addition to researcher asked an approval from Director of Preventive Medicine in MOH for purpose of providing suitable treatment for the infected farmers. To guarantee/protect participants rights, a consent form indicating that the participation is voluntary and confidentiality assured for all participants before interviews and samples collection, as shown in Annex (10).

3.7 Samples Size and Process

3.7.1. Farmers participants:

Two awareness/orientation sessions were conducted in May, 2016 for exposed and non-exposed farmers' group respectively to increase farmers awareness, knowledge about parasitic infection that result from working in agriculture and in the same time to obtain their consent for participation in the study. Most of farmers had agreed to participate, cooperate and commit in the study requirements (providing stool, soil, irrigation water, and hand washing water samples at the two phases in addition to filling questionnaire). The number of exposed group was 36 participants, while the number of non-exposed group was 19 participants (2:1).

Sampling approaches (Probability and Non-probability) were not used in this study because researcher used all accessible population in the two study areas.

3.7.2. Stool samples:

Each farmer was asked to provide three consequently stool samples on separate days to be submitted with no more than 10 days at the two phases. Three stool samples are considered a minimum for an adequate parasitic detection since many organisms particularly the intestinal protozoa do not appear in stool in consistent numbers on a daily basis (Garcia & Bruckner, 2001). In addition to educational materials about collecting representative stool sample, three stool cups with 4ml of 10% formalin as a preservative, and three paper bags were distributed to each participant to provide preserved samples.

3.7.3. Treatment of the infected farmers in the first phase:

After the 1st phase and the 2nd phase each farmer had infection, he/she treated by proper chemotherapy with coordination with in Rimal healthcare center and under supervision a physician at Al-Zaitoun Healthcare center, Annex (11) shows samples from the medical prescription documents.

Table 3.1 : Medication types that used for treated infected farmers

Parasite	Medication	Frequency
Entamoeba histolytica/dispar cyst	Cystogen	2*3*10 (adults) 5cc *3*10 (children)
Giardia lamblia cyst	Cystogen	2*3*10 (adults) 5cc *3*10 (children)
Cryptosporidium sp. (Oocyst)	Azicare	5 tables (500mg) per day (adults) 5cc per day (children)
Microsporidium sp. (Oocyst)	Albendazole	1*2*14 (adults and children)
Ascaris lumbricoides	Vermox	5cc *2*3 (children)
Strongyloides stercoralis	Albendazole	0.5*2*14 (children)

3.7.4. Soil samples:

Soil composite samples from each farm of participant were taken randomly (2-3 samples per each donum) by using a soil auger and sterile spatulas from the top of 0 – 20 cm layer that around trees in the two phases. Where crops and farmers are more susceptible for microorganisms in this depth.

3.7.5. Irrigation water samples:

Sampling of irrigation water was carried out between 07:30 and 12:00 AM and between 05:30 and 07:30 PM when farmers were irrigating. Two liter of irrigation water were collected directly from irrigation water pipes by using 4 L plastic container from each farmer "to be sufficient to contain the sample and the preservative solution". The irrigation water source in the first phase was GW for the two farmer' groups, but in the second phase it was TWW regarding the exposed group only.

Through the second phase monthly wastewater samples from GWWTP inlet, outlet and from the wastewater treatment systems reservoir were taken to monitor wastewater quality.

3.7.6. Farmers Hand washing water samples

Each farmer was asked to give hand washing water. Distilled water (1 L for each farmer) was used to wash farmers hands, and 1.5 L plastic container was used for collecting their hands washing water.

3.8 Laboratory Procedure

All collected samples were sent to Islamic University Lab, for preservation and parasitic analysis.

3.8.1 Equipment sterilization:

Samples collection equipment were washed with soap, rinsed with distilled water, disinfected with 70% ethanol, and then put to air-dried. Working benches and all equipment that used in the analysis were cleaned and disinfected with 70% ethanol before and after use to avoid microbial contamination and to sterilize the materials used for analysis and prevent cross contamination.

3.8.2 Samples labeling:

Each sample was labeled; date, time of collection in addition to any special notes were written through samples collection.

3.8.3 Samples preservation:

All samples were preserved through collection process to facilitate collection and to keep the morphology of the parasites stages. As reported in standard methods for the examination of water and wastewater book; nematode mortality and deterioration of diagnostic characteristics begins at time of collection, so process samples for diagnosis should be within 24 hr. and completing the full diagnostic processing should be within 48 hr. (APHA, 2005). Samples preservation were depended in this study, as there is a lag time from samples collection time and the examination process in laboratory since the number of samples are high, researcher can't do all required analysis in short period, in addition to the researcher is restricted in assigned working hours in the laboratory.

The following preservation methods were followed to preserve the different samples:

3.8.3.1 Stool samples preservation:

The collected stool samples preserved by using 10% formalin to keep protozoan morphology and to prevent the continued development of some helminth eggs and larvae. According to studies formalin has been used for many years as an all-purposes fixative that is appropriate for helminth eggs, larvae and protozoan cysts, oocysts, and spores (Garcia & Bruckner, 2001).

3.8.3.2 Irrigation water and hand washing water samples preservation:

Liquid samples were preserved by adding equal volume of 8% formalin solution to sample. As the cold storage retards, but does not entirely halt deterioration and rot (APHA, 2005).

3.8.3.3 Soil samples preservation:

Soil samples were preserved by using "hot preservative" as follows:

1. About 100 ml (40 %) formalin + 10 ml Glycerine + 890 ml distilled water were added in thermal beaker at about $80^{o}C$
2. Then hot preservative was added to the all collected soil sample "each sample was around one kilogram".
3. Soil and hot preservative was shaken in order to hot preservative fully penetrates through all soil sample.
4. Finally, soil samples were stored at room temperature ($21^{o}C$).

A study revealed that the numbers of nematodes were recovered from the fixed samples by hot preservative were significantly greater than those recovered from non-fixed samples for six studied nematodes species out of seven nematodes species (Elmiligy & Grisse, 1970).

3.9 Detecting of parasites stages in stool, irrigation water, hand washing water, and soil samples

3.9.1 Detecting of parasites in stool samples:

In this study, the microscopic examination of the stool samples consists of three separate techniques: direct wet smear, concentration (sedimentation), and permanent stained smear.

3.9.1.1 Direct Wet Mount method:

Principle:

Direct wet smear is a rapid screening technique (Leventhal & Cheadle, 2002).

Procedure:

Direct wet mount was applied according to (Garcia & Bruckner, 2001) as follows:

1. One drop of saline NaCl (0.85%) was placed on slide by using dropper,
2. A small amount of stool sample picked up by using a wooden applicator stick,
3. Stool drop was put on slide and thoroughly emulsified in the saline,
4. Slide (suspension) was covered by 22 mm coverslip (no. 1),
5. Suspension systematically was scanned with 10X objective and 40X objective.

3.9.1.2. Concentration (Sedimentation) method:

Principal:

All parasites were detected on a direct mount of preserved stool, it certainly be seen through the concentration examination, in addition to concentration technique allows detection the small numbers of organisms that may be missed by using direct wet smear. There are two types of concentration procedures, sedimentation and flotation, both of them are designed to separate protozoan organisms and helminth eggs and larvae from fecal debris by centrifugation and/or differences in specific gravity, but the sedimentation procedure is recommended as being the easiest to perform and the least subject to technical error (Garcia & Bruckner, 2001).

Procedure:

As the stool samples were preserved in 10% formalin, the procedure was applied according to (Garcia & Bruckner, 2001) for preservative samples as follows:

1. Stool preservative mixture was stirred,
2. A sufficient quantity 3-4 ml of the stool formalin mixture was strained through small screen in a conical centrifuge tube to give the desired amount of sediment (0.5 to 1 ml),
3. About 10% formalin was added to the top of the tube, centrifuged for 10 min at (500 Xg). The amount of sediment obtained should be approximately 0.5 – 1 ml.

4. The supernatant fluid was discarded and the sediment on the bottom of the tube was suspended in (7ml) 10 % formalin (fill the tube half full only), then 4 to 5 ml of ethyl ether was added, tubes were stoppered and shacked vigorously for at least 30s. and holded so that the stopper is directed away from face.
5. After a 15 – 30s waiting, tubes centrifuged for 10 min. at 500 Xg, as a result four layers were resulted: a small amount of sediment (containing the parasites) in the bottom of the tube, a layer of formalin, a plug of fecal debris on top of the formalin layer, and a layer of ethyl ether at the top.
6. All supernatant fluid was decanted and discarded.
7. From 1 to 2 drops of formalin were added to the sediment, then tubes kept for microscopic reading.
8. Small amount of sediment was added to a slide, then coverslip (22mm by 22mm, No. 1) was added and slide was examined under microscope with 10X objective and 40X objective.

3.9.1.3. Permanent stained smear (Modified Ziehl-Neelsen Technique (Acid-fast stain)):

Principal:

Permanent stained smear (Acid-fast staining) was used for detection and identification of small protozoan organisms that missed with the direct smear and concentration methods as *Cryptosporidium* and *Microsporidia*.

Procedure:

Acid-fast stain was applied according to (WHO, 1994) as follows:

1. A thin smear of feces was prepared on frosted slide by using a wooden applicator,
2. Smear was left in air till be dried,
3. After smear became dried, slides was fixed in absolute methanol for 2-3 min,
4. Then, slides were stained with hot carbol-fuchsin for 5-10 min, then differentiate in 1% HCl-ethanol until color ceases to flow out of smear; after that slides were rinsed in tap water, (for preparation 1 liter of 1% HCL; 990ml (70% ethanol) was added to 10ml concentrated HCL.
5. Slides were counterstained with 0.25% methylene blue for 30 sec., then rinsed in tap water,

6. Finally slides were blotted or drained dry and became ready for microscopic using an oil objective (100X).

3.9.2. Detecting of parasites in irrigation water/Hand washing water and Soil samples:

Detecting helminth eggs and protozoa in irrigation water, hand washing water (Liquid samples), and soil samples conducted by using method was adapted from Reimer et al (1981) (as cited in (Yanko, 1988)) and the Modified EPA method (Schwartzbrod, 1998).

Principal:

Many methods for detection and identification helminths and protozoa in environment mediums were revised. The method that performed in this study for the only method it found suitable for detection helminths and protozoa in the same time (simultaneously), as the other methods were for detection a specific helminths or protozoa species. In addition to all other methods used a number of different chemicals for flotation the parasites, while the performed methods in this study used Zinc Sulfate Heptahydrate with specific gravity of 1.2. Studies revealed that for many years there is a certain substances were more efficient in floating protozoan cysts while others were more satisfactory in recovering helminth eggs (Farr & Luttermoser, 1941), it was found by Faust et al (1938,1939) (as cited in (Farr & Luttermoser, 1941)) zinc sulfate with specific gravity of 1.18 is the flotation solation that can recover the largest number of protozoan cysts and helminths eggs.

Procedure:

Test for protozoan:

1. For liquid (Irrigation water (GW/TWW)/ hand washing water samples); homogeneous samples of 2 liter volume was put in 3 liter beaker; while for solid samples (soil samples) 30 gram dry weight of soil was put in 1 liter beaker,
2. Then 100 ml sterile phosphate buffer solution containing 0.1 " concentrated tween 20" were added for the prepared beakers,
3. Homogenized sample of 100 ml volume was measured into two 50 ml centrifuge tubes and centrifuged at 1250 RPM for 6 min,
4. Supernatant was poured off and pellet re-suspended in Zinc Sulfate Heptahydrate (1.2),
5. Tubes (sample plus Zinc Sulfate Heptahydrate (1.2)) were centrifuged at 1250 RPM for 6 min,

6. Surface of the Zinc Sulfate Heptahydrate was carefully aspirated and transferred to a 50 ml conical centrifuge tube,
7. Deionized water (10ml) was added to the Zinc Sulfate Heptahydrate and centrifuged at 1400 RPM for 6 min,
8. Supernatant was poured off and pellet re-suspended in (7ml) acid-alcohol solution (0.1 N sulfuric acid in 35% ethanol) solution, for preparing 1 liter acid-alcohol solution; 350 ml absolute ethanol was added to 5.16 ml ethanol H_2SO_4 and then solution completed to 1 liter by using distilled water.
9. Approximately 3 ml of ether was added,
10. The tube was centrifuged at 1800 RPM for 6 min, then acid – alcohol, ether (350 ml ethanol and 5.16 ml H2SO4, add sufficient distilled water to produce 1L of the solution) and plug was poured off and the tube inverted over a paper towel to prevent reagent from running back into tube.
11. After well drained, two drops of formalin were added to the pellet and mixed to preserve the sample waiting the microscopic reading.

Test for helminths ova:

1. The remaining volume of homogenized sample after the 100 ml was taken, was left in the beaker to settle overnight,
2. The supernatant was siphoned off to just above the settled layer of solids,
3. The settled material in the beaker was mixed by swirling and poured into 100 ml centrifuged tubes,
4. The beaker was rinsed two or three times and rinsing poured into 100 ml centrifuge tubes,
5. The tube were balanced and centrifuged at 1250 RPM for 6 min,
6. The supernatant was poured off and pellet re-suspended thoroughly in Zinc Sulfate Heptahydrate (1.2)
7. Zinc Sulfate Heptahydrate was centrifuged at 1250 PPM for 3 min,
8. The Zinc Sulfate Heptahydrate supernatant was poured into a 500 ml flask, diluted with deionize water, covered and allowed to settle 3 hr. or overnight,
9. The supernatant was aspirated off to just above settled material,

10. The sediment was re-suspended by swirling an pipetted into conical centrifuge tubes,
11. The flask was rinsed with deionized water two to three times and rinse water pipted into tubes,
12. Tubes were centrifuged at 1400 RPM for 6 min,
13. Pellets were combined into one tube and centrifuged at 1400 RPM for 6 min,
14. Pellets were re-suspended in acid alcohol solution and proceeded as previously in the protozoan cysts procedure.

NB. Some steps were amendment according to lab, instruments, and samples conditions, as we increased the time of centrifuging to 6 minutes in order to prevent sediments from losing in the supernatant, especially if the sample is liquid and has minor sediments.

3.10 Data Entry and Analysis

After the experimental work and filling the questionnaire were finished. Data entry was done using SPSS (Statistical Package for Social Science) software version 21.

Firstly data cleaning was done to detect the missing values, to ensure integrity and reliability and to ensure that all data entered accurately and in appropriate way. Data cleaning was conducted through operating frequencies and descriptive statistics for all dependent and independent variables. Frequencies tables were used to distribute the collected data and to show samples characteristics. Inferential statistics were used to compare means of dependent and independent variables. Chi square test was used to compare categorical variables, and t-test or one way ANOVA test was used to compare to compare the relationship between the categorical and numeric variables. The level of significance was set at a P value of less than 0.05.

3.11 Study Limitations

1. Asking farmers to provide three consequently three stools samples at least in the two rounds decreased the farmers response and this affected on the participants number.
2. Existence of maintenance works in GWWTP delayed TWW discharge for the exposed group for four months, this disrupted the time line of the proposed study.
3. Unavailability of some chemicals in Gaza strip as Zinc Sulfate Heptahydrate.
4. High cost of chemicals and field work.

5. Limited capacity of Gaza laboratories especially for detection the parasites in the environmental samples.
6. Low academic qualification for most participants had put extra effort on researcher to explain the research requirements for them more than one time.
7. Some participants asked the researchers many times to give them an incentives, register them in agriculture associations, and to provide them by irrigation facilities.

CHAPTER IV

Results and Discussion

This chapter presents the main findings which collected by the experimental analysis of stool, soil, irrigation water, and hand washing water samples in the two study phases and the interview questionnaire. This chapter includes the analysis results of lab experiments, then descriptive statistics of the questionnaire data (percentage and frequency distribution) including socio-demographic characteristics, housing characteristics, agricultural overview, water and sanitation status, animals and birds breeding, and farmer's hygiene behavior, and health status, and finally the data inferential analysis which used to illustrate the effect of Hygiene behavior and parasitic infection risk factors on Parasitic infection among farmers, as all relationships were done between HB and other independent variables were for finding a justification for existence a parasitic infection.

The results of this study could help the researcher in raising and suggesting suitable recommendations to reduce the parasitic infection among farmers in GS.

4.1. Study Participants

The number of participants in this study was 55 farmer. Participants were distributed according to the source of the used irrigation water into two groups of farmers: MWUs and GWUs, as shown in table and figure (4.1).

The number of MWUs, farmers who are using the TWW and GW, was 36; while the number of GWUs, farmers who are using the GW only, was 19.

Table 4.1: Distribution of the study participants by the source of the used irrigation water

Variable	Category	Total	
		Number	Percentage
Irrigation water source	Mixed water (MW) (TWW and GW)	36	65.5 %
	Groundwater (GW)	19	34.5 %
Total		**55**	**100%**

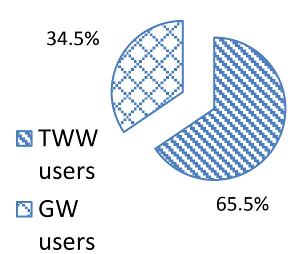


Figure (4.1): Study participants distribution

MWUs represented about two thirds of study participants (65.5%), while the GWUs represented one third of study participants (34.5%). Number of participants depend on the total number of farmers in the study areas and their response to participate in the study.

4.2. Collected Samples Analysis Results

4.2.1. Stool, soil, irrigation water (GW), and hand washing water samples analysis results in the first phase:

Regarding stools samples analysis results in the first phase, it was found (17) participants had parasitic infection; about (10) (58.8%) of the infected participants were from the MWUs group, while (7) (41.1%) were from the GWUs group.

Five parasites species were identified in stool samples as follow, *Cryptosporidium*, *Entamoeba histolytica/dispar*, *Microsporidia*, *Giardia lamblia*, and *Strongyloides setercoralis*

It was found (54.5%, 7.3% & 41.7%) of soil, irrigation water (GW), and hand washing water samples respectively had parasitic contamination as per table (4.2).

4.2.2. Stool, soil, irrigation water (GW & TWW), and hand washing water samples analysis results in the second phase:

Regarding stools samples analysis results in the second phase, it was found (26) participants had parasitic infection; about (18) (69.2%) of the infected participants were from the MWUs group, while (8) (30.7%) were from the GWUs group.

Five parasites species were identified in stool samples, *Entamoeba "histolytica/dispar and Coli", Cryptosporidium, Microsporidia, Giardia lamblia, and Ascaris lumbricoides*.

It was found (61.5%, 0.001% &2.6) of soil, irrigation water (GW, TWW), and hand washing water samples respectively had parasitic contamination as per table (4.2). Comparison between results of the 1st and the 2nd phases by figures is shown in Annex (12).

Table 4.2 Distribution of the study participants based on samples analysis results in the two phases

#	Variable	Category	1st Phase		2nd Phase	
			Total		Total	
			Number	%	Number	%
1.	Stool results	Infected Non-infected	17 38	30.9% 69%	26 19	47.3% 52.7%
2.	Parasitic Species	*Entamoeba histolytica/dispar cyst*	2	11.8%	7	12.7%
		Cryptosporidium sp. (Oocyst)	6	35.3%	6	10.9%
		Giardia lamblia cyst			1	1.8%
		Microsporidia sp. (Oocyst)	3	17.6%	2	3.6%
		Cryptosporidium sp. (Oocyst) and Microsporidia sp. (Oocyst)			1	1.8%
		Entamoeba coli cyst, Giardia lamblia cyst and Microsporidia sp. (Oocyst)			1	1.8%
		Entamoeba histolytica/dispar cyst and Cryptosporidium sp. (Oocyst)	1	5.9%	2	3.6%
		Entamoeba histolytica/dispar cyst and Giardia lamblia cyst	2	11.8%	3	5.5%
		Entamoeba histolytica/dispar cyst and Microsporidia sp. (Oocyst)	2	11.8%	1	1.8%
		Entamoeba histolytica/dispar cyst, Ascaris lumbricoides, and Cryptosporidium sp. (Oocyst)			1	1.8%
		Entamoeba histolytica/dispar cyst, Entamoeba coli cyst and Cryptosporidium sp. (Oocyst)			1	1.8%
		S. setercoralis larvae, Cryptosporidium sp. (Oocyst), and Microsporidia sp. (Oocyst)	1	5.9%		
3.	Soil samples results	Positive Negative	30 25	54.5% 45.5%	32 20	61.5% 36.4%
4.	Irrigation water results	Positive Negative	4 51	7.3% 92.7%	55	100%
5.	Hand washing water results	Positive Negative	5 7	41.7% 58.3%	1 38	2.6 97.4

It was found that the multiple parasitic infection in the 1st phase was observed in (6) (35.2%) s, while (11) (64.7%) of the infected participants had single parasitic infection. In the 2nd phase the multiple parasitic infection was observed in (10) (38.5%) of the infected participants, while (16) (61.5%) of the infected participants had single parasitic infection as shown in figure (4.2).

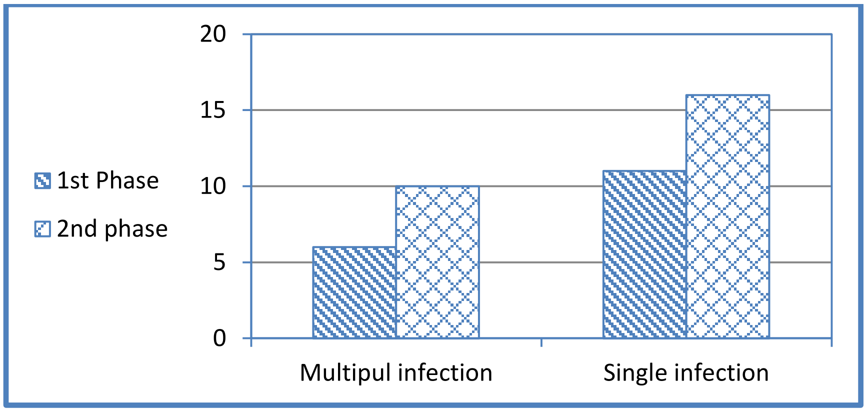


Figure (4.2): Multiple and single infection at the infected participants in the two study phases

4.2.3. Wastewater characteristics through study period:

It's worth to mention that, through the irrigation period by TWW, wastewater samples were taken from the GWWTP inlet, outlet, and from the outlet of the post WWT system for monitoring the parasitic contamination as shown in the table (4.3). No parasitic contamination was revealed in treated wastewater samples that were taken from outlet of the post WWT system. All detected parasites are found in Annex (13).

Table 4.3: Wastewater characteristics through study period

Time	Sample source	pH	EC	TSS (mg/l)	BOD_5 (mg/l)	Parasitic contamination
First month	GWWTP inlet	8.5	3300	550	430	Positive
	GWWTP outlet	8.3	3280	200	140	Positive
	Post WWT system outlet	8	3500	70	25	Negative
Second month	GWWTP inlet	8.3	3220	1147	480	Positive
	GWWTP outlet	8.5	3100	220.2	110	Positive
	Post WWT system outlet	6.3	3400	81.6	32	Negative
Third month	GWWTP inlet	8	3220	558	440	Positive
	GWWTP outlet	7.79	3240	587.6	220	Positive
	Post WWT system outlet	8.93	3770	253.6	25	Negative

4.3. Parasitic Prevalence

4.3.1. Parasitic infection prevalence among participants:

4.3.1.1. Parasitic infection prevalence in the first phase:

At the 1st phase, based on odds ratio calculations in table (4.4); the overall prevalence of parasitic infection at participants was (30.9%), The parasitic infection prevalence between MWUs and GWUs were (27.8%), (36.8%) respectively (OR=0.659, CI (0.202-2.153), negative association, not statistically significant) as shown in figure (4.3). This prevalence results were more than the intestinal parasites prevalence among farmers from Bait-Lahia, Gaza strip (18.6%) by using wet mount method; may be the differences occurred as result of using the Modified Ziehl-Neelsen technique (acid-fast stain) in this study that detected the infection by Cryptosporidium sp. and Microsporidia sp. (A. Al-hindi et al., 2013).

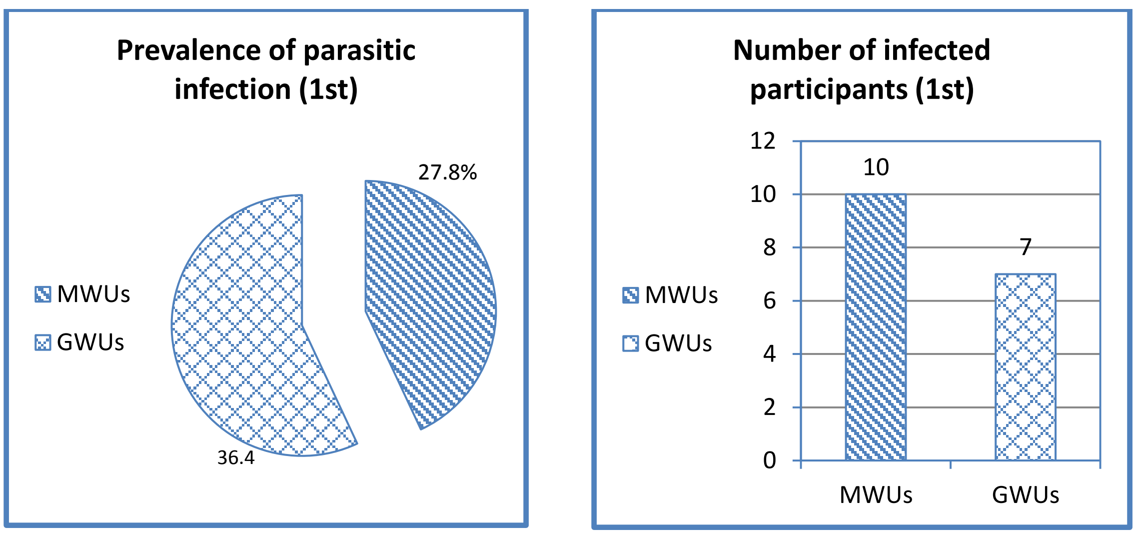


Figure (4.3): Parasitic infection at the first phase

The prevalence of the five parasites species that found in stool samples in the 1st phase were as follows *Cryptosporidium* was the predominant recognized genus with a prevalence of (14.5%) followed by *Entamoeba histolytica/dispar*, *Microsporidium*, *Giardia lamblia cyst*, *and Strongyloides setercoralis larvae* with a prevalence of (12.7%), (10.9%), (3.63%), (1.81%) respectively as shown in figure (4.5,a). The first predominant identified genus in this study at the 1st phase was in agreement with a study carried out in GS that revealed the

Cryptosporidium oocysts was the first predominant identified genus as its found in 62 (14.9%) of 416 child who attends Al-Nasser Hospital (A. I. Al-Hindi et al., 2007).

Table 4.4: Parasitic infection prevalence between farmers group in the first round

	Diseased (Parasitic infected)	Non-disease(non-parasitic infected)	Total
Exposed	10	26	36
Non-exposed	7	12	19
Total	17	38	55

OR= $\frac{a/c}{b/d}$= $\frac{10/7}{26/12}$ = 0.659 (0.202-2.153) (negative association, not statistically significant)

Total parasitic Prevalence in the first round = $\frac{17}{55} * 100 = 30.9\%$

Prevalence of parasitic infection between MWUs = $\frac{10}{36} * 100 = 27.8\%$

Prevalence of infection between GWUs = $\frac{7}{19} * 100 = 36.8\%$

4.3.1.2. Parasitic infection prevalence in the second phase:

At second phase, based on odds ratio calculations in table (4.5) the overall parasitic infection prevalence of participants increased to became (47.3 %). The prevalence between MWUs and GWUs were (50%), (42.1%) respectively (OR=1.37, CI (0.448-4.21), Positive association, not statistically significant) as shown in figure (4.4).

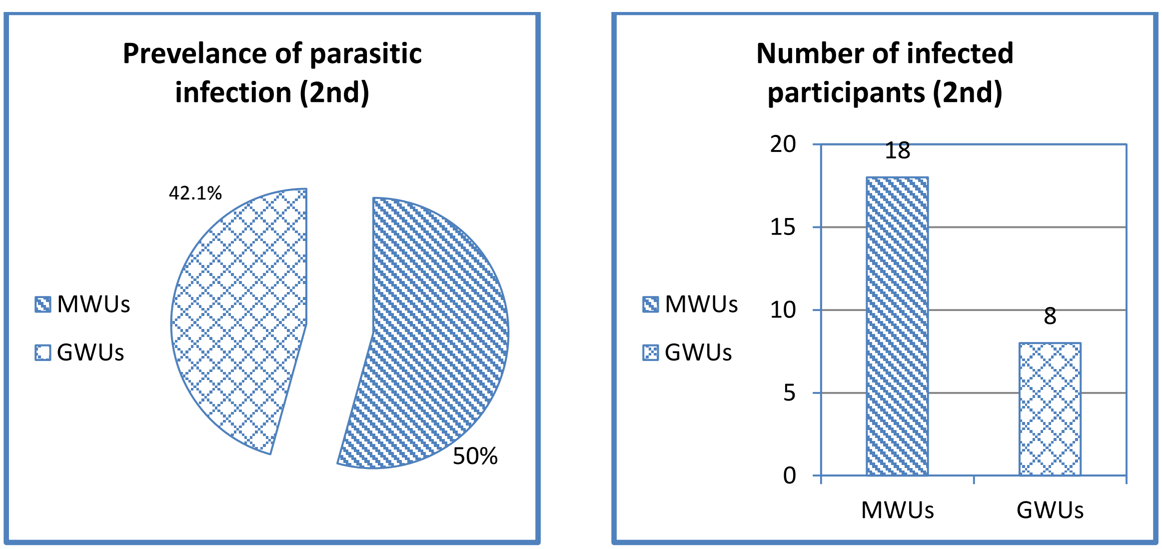


Figure (4.4): Parasitic infection at the second phase

The prevalence of the five parasites species that found in stool samples at the 2nd phase were as follows *Entamoeba histolytica/dispar/coli* was the predominant identified genus with a prevalence of (25.4%) followed by *Cryptosporidium*, *Microsporidium*, *Giardia lamblia cyst*, *and Ascaris lumbricoides* with a prevalence of (18.1%), (9.1%), (5.45) (1.81) respectively as shown in figure (4.5,b).

Table 4.5: Parasitic infection prevalence between farmers in the second round

	Diseased	**Non-diseased**	**Total**
Exposed	18	18	36
Non-exposed	8	11	19
Total	26	29	55
OR= $\frac{a/c}{b/d}$= $\frac{18/8}{18/11}$ = 1.37 (0.448-4.21) (Positively association, not statistically significant)			
Total parasitic Prevalence in the first round = $\frac{26}{55} * 100 = 47.2\%$			
Prevalence of parasitic infection between MWUs = $\frac{18}{36} * 100 = 50\%$			
Prevalence of infection between GWUs = $\frac{8}{19} * 100 = 42.1\%$			

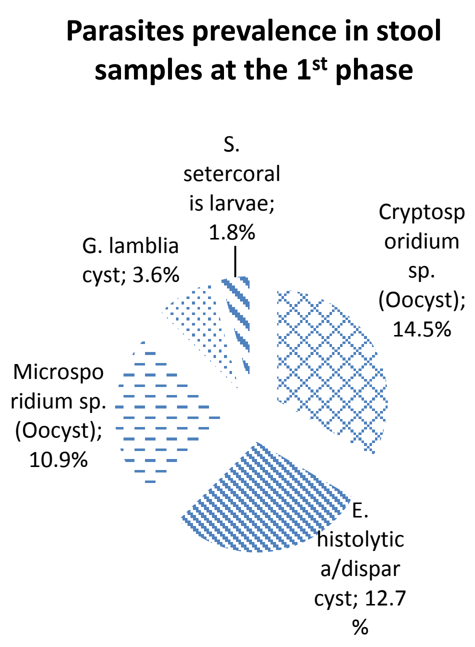


Figure (4.5,a): Parasites prevalence in stool samples at the 1st phase

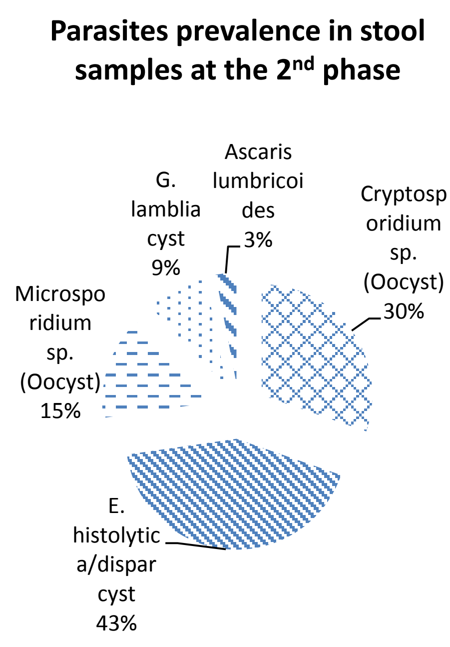


Figure (4.5,b): Parasites prevalence in stool samples at the 2nd phase

Figure (4.5): Parasites prevalence in stool samples at the two phases.

According to the above odds ratio calculations, we revealed the prevalence of PI between MWUs were higher than the PI between GWUs after three months study through it MWUs used the TWW in irrigation, while the GWUs used GW and there is a positive not statically significant association between the PI prevalence and using treated wastewater in irrigation.

4.3.1.3. Parasitic infection comparison between GWUs and MWUs:

Chi- square test revealed that there is no statically significant difference in the PI prevalence between the two groups at two phases and between the group itself.

Table 4.6: Parasitic infection comparison between GWUs and MWUs in the two phases by using Chi-square:

#	Variable		Parasitic infection (1st)				Person chi-square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Irrigation water type	MWUs GWUs	10 7	27.8 36.8	26 12	72.2 63.2	0.478	0.489
#	**Variable**		**Parasitic infection (2nd)**				**Person chi-square**	**P value**
			Positive		**Negative**			
			Freq.	**Row %**	**Freq.**	**Row %**		
2.	Irrigation water type	MWUs GWUs	18 8	50 42.1	18 11	50 57.9	0.311	0.577
#	**Variable**		**Parasitic infection (2nd)** between MWUs				**Person chi-square**	**P value**
			Positive		**Negative**			
			Freq.	**Row %**	**Freq.**	**Row %**		
3.	**Parasitic infection (1st)** between MWUs	Positive Negative	6 13	60 46.2	4 14	40 53.8	0.554	0.457
#	**Variable**		**Parasitic infection (2nd)** between GWUs				**Person chi-square**	**P value**
			Positive		**Negative**			
			Freq.	**Row %**	**Freq.**	**Row %**		
4.	**Parasitic infection (1st)** between GWUs	Positive Negative	2 6	28.6 50	5 6	71.4 50	0.833	0.361

* The relationship or difference is statistically significant at P value < 0.05

Similar study was done in India by Sehgal & Mahajan (1991) and showed there is no significant difference between prevalence of intestinal parasites and Giardia infection among agricultural workers using untreated wastewater or treated wastewater compared with controls who did not irrigate with wastewater (Sehgal & Mahajan, 1991), in addition to another study revealed there is no excess risk was found in individuals exposed to untreated wastewater compared with controls (OR 1.07, 95% CI 0.84–1.36); the group using reservoir water was not different from the controls (OR 1.22, 95% CI 0.94–1.58) (Cifuentes, et al., 2000). A non-compatible study with our results showed an increased risk of intestinal nematode infection and hookworm infection, in particular, in wastewater farmers (OR= 31.4, 95% CI 4.1-243) and their children (OR=5.7, 95% CI 2.1-16) when compared with farming households using regular (non-wastewater) irrigation water (Ensink, et al., 2005)

In spite of MWUs HB was better than GWUs HB, their soil were less parasitic contaminated, and they used localized irrigation technique "drip irrigation system" that offer them the most health protection because the wastewater is applied directly to the plants, the high parasitic infection between them may be attributed to two possibly reasons a) About 80% of participant within age group ≤ 18 year were from MWUs group; another study revealed that the parasite load of Ascaris infection was much higher among children living in wastewater-exposed areas than unexposed areas (Al Salem & Abouzaid, 2006); b) Increasing soil organic matter in MWUs soil after using TWW for three months lead to increasing soil microorganisms activity and survival and then the PI opportunities. It was found the soil organic matter increased for good contents after irrigation with well water, while excellent content obtained with irrigation with treated wastewater (Al-Sbaihi et al., 2013). Another study showed the presence of organic matter extends the survival of total and fecal coliforms, and Helminth eggs. In addition to its reported that the wastewater application to soil generally raises activity of soil microorganisms by increasing soil organic matter and it’s a condition to pose an actual risk from using TWW in agriculture either an effective dose of an excreted pathogen reaches the field or the pathogen multiplies in the field to form an infective dose (WHO, 1989) (Toze, 1997).

4.3.2. Prevalence of some parasitic species:

It was found the OR value for *Entamoeba histolytica/dispar/coli and Giardia lamblia* prevalence increased to be more than one in the second phase meaning there is a positive association between prevalence of *Entamoeba histolytica/dispar/coli and Giardia lamblia* and irrigation water type.

Table 4.7: Prevalence of E. histoltical/dispar/coli in the second round

	Diseased by ***E. histoltical/dispar/coli***	**Non-diseased by** ***E. histoltical/dispar/coli***	**Total**
Exposed	11	25	36
Non-exposed	5	14	19
Total	16	39	55
OR= $\frac{a/c}{b/d}$= $\frac{11/5}{25/14}$ = 1.23 (0.401-3.776) (Positively association, not statistically significant)			

Table 4.8: Prevalence of G. lamblia in the second round

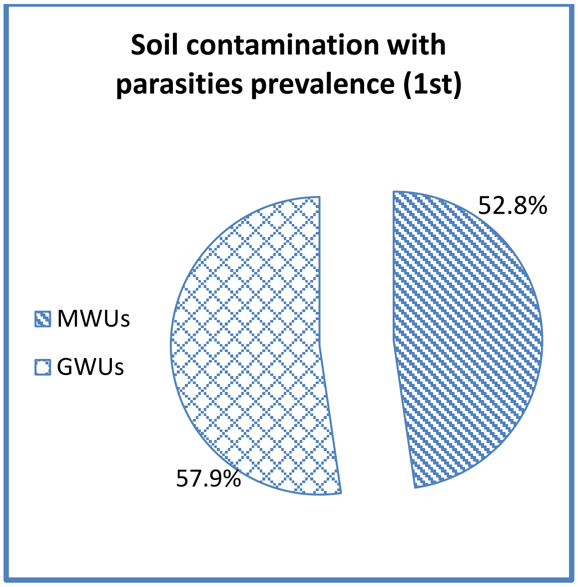
	Diseased by ***G. lamblia***	**Non-diseased by** ***G. lamblia***	**Total**
Exposed	6	31	37
Non-exposed	1	19	20
Total	7	50	57
OR= $\frac{a/c}{b/d}$ = 1.51 (0.401-3.776) (Positively association, not statistically significant)			

OR calcualtions revealed that *infection by Entamoeba histolytica/dispar/coli and Giardia lamblia* are the most wastewater related waterborne diseases. Crittenden et al. 2005 as cited in ((Roy et al., 2007)) revealed the protozoans associated with waterborne disease mainly include Entamoeba histolytica, Entamoeba dispar, Giardia lamblia, and Cryptosporidium parvum.

4.3.3. Soil parasitic contamination prevalence:

4.3.3.1. Soil parasitic contamination prevalence in the first phase:

Based on table (4.9) soil parasitic contamination prevalence in the 1st phase was (54.5%). The soil parasitic contamination prevalence at MWUs and GWUs were (52.8%), (57.9%) respectively (OR= 0.813, CI (0.265-2.495), negative association not statistically significant) as shown in figure (4.6).



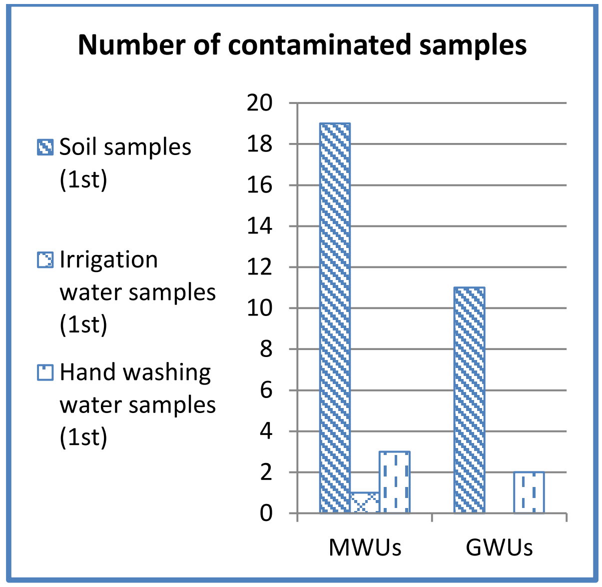


Figure (4.6): Parasitic contamination in soil, irrigation water, and hand washing water samples at the first phase

Table 4.9: Relationship between soil parasitic contamination and irrigation water type in the 1st phase

	Parasitic contaminated soils	Non-parasitic contaminated soils	Total
Exposed to TWW	19	17	36
Non-exposed to TWW	11	8	19
Total	30	25	55

OR= $\frac{a/c}{b/d}$= $\frac{19/11}{17/8}$ = 0.813 (0.265-2.495) (negative association, not statistically significant)

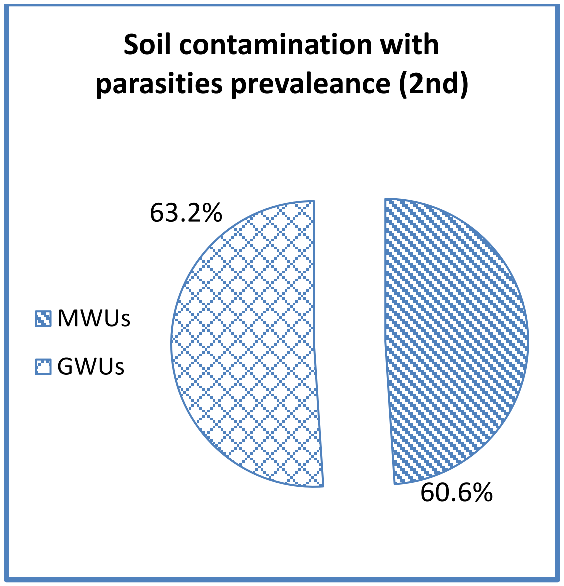
Total soil parasitic contamination prevalence in the first round = $\frac{30}{55} * 100 = 54.5\%$

Prevalence of soil parasitic contamination at MWUs = $\frac{19}{36} * 100 = 52.8\%$

Prevalence of soil parasitic contamination at GWUs = $\frac{11}{19} * 100 = 57.9\%$

4.3.3.2. Soil parasitic contamination prevalence in the second phase:

At the second phase, the soil parasitic contamination prevalence increased to became (61.5%). The soil parasitic contamination prevalence at MWUs and GWUs were (60.6%), (68.4%) respectively (OR=0.897, CI (0.280-2.87), negative association, not statistically significant) as shown in figure (4.7) and table (4.10). A study in Kumasi was not compatible with us and revealed wastewater irrigated plots had higher numbers of coliforms and helminth counts than those obtained from the potable water irrigated (Kwashie, 2011).



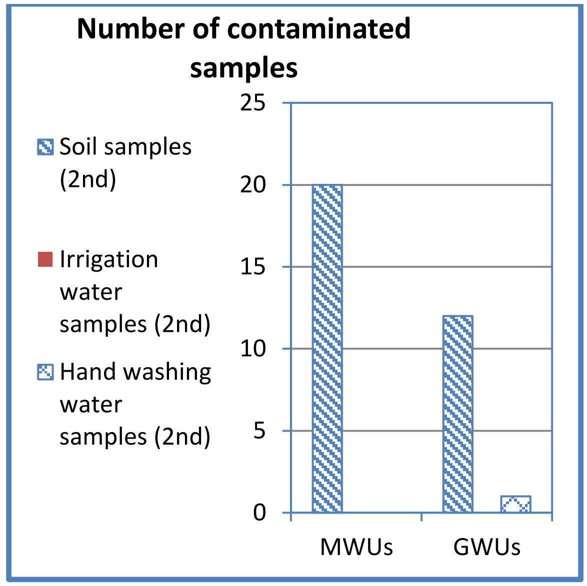


Figure (4.7): Parasitic contamination in soil, irrigation water, and hand washing water samples at the second phase

Table 4.10: Relationship between soil parasitic contamination and irrigation water type in the 2nd phase

	Parasitic contaminated soils	Non parasitic contaminated soils	Total
Exposed to TWW	20	13	33
Non-exposed to TWW	12	7	19
Total	32	20	52

OR= $\frac{a/c}{b/d}$= $\frac{20/12}{13/7}$ = 0.897 (0.280-2.87) (negative association, not statistically significant)

Total soil parasitic contamination prevalence in the second round = $\frac{32}{52} * 100 = 61.5\%$

Prevalence of soil parasitic contamination at MWUs = $\frac{20}{33} * 100 = 60.6\%$

Prevalence of soil parasitic contamination at GWUs = $\frac{12}{19} * 100 = 63.2\%$

4.3.3.3. Relationship between soil samples results and other factors:

Chi-square test as per table (4.11) revealed that the percentage/prevalence of contaminated soils were slightly higher at GWUs, and the relationship between soil parasitic contamination and irrigation water source (farmers' group) was not statically significant. In addition to Chi-square test revealed there is astatically significant difference in soil parasitic contamination prevalence between the two phases (P=0.042); as the prevalence of parasitic contamination increased from 54.5% in the 1st phase to 61.5% in the 2nd phase. But there was no statistically significant difference between the soil parasitic contamination prevalence in the same group between the two phases.

Table 4.11: Relationship between soil samples results and other factors

1.	**Relationship between soil parasitic contamination and irrigation water type**							
#	**Variable**		**Soil parasitic contamination**				**Person Chi square**	**P value**
			Positive		**Negative**			
			Freq.	**Row %**	**Freq.**	**Row %**		
1.	Farmers' group	MWUs(1st)	19	52.8	17	47.2	0.131	0.47
		GWUs	11	57.9	8	42.1		
2.	Farmers' group	MWUs (2nd)	20	60.6	13	36.1	0.033	0.855
		GWUs	12	63.2	7	36.8		
2.	**Relationship between soil parasitic contamination in the 2nd phase and the soil parasitic contamination in the 1st phase**							
#	**Variable**		**Soil parasitic contamination (2nd)**				**Person Chi square**	**P value**
			Positive		**Negative**			
			Freq.	**Row %**	**Freq.**	**Row %**		
1.	Soil parasitic contamination (1st)	**Positive**	15	50	15	50	3.98	0.042 *
		Negative	17	77.3	5	22.7		
3.	**Relationship between soil parasitic contamination in the 2nd phase and the soil parasitic contamination in the 1st phase at MWUs**							
#	**Variable**		**Soil parasitic contamination (2nd) (MWUs)**				**Person Chi square**	**P value**
			Positive		**Negative**			
			Freq.	**Row %**	**Freq.**	**Row %**		
1.	Soil parasitic contamination (1st) (MWUs)	**Positive**	10	52.6	9	47.4	1.19	0.275
		Negative	10	71.4	4	23.5		
	Total		**20**	**60.6**	**13**	**39.4**		
4.	**Relationship between soil parasitic contamination in the 2nd phase and the soil parasitic contamination in the 1st phase at GWUs**							
#	**Variable**		**Soil parasitic contamination (2nd) (GWUs)**				**Person Chi square**	**P value**
			Positive		**Negative**			
			Freq.	**Row %**	**Freq.**	**Row %**		
1.	Soil parasitic contamination (1st) (GWUs)	**Positive**	5	45.5	6	54.5	3.51	0.061
		Negative	7	87.5	1	12.5		
	Total		**12**	**63.2**	**7**	**36.8**		

* The relationship or difference is statistically significant at P value < 0.05

4.4. Relationship Between Parasitic Contamination In the Collected Samples (Soil, Irrigation Water, and Hand Washing Water) And Parasitic Infection

4.4.1. Relationship between soil parasitic contamination and parasitic infection:

A statistically significant relationship was found between soil parasitic contamination and stool parasitic in the first phase only (P=0.029), may be this because the percentage of participants who within the age group ≤ 18 year who had negative/non contaminated soils increased from 32% in the first phase to 45% in the second phase, see Annex (14).

Table 4.12: Relationship between soil samples results and parasitic infection

#	Variable		Stool parasitic infection (1nd)				Person Chi square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Soil parasitic contamination (1st)	Positive	13	43.3	17	56.7	4.77	0.029*
		Negative	4	16	21	84		
	Total		17	30.9	38	69.1		
#	Variable		Stool parasitic infection (2nd)				Person Chi square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Soil parasitic contamination (2nd)	Positive	12	37.5	20	62.5	2.50	0.113
		Negative	12	60	8	40		
	Total		24	46.2	28	53.8		

* The relationship or difference is statistically significant at P value < 0.05

4.4.2. Relationship between irrigation water samples and hand washing water results and parasitic infection:

Chi-square test revealed there is no statically significant relationship between irrigation water and hand washing water samples results and parasitic infection.

4.5 Descriptive Statistics of the Interview Questionnaire

4.5.1. Socio-demographic characteristics of the study participants:

As shown in table (4.13) all participants were mainly from two areas which were Al-Zaitoun-next to Gaza car shop and Al-Zaitoun-Abu maeali district; most of the MWUs were from the first area (49.1%) and most of the GWUs were from the second area (27.3%); the other participants (23.7%) were from different areas (Joher El-Deek, Asqola, Salah El-Deen street, and El-Shiekh Ejleen). Males (83.6%) were more represented in this study than females (16.4%) because males in the two study areas mainly work in agriculture and females only provide the assistance at need. The age of farmers divided into three main groups, the majority of farmers were distributed equally at age group ≤ 18 year (38.2%) and 19-46 year (38.2%), farmers at age group ≥ 46 year represented the least group (23.6%). According to family size participants were divided into two groups ≤ 7 members and ≥ 8 members; (56.4 %) of them had 8 members and above. Around half of participants (50.9%) had preparatory or general secondary, (40%) had primary school and less, and the other had high studies (9.1%). The financial and economic status for participants were as follows (23.6%) excellent, (12.7%) very good, (41.8%) good, and (21.8%) bad.

Table 4.13: Distribution of the study participants by socio-demographic characteristics

#	Variable	Category	Total	
			Number	Percentage
1.	Farmer's address	Al-Zaitoun, Gaza car shop Al-Zaitoun, Abu maeali Other areas	27 15 13	49.1% 27.3% 23.7%
2.	Gender	Male Female	46 9	83.6% 16.4%
3.	Age	≤18 year 19-45 year ≥ 46 year	21 21 13	38.2% 38.2% 23.6%
4.	Family Size	≤ 7 members ≥ 8 members	24 31	43.6% 56.4%
5.	Academic qualification	Primary School and less Preparatory and General Secondary Bachelors/Diploma/High studies	22 28 5	40% 50.9% 9.1%
6.	Financial and economic status	Excellent Very Good Good Bad	13 7 23 12	23.6% 12.7% 41.8% 21.8%

4.5.2. Housing characteristics of the study participants:

As shown in table (4.14) most of participants had concrete building homes (94.5%); only (5.5%) of participants had asbestos building homes. Most of participants are living in a populated areas as the distance between homes of (89.1%) participants were ≤ 30 meters. Regarding participants home land type, (72.7%) of participants' home land were covered by court, while (27.3%) of participants their home land were covered by court and some areas were not courted but were covered by concrete or soil (landless). Most of participants are living in a weak infrastructural areas, as (90.9%) of them live in unpaved streets "have soil around their homes"; the other participants (9%) have paved streets, or paved streets but there is soil or grass areas around their homes.

Table 4.14: Distribution of the study participants by housing characteristics

#	Variable	Category	Total	
			Number	Percentage
1.	Farmer's home type	Concrete Asbestos	52 3	94.5% 5.5%
2.	Distance between farmer's home and the closest neighbor	≤ 30 meters ≥ 31 meters	49 6	89.1% 10.9%
3.	Type of farmer's home land	Court others (court and concrete / court and soil)	40 15	72.7% 27.3%
4.	Type of the land around farmer's home	Soil Others (concrete, grass, or concrete and soil)	50 5	90.9% 9%

4.5.3. Agriculture overview of the study participants:

As shown in table (4.15); more than half of participants (52.7%) worked mainly as a farmers; while (47.3%) didn’t work mainly as farmers, since (57.6%) of them were students. High percentage of participants (90.9%) worked in their agricultural lands with assistants, as their family members share/assist them (father, mother, sons, brothers, sisters, wives, and husband); participants reported the working in agriculture need assistance especially in planting and harvesting periods, so they ask help from their family members and if they cannot secure sufficient number from them they ask help from non-relatives people.

Regarding the distance between participants home and their agricultural lands (23.6%) of participants lived in the farm, (27.3 %) lived beside or close to their farm; while (49.1%) of participants lived far away from their farms. Living in or beside farm means approximately there is a good access to toilet and washing facilities at need

Participants' daily spent time in the farm divided into two groups; (61.8%) of participants spent ≤ 6 hours per day in working in agriculture; while (38.2%) spent ≥ 7 hours per day. Also the years of working in agriculture divided into two groups; (58.2 %) of participants worked in agriculture for period of ≥ 11 year; while (41.8%) worked in agriculture for period of ≤10 year. Regarding area of participants farm (58.2%) of them had ≥ 4 dunums; while the other participants (45.5%) had ≤ 3 dunums. Through irrigation by GW 92.7% of participants used fertilizers procured from shops in Gaza or from their or other farms, they frequently used birds, chemical, animals respectively.

Using TWW in the first study area (Al-Zaitoun area) began in 2004; (63.9%) of MWU's participants were new users for TWW as they used it only from 2-5 years; while (36.1%) were used it for a period of ≥ 6 years. In spite of the fertility advantage for TWW (25%) of MWU's used fertilizers through irrigation by TWW periods, the other participants used it sometimes or at need. All MWU's reported that they are eating the irrigated plants by TWW, all of them stop the irrigation by TWW before two weeks from harvesting, and they used the TWW for irrigation olive, citrus, and fruits trees.

Table 4.15: Distribution of the study participants by agricultural practices characteristics

#	Variable	Category	Total	
			Number	Percentage
1.	Farming is the main job for participant	Yes No	29 26	52.7% 47.3%
2.	Years of working in agriculture	≤10 years ≥ 11 years	23 23	41.8% 58.2%
3.	Farmer works with assistants in his/her farm	Yes No	50 5	90.9% 9.1%
4.	Farm address	Home exists inside farm Farm beside/close to farmer's home Farm is far away from farmer's home	13 15 27	23.6 27.3 49.1
5.	Daily spent time in the farm	≤ 6 hours ≥ 7 hours	34 21	61.8% 38.2%
6.	Farm area	≤ 3 dunums ≥ 4 dunums	25 30	45.5% 54.5%
8.	Using fertilizers	Yes Sometimes	51 4	92.7% 7.3%
9.	Area of the agricultural lands that irrigated by TWW	≤ 3 dunums ≥ 4 dunums	15 12	41.7% 58.3%
11.	Years of using TWW in agriculture	2 – 5 years ≥ 6 years	23 13	63.9% 36.1%
12.	Eating plants that irrigated by TWW	Yes	36	100%
13.	Using fertilizes through irrigation by TWW periods	Yes Sometimes "at need" No	9 14 13	25% 38.9% 36.1%

4.5.4. Water status of the study participants:

As shown in table (4.16), all participants depend on the desalination water plants for drinking water. For non-drinking water purposes (56.4%) of participants used municipal water wells, (25.5%) used agricultural water wells, (18.2%) used more than one source as the municipal and agricultural water wells or municipal and private wells.

All participants reported that, they use the desalinated water directly without doing anything as chlorination, filtration, boiling, or other techniques in order to ensure the water is free from microbiological contamination.

Table 4.16: Distribution of the study participants by water status characteristics

#	Variable	Category	Total	
			Number	Percentage
1	Drinking water source	Private water plants (Desalination water plant)	55	100%
2	Non-drinking water source	Municipality water Agricultural water wells More than one source (municipal and agricultural water wells or municipal and private wells)	30 15 10	56.4% 25.5% 18.2%

4.5.5. Sanitation status of the study participants:

As illustrated in table (4.17) most participants (76.7%) disposed their toilet wastewater into sewage network, (9.1%) pumped it directly to their farm, and (14.5%) used cesspits exist beside their homes . About (60%) of participants had toilet in their farm; (72.7%) of them discharged farm toilet wastewater into septic tanks constructed under the toilet and the other (27.3%) discharged it directly into the farm. It was found (66.7%) of participants who had no toilet in their farm used their home toilet at need, while (21.2%) urinated between plants, and (12.1%) urinated on the edge of the farm. About (81.8%) of participants who had toilet in their farm avail an easy access to toilet to other farmers.

Table 4.17: Distribution of the study participants by sanitation status characteristics

#	Variable	Category	Total	
			Number	Percentage
1.	Sanitation disposal place of home's toilet	Pumped to the Farm Pumped to cesspits Pumped to WW network	5 8 42	9.1% 14.5% 76.7%
2.	Having toilet in the farm	Yes No	22 33	40% 60%
3.	Other farmers share your farm's toilet	Yes No	18 4	81.8% 18.2%
4.	Sanitation disposal place of farm's toilet	Pumped to the farm Pumped to septic tanks	6 16	27.3% 72.7%
5.	Urinating place for farmers who have not toilet in the farm	Home between plants On the edge of the farm	22 7 4	66.7% 21.2% 12.1%

4.5.6. Birds and animals breeding of the study participants:

It obvious from table (4.18); breeding birds or animals is a common habit between farming communities, as (89.1%) of participants were breeding birds or animals, 87.7% of them were breed the birds/animals inside or beside their home. About (49%) of participants who breed birds/animals were using closed place for the birds/animals, (32.7%) were not using closed place, and (18.4%) were not using closed place at all times. From the farmers who breed birds/animals (67.3%) were using the remaining plants for feeding the birds and animals, (44.9%) were breeding birds only, (20.4%) were breed cattle, and (34.7%) of them were breed more than one species birds/cattle, birds/cattles/cats, or birds/cats.

Table 4.18: Distribution of the study participants by bids and animals breeding characteristics

#	Variable	Category	Total	
			Number	Percentage
1.	Breeding birds and/or animals	Yes No	49 6	89.1% 10.9%
2.	Place of breeding birds and/or animals	Inside/beside home In the farm	43 6	87.7% 12.3%
3.	Birds and animals exist in closed place	Yes Sometimes No	24 9 16	49% 18.4% 32.7%
4.	Birds and animals eat the agricultural remaining	Yes Sometimes No	33 4 12	67.3% 8.2% 24.5%
5.	Birds and animals species	Birds Cattle More than one species (birds/cattle, birds/cattles/cats, or birds/cats)	22 10 17	44.9% 20.4% 34.7%

4.5.7. Hygiene behavior of the study participants:

Hygiene behavior (HB) of the study participants divided into three types/models: HB. for participants inside their homes, HB. for participants through harvesting process, and HB. for participants through working in the farm**,** as illustrated in tables (4.19.1,2&3).

Regarding HB. for participants inside their homes (table (4.19.1)), it was found (76.4%) of participant families consumed ≤ 3 soap piece/week, while (23.6%) of them consumed 4-7 soap piece/week. Participants divided into three categories regarding cooking place; about (63.6%)

of them cooked in their home kitchen, (5.5%) cooked outside their home, (30.9%) cooked outside the home and sometimes cooked inside it in the kitchen. It was found that (63.6%) of participants always wore shoes when they going out around their home, while (14.5%), (9.1%), and (12.7%) were almost, rarely, and never wear shoes when they going out respectively.

Table 4.19.1: Distribution of the study participants by hygiene behavior inside \ home characteristics

#	Variable	Category	Total	
			Number	**Percentage**
1.	Soap consumption in home	≤ 3 peace/family. week 4-7 peace/family. week	42 13	76.4% 23.6%
2.	Cooking place	In the home kitchen Outside the home In the home kitchen and outside the home	35 3 17	63.6% 5.5% 30.9%
3.	Wearing shoes when going out around home	Always Almost Rarely Never	35 8 5 7	63.6% 14.5% 9.1% 12.7%

Regarding HB. for participants through harvesting process, it was found that through irrigation by GW periods, HB. for MWUs were better than the HB. for GWUs in dealing with crops that fall on soil if they want to eat it. While the GWUs were better than MWUs in dealing with crops that fall on soil through harvesting process if they want to put it in boxes for consumers selling.

It was found the HB. for MWUs in dealing with crops that fall on soil through harvesting process were improved when they used TWW in irrigation.

Table 4.19.2: Distribution of the study Participants by hygiene behavior through harvesting process

#	Variable	Participants	Get rid them	Wash them very well	Clean it by using my hands or my clothes	Eat them directly/ collect it	Mean	RII *
1.	At harvest, how do you deal with fruits that fall on soil if you want to eat it	GWUs (GWIP)	0	1	16	2	1.94	49
		MWUs (GWIP)	0	11	17	8	2.08	52
		MWUs (TWWIP)	0	5	19	7	3.52	88
2.	At harvest, how do you deal with fruits that fall on soil if you want to sell it	GWUs (GWIP)	16	0	0	3	3.87	97
		MWUs (GWIP)	30	1	0	1	1.93	48
		MWUs (TWWIP)	26	1	0	1	3.85	96

*Relative importance index

Regarding HB. for participants through working in the farm, it was found that through irrigation by GW periods, frequency of using the faucet that existed in the farm for washing had taken the highest score at the two farmer groups (95%, GWUs), (66%, MWUs), while washing hands after touching the irrigation water had taken the lowest score also at the two farmer groups (25%, GWUs), (32%, MWUs).

It was found that, through irrigation by TWW, washing hands after touching the irrigation water had taken the highest score (68%), while wearing gloves and special clothes had taken the least score (35%).

Table 4.19.3: Distribution of the study participants by hygiene behavior through working in farm characteristic

#	Variable	Participants	Always	Almost	Rarely	Never	Mean	RII
1.	Existence soap in the farm	GWUs (GWIP)	13	0	2	4	3.26	82
		MWUs (GWIP)	5	0	9	22	1.91	48
2.	Frequency of using the faucet	GWUs (GWIP)	16	2	1	0	3.78	95
		MWUs (GWIP)	3	15	9	2	2.65	66
3.	Washing hands by using used water for multiple times	GWUs (GWIP)	0	0	0	19	1	25
		MWUs (GWIP)	0	2	0	34	1.11	28
4.	Washing fruits and vegetables before eating them	GWUs (GWIP)	10	1	1	7	2.73	68
		MWUs (GWIP)	7	13	4	12	2.41	60
		MWUs (TWWIP)	13	4	3	11	2.61	65
5.	Washing hands after operating the irrigation pump	GWUs (GWIP)	2	0	1	16	1.36	34
		MWUs (GWIP)	4	3	0	7	1.75	44
		MWUs (TWWIP)	6	4	0	14	2.08	52
6.	Washing hands after maintaining any faults in water irrigation network	GWUs (GWIP)	5	2	1	11	2.05	51
		MWUs (GWIP)	7	1	4	12	2.12	53
		MWUs (TWWIP)	10	2	1	8	2.66	67
7.	Washing hands when they had touch soil	GWUs (GWIP)	2	1	0	16	1.42	36
		MWUs (GWIP)	3	4	0	29	1.47	37
		MWUs (TWWIP)	4	2	0	25	1.51	38
8.	Touching with the irrigation water	GWUs (GWIP)	14	4	1	0	3.68	92
		MWUs (GWIP)	9	5	18	4	2.52	63
		MWUs (TWWIP)	6	2	14	9	2.16	54
9.	washing after Touching with the irrigation water	GWUs (GWIP)	0	0	0	19	1	25
		MWUs (GWIP)	3	0	1	32	1.27	32
		MWUs (TWWIP)	13	4	3	9	2.72	68
10.	Wearing special footwear through working in the field	GWUs (GWIP)	3	2	7	7	2.05	51
		MWUs (GWIP)	4	4	7	21	1.75	44
		MWUs (TWWIP)	6	3	6	16	1.96	49
11.	Wearing gloves when you work in the field	GWUs (GWIP)	1	0	5	13	1.42	36
		MWUs (GWIP)	1	0	7	28	1.27	32
		MWUs (TWWIP)	2	0	7	22	1.41	35
12.	Wearing special clothes when you work in the field	GWUs (GWIP)	13	0	0	0	3.05	76
		MWUs (GWIP)	7	0	6	23	1.75	44
		MWUs (TWWIP)	2	0	6	23	1.38	35

*Relative importance index

4.5.8. Health status of the study participants:

As illustrated in table (4.20.1); about (54.5%) of participants had not been diagnosed for intestinal parasites in their life, only (45.5%) of them did, (44%) of them were diagnosed for intestinal parasites through their childhood, (20%) were frequently diagnose for intestinal parasites as (every year , six months, or four months), the others (36%) were non frequently diagnose. About (72%) of participants received anti-parasitic drugs after diagnosis, (20%) didn’t treated by anti-parasitic drugs after diagnosis, and about (8%) were sometimes treated by anti-parasitic drugs after diagnosis. There were three Participants mentioned they previously had infected by the *Ascaris lumbricoides* and two other farmer families complain from *Enterobius vermicularis* infection.

Regarding health status; about (61.8%) of participants informed they had excellent health status, (23.6%) had good health status, (14.3%) had acceptable health status. All MWU's informed their health status didn’t differ after using TWW in irrigation.

Regarding farmers' children health status, (51.2%) of participants informed their children health status is excellent, while the others informed as follows; (29.3%) good, (9.8%) acceptable, and (9.8%) bad. About (95.5%) from MWUs informed their children health status didn’t differ after using TWW in irrigation, the other MWUs informed they can't evaluate their children health after using TWW.

About (72.2%) of participants informed the using TWW in agriculture increases the disease infection, (38.2%) of them informed the infection happened if the farmer touch the TWW, if the TWW was bad quality, or if the farmer doesn’t take suitable precautions.

Table 4.20.1: Distribution of the study participants by health status characteristics

#	Variable	Category	Total	
			Number	Percentage
1.	Have you ever been diagnosed with intestinal parasites	Yes No	25 30	45.5% 54.5%
2.	When/How you had been diagnosed with intestinal parasites	Childhood Frequently Non- frequently	11 5 9	44% 20% 36%
3.	Having previously anti-parasitic drugs	Yes No Sometimes	18 5 2	72% 20% 8%
4.	Farmers' health status	Excellent Good Acceptable Bad	34 13 18 0	61.8% 23.6% 14.3% 0
5.	Farmers' children health status	Excellent Good Acceptable Bad	21 12 4 4	51.2% 29.3% 9.8% 9.8%
6.	Using TWW in agriculture increased your diseases infection	Yes No I do not know Yes, if farmers touch it, if it has bad quality, or if farmer does not take suitable precautions	19 11 21 4	34.5% 20% 7.3% 38.2%

Abnormal stool with blood (100%) and abnormal vomiting (96%) were the least self-reported symptoms at GWUs. While abnormal stool with blood (100%) and abnormal diarrhea (97%) were the least self-reported symptoms at MWUs.

Abnormal abdominal pain (75%), abnormal diarrhea (79%), and abnormal loss of appetite (79%) were the most self-reported symptoms at GWUs. While the same symptoms excluding abnormal diarrhea were the most self-reported symptoms at MWUs (84%) and (85%) respectively.

Table 4.20.2: Distribution of the study participants by farmers' self-reported symptoms

#	Variable	FG	Yes	Sometimes	No	Mean	RII
1.	Suffering from abnormal diarrhea	GWUs	5	2	12	2.36	79
		MWUs	0	3	33	2.91	97
2.	Suffering from abnormal constipation	GWUs	5	1	3	2.42	81
		MWUs	2	5	29	2.75	92
3.	Suffering from abnormal abdominal pain	GWUs	7	0	12	2.26	75
		MWUs	6	5	25	2.52	84
4.	Suffering from abnormal stool with blood	GWUs	0	0	19	3	100
		MWUs	0	0	36	3	100
5.	Suffering from abnormal vomiting	GWUs	1	0	18	2.89	96
		MWUs	3	4	29	2.72	91
6.	Suffering from abnormal fever	GWUs	2	1	16	2.73	91
		MWUs	1	3	32	2.86	95
7.	Suffering from abnormal weakness	GWUs	3	1	1.5	2.63	88
		MWUs	2	2	32	2.83	94
8.	Suffering from abnormal headache	GWUs	5	1	13	2.42	81
		MWUs	5	2	29	2.66	89
9.	Suffering from abnormal loss of appetite	GWUs	6	0	13	2.36	79
		MWUs	6	4	24	2.55	85

*Highest RRI mean there are low self-reported symptoms.

4.6 Inferential Statistics of the Interview Questionnaire

4.6.1. Socio-demographic factors

As shown in table (4.21&22); Chi-square test revealed that the highest parasitic infection was among females (33.3%) compared to males (30.4%) but no statistically significant difference was found (P=0.863), in the same time there were a statistically significant differences between mean of HB and gender (P=0.001), as the HB mean of males were (1.65) more than the HB mean of females (1.05). This result was compatible with study was carried in Iran that showed there is no statically significant difference in parasitic infection (PI) between males and females (p=0.177) (Kiani et al., 2016); and with another study revealed that the parasites were slightly more common in females (54.7%) than males (41.7%) (Sinniah et al., 2012), but it was non-compatible with study was carried in Turkey on children of farm workers that showed there is a statically significant difference between parasitic infection and gender (Doni et al., 2015).

ANOVA test and Chi-square test revealed there is no statistical significant relationship between PI or HB with participants age (P= 0.107), however; the participants were in age group ≤18 year had the highest PI percentage (42.9%) and the least HB mean (1.27). It was found a compatible study with our results that revealed the parasites were more common in age groups from (1-20) (Sinniah, et al., 2012).

Chi-square test revealed that there is a statistical significant difference (p=0.04) between PI and family size, as the farmers' families who had ≥ 8 members were hosting parasites more than the other group who had ≤ 7 members. Another study showed the family size significantly associated (p=0.044) with the intestinal parasitic infection (Tulu et al., 2014).

Regarding academic qualification, our results showed that there is no statistically significant association between HB or PI with academic qualification of the participants (P ≥ 0.05), while the PI was the highest and HB mean was the least between participants who had primary school and less. A study on risk factors of intestinal parasitic infection between prisoners showed compatible results, as it revealed the level of education was inversely related to the risk of intestinal parasites infection where the post primary education prisoners were least infected with intestinal parasites infection when compared to unschooled prisoners, but the relationship wasn’t statically significant (P =0.07) (Rop et al., 2016). In addition to another study was compatible with our result as it revealed that the inhabitant with higher education background had significantly lower infection rates of *Ascaris* and *Trichuris* (Toma et al., 1999).

Regarding farmers' financial and economic status, Chi-square revealed there is no statically significant relationship between financial and economic status and PI, but the highest PI was found between participants who had bad financial and economic status, in addition a statistically significant association was found between participants financial and economic status and HB (p=0.005); Post hoc test showed that the main statistical significant was found among participants who had good financial and economic status and participants who had excellent financial and economic status; as stated in another study the effect of poverty on the intestinal parasitic infection is complex and could be attributed to many factors, such as an unhygienic environment, lack of safe potable water, protective clothes, and poor nutrition; as many studies conducted in different countries showed that parasitic infections were higher in those with a low socioeconomic status and was more common among immigrants (Doni, et al., 2015). Another study found that people from households with an average socio-economic status had a much higher risk of *E. histolytica* infection compared with those from households with a good socioeconomic status (p=0.01) (Duc et al., 2011).

Table 4.21: Relationship between socio-demographic factors and parasitic infection

#	Variable		Parasitic Infection (1st phase)				Pearson Chi-square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	**Gender**	Male	14	30.4	32	69.6	0.03	**0.863**
		Female	3	33.3	6	66.7		
2.	**Age**	≤18 year	9	42.9	12	57.1	4.46	**0.107**
		19-45 year	3	14.3	18	85.7		
		≥ 46 year	5	38.5	8	61.5		
3.	**Family Size**	≤ 7 members	4	16.7	20	83.3	4.04	**0.040***
		≥ 8 members	13	41.9	18	58.1		
4.	**Academic qualification**	Primary School and less	9	40.9	13	59.1	3.33	**0.188**
		Preparatory and General Secondary	8	28.6	20	71.4		
		Other(Bachelors/Diploma/High studies)	0	0	5	100		
5.	**Financial and economic status**	Excellent	4	30.8	9	69.2	6.03	**0.110**
		Very Good	1	14.3	6	85.7		
		Good	5	21.7	18	78.3		
		Bad	7	58.3	5	41.7		

* The relationship or difference is statistically significant at P value < 0.05

Table 4.22: Relationship between socio-demographic factors and hygiene behavior

#	Variable	Category	N	Mean	SD	Factor	Value	P value
1.	**Hygiene behavior**	Gender						
		Male Female	46 9	1.64 1.05	0.807 0.110	t	4.74	0.001 *
2.		Age						
		≤18 year 19-45 year ≥ 46 year	21 21 13	1.27 1.69 1.76	0.552 0.790 0.949	F	2.33	0.107
3.		Family Size						
		≤ 7 members ≥ 8 members	24 31	1.51 1.58	0.928 0.637	t	-0.317	0.753
4.		Academic qualification						
		Primary School and less Preparatory and General Secondary Other (Bachelors/Diploma/High studies)	22 28 5	1.37 1.69 1.5	0.739 0.834 0.353	F	1.08	0.345
5.		Financial and economic status						
		Excellent Very Good Good Bad	13 7 23 12	1.53 1.92 1.41 1.55	0.742 0.893 0.606 0.770	F	4.83	0.005 *

* The relationship or difference is statistically significant at P value < 0.05

4.6.2. Housing factors:

As illustrated in table (4.23); all housing factors were found not statistically significant with the parasitic infection. It's worth to mention that the parasitic infection between farmers who had landless areas inside their homes (covered by soil) (33.3%) were higher than the PI infection of farmers who had not landless areas and all their homes area are covered by court (30%). Also the parasitic infection between farmers who had areas covered by (concrete, grass, or concrete & soil) around their homes (40%) were higher than the PI between farmers who had only sandy areas around their homes (30%). Studies found the soil contact is a mode of geo-helminths transmission (Amenu, 2014), and there is a statistically significant relationship ($p < 0.05$) between PI and population who live in cardboard-tin, wooden house, or dirt floor (Basualdo et al., 2007).

Table 4.23: Relationship between Housing factors and parasitic infection

#	Variable		Parasitic Infection (1st phase)				Pearson Chi-square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Farmer's home type	Concrete Asbestos	17 0	32.7 0	35 3	67.3 100	1.42	**0.233**
	Total		**17**	**30.9**	**38**	**69.1**		
2.	Type of farmer's home land	Court others (court & concrete / court & soil)	12 5	30 33.3	28 10	70 66.7	0.057	**0.812**
	Total		**17**	**30.9**	**38**	**69.1**		
3.	Land type around farmer's home	Soil Others (concrete, grass, or concrete & soil)	15 2	30 40	35 3	70 60	0.213	**0.645**
	Total		**17**	**30.9**	**38**	**69.1**		

* The relationship or difference is statistically significant at P value < 0.05

4.6.3. Agricultural factors:

As illustrated in table (4.24& 4.25); Chi-square test revealed there is no statistically significant relationship between working in agriculture and the parasitic infection (p=0.573), but the parasitic infection was least in participants who work mainly as farmers, may be this because (73.1%) of participants who didn't work mainly in agriculture were within age group ≤18 year (the group that had least HB mean and highest PI), Annex (14) shows the relationship between age groups and other variables. In addition it was found a statistically significant differences between HB and participants job (p=0.047), as the HB for participants who work mainly as farmers was better than the HB for participants who didn't work mainly in agriculture. Our study was non-compatible with study that revealed the *E. histolytica* infection in people who work in agricultural higher than people who work in non-agricultural work (p=0.7) (Duc, et al., 2011), and compatible with another study that showed the occupation has an important influence on hookworm epidemiology, as the hookworm infection has been noted to be more common in families who are involved with agricultural pursuits (Brooker et al., 2004).

The relationship between years of working in agriculture and PI was not statically significant (p=0.087), but we found higher PI percentage between the participants group who had work in agriculture for period of ≤ 10 years, may be this because the HB mean for them was less than the HB mean for other group who had work in agriculture for period of ≥ 11 years, may this attribute to existence (82.6%) from participants who work in agriculture for period of ≤10 years were within the age group ≤18 year (the group that had least HB mean and highest PI), see Annex (14).

It was found there is no statically significant relationship between daily working hours in the farm with PI and HB (P value= 0.266, 0.768 respectively). The HB mean for participants who work in their farm ≤ 6 hours per day was less than the other group who work ≥ 7 hours per day, this may effect on their parasitic infection as we found higher PI percentage between the participants group who had least HB mean; may be this was also for the same previous reason, as (52.9%) from participants who work in their farm ≤ 6 hours per day were within the age group ≤18 year (the group that had least HB mean and highest PI), see Annex (14).

The parasitic infection between participants who work/had farm far away from their homes was the highest, but the relationship was not statically significant (p=0.904), in the same time the relationship between HB and farm address was not statically significant (p=0.424). The HB mean for farmers participants who had the farms inside their homes was the best; may be this because they had good access for water and home toilet.

The relationship between using fertilizers and PI was not statistically significant (p=0.391). Our result was compatible with study that showed handling animal excreta in the field had a significantly lower risk for an *E. histolytica* infection than those who have no contact with animal excreta. But it's worth to mention that several points are important with regard to this result since the animals do not harbour *E. histolytica* infections and it is rarely found in domestic animals, including dog and cat (Duc, et al., 2011).

Table 4.24: Relationship between agricultural factors and parasitic infection

#	Variable		Parasitic infection (1st phase)				Pearson Chi-square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Is farming your main job	Yes	8	27.6	21	72.4	0.317	**0.573**
		No	9	34.6	17	65.4		
2.	Years of working in agriculture	≤10 years	10	43.5	13	56.5	2.92	**0.087**
		≥ 11 years	7	21.9	25	78.1		
3.	Farm address	Home exists inside farm	4	30.8	9	69.2	0.201	**0.904**
		Farm beside/close from farmer home	4	26.7	11	73.3		
		Farm is far away from farmer home	9	33.3	18	66.7		
4.	Area of the agricultural lands	≤ 3 dunums	9	36	16	64	0.556	**0.456**
		≥ 4 dunums	8	26.7	22	73.3		
4.	Using fertilizers	Yes	15	29.4	36	70.6	0.736	**0.391**
		Sometimes	2	50	2	50		
5.	Daily spent time in the farm	≤ 6 hours	11	32.4	23	67.6	0.087	**0.768**
		≥ 7 hours	6	28.6	15	71.4		

* The relationship or difference is statistically significant at P value < 0.05

Table 4.25: Relationship between agricultural factors and hygiene behavior

#	Variables		N	Mean	SD	Factor	Value	P value
1.	**Hygiene behavior**	Is farming your main job						
		Yes	29	1.74	0.864			
		No	26	1.33	0.595	t	2.03	0.047*
2.		Years of working in agriculture						
		≤10 years	23	1.27	0.51			
		≥ 11 years	32	1.75	0.866	t	-2.56	0.013*
3.		Farm address						
		Home exists inside farm	13	1.73	0.753			
		Farm beside/close from farmer home	15	1.35	0.596	F	0.872	0.424
		Farm is far away from farmer home	27	1.57	0.859			
4.		Daily spent time in the farm						
		≤ 6 hours	34	1.44	0.623			
		≥ 7 hours	21	1.71	0.956	t	-1.13	0.266

* The relationship or difference is statistically significant at P value < 0.05

4.6.3.1. Using TWW in agriculture:

Parasitic infection between new MWUs (who use the TWW for period of 2 – 5 years) was higher than old MWUs (who use the TWW for ≥ 6 years) but the relationship was not statistically significant, may be this because the new MWUs are not aware or experienced in dealing with TWW as the old MWUs. Chi-square test revealed that (56.5%) of MWUs (who use the TWW for period of (2 – 5 years) were within age group ≤18 year (the group had PI and the least HB mean) and t-test revealed they have HB mean less than the HB mean for the other group. See Annex (14).

In the same time the PI between MWUs who used the TWW for irrigation ≥ 4 dunums agricultural lands was higher than the PI between MWUs who used the TWW for irrigation ≤ 3 dunums, but the relationship was not a statically significant; may be this attributed to the high exposure for contaminated agricultural soils. Number of MWUs' who use fertilizers with TWW was 23 out of 36, the relationship between using fertilizers in combination of irrigation with TWW was not statistically significant with PI, but it's worth to mention that least PI was found between famers who didn't use fertilizers through using TWW in irrigation.

Table 4.26: Relationship between period of using TWW in agriculture factors and parasitic infection

#	Variable		Parasitic infection between MWUs only				Pearson Chi-square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Years of using TWW in agriculture	2 – 5 years	8	34.8	15	65.2	1.55	**0.212**
		≥ 6 years	2	15.4	11	84.6		
	Total		**10**	**27.8**	**26**	**72.2**		
2.	Area of the agricultural lands that irrigated by TWW	≤ 3 dunums	4	26.7	11	73.3	0.556	**0.456**
		≥ 4 dunums	6	28.6	15	71.4	0.016	**0.900**
	Total		**10**	**27.8**	**26**	**72.2**		
3.	Using fertilizers through irrigation by TWW	Yes	3	33.3	6	66.7	0.286	**0.867**
		No	3	23.1	10	76.9		
		Sometimes, at need	4	28.6	10	71.4		
	Total		**10**	**27.8**	**26**	**72.2**		

* The relationship or difference is statistically significant at P value < 0.05

4.6.4.Water status:

All participants were found using one source of drinking water which was desalinated water plants. Water studies in Gaza revealed that more than 90% of the population of the Gaza strip depend on desalinated water for drinking purposes (Al-Agha & Mortaja, 2005). It's worth to mention that in 2016 an assessment of parasitological water quality from house kitchens and desalination plants filters in Gaza Strip found that a total of 8 (1.9%) out of 420 samples of various drinking water sources in were contaminated by *Cryptosporidium* oocysts (Ghuneim & Al-Hindi, 2016).

Regarding non-drinking water sources, as shown in table (4.27) there is no statistically significant relationship between the non- drinking water sources and PI. Other researchers revealed there was a direct relation between the prevalence of some parasitic diseases and the presence of those etiologic agents in water (Yousefi et al., 2010). In Gaza strip researches found the total and fecal coliform contamination exceeded the World Health Organization's limit for drinking water purposes. However, the contamination percentages were higher in domestic water networks than in GW wells. In the same time the diarrheal diseases were strongly correlated with fecal coliform contamination in water networks ($r = 0.98$). Such diseases were more prevalent among subjects who drank municipal water than subjects who drank desalinated or home-filtered water (odds ratio = 2.03) (Amr & Yassin, 2008).

The non-drinking water consumption (Liter/person. day) calculated based on participants family size and the total non-drinking water consumption per day for each participants' families. Pearson correlation revealed there is no statistically significant relationship between HB and non-drinking water consumption (Liter/person. day). However, the direction of the relationship was positive meaning that these variables tend to increase together, but the magnitude, or strength, of the association is approximately none or very weak.

The mean of non-drinking water consumption (Liter/person. day) for parasitic infected participants was less than the mean of non-drinking water consumption (Liter/person. day) for non-parasitic infected. Our study was compatible with the study was carried in Ethiopia that revealed the prevalence of diarrhoea among under- 2-year-olds from families with higher water usage rates per person was less than that among comparable children from families with lower rates (Freij & Wall, 1977), and with another study in Lesotho that revealed the use of smaller amounts of water was associated with higher rates of infection with *Giardia lamblia* (Esrey et al., 1989).

Table 4.27: Relationship between water status and parasitic infection

<table>
<tr><td colspan="10">1. Relationship between non- drinking water source and parasitic infection</td></tr>
<tr><th rowspan="3">#</th><th rowspan="3" colspan="2">Variable</th><th colspan="4">Parasitic infection (1st phase)</th><th rowspan="3">Person chi square</th><th rowspan="3" colspan="2">P value</th></tr>
<tr><th colspan="2">Positive</th><th colspan="2">Negative</th></tr>
<tr><th>Freq.</th><th>Row %</th><th>Freq.</th><th>Row %</th></tr>
<tr><td rowspan="3">1.</td><td rowspan="3">non-drinking water source</td><td>Municipality water</td><td>9</td><td>30</td><td>21</td><td>70</td><td rowspan="4">0.525</td><td rowspan="4" colspan="2">0.769</td></tr>
<tr><td>Agricultural water well</td><td>4</td><td>26.7</td><td>11</td><td>73.3</td></tr>
<tr><td>more than one source</td><td>4</td><td>40</td><td>6</td><td>60</td></tr>
<tr><td colspan="3">Total</td><td>17</td><td>30.9</td><td>38</td><td>69.1</td></tr>
<tr><td colspan="10">2. Effect of non-drinking water consumption (Liter/person. day) on farmers hygiene behavior</td></tr>
<tr><th colspan="3">Variable</th><th colspan="2">Mean</th><th>SD</th><th>Factor</th><th>Value</th><th colspan="2">P value</th></tr>
<tr><td colspan="3">Farmers behavior</td><td colspan="2">1.55</td><td>0.77</td><td rowspan="2">Pearson Correlation</td><td rowspan="2">0.072</td><td rowspan="2" colspan="2">0.602</td></tr>
<tr><td colspan="3">Water consumption (Liter/person.day)</td><td colspan="2">135.3</td><td>72.9</td></tr>
<tr><td colspan="10">3. Effect of non-drinking water consumption (Liter/person. day) on farmers parasitic infection</td></tr>
<tr><th colspan="2">Variable</th><th>Category</th><th>N</th><th>Mean</th><th>SD</th><th>Factor</th><th>Value</th><th colspan="2">P value</th></tr>
<tr><td colspan="2">Water consumption (Liter/person.day)</td><td>Parasitic infection
Positive
Negative</td><td>
17
38</td><td>
119.7
142.3</td><td>
33.5
84.3</td><td>t</td><td>-1.42</td><td colspan="2">0.160</td></tr>
</table>

* The relationship or difference is statistically significant at P value < 0.05

4.6.5. Sanitation status:

The relationship between home toilet sanitation disposal method and PI was not statistically significant (P=0.197); however, the highest PI was between participants who disposed their homes' toilet sanitation by discharging it for their farms; Chi-square test revealed that there is a statically significant relationship between farm address and sanitation disposal method, as all of participants who disposed their homes' toilet sanitation by discharging it for farms had the farm inside their home; and this may be increased their exposure for sanitation and then increased their PI. Some mortality studies reported that the method of disposing of excreta determined the magnitude of the health impact (Anker & Knowles, 1980; Haines & Avery, 1982; Waxler et al., 1985). A longitudinal cohort study in Salvador, Brazil, found that an increase in sewerage coverage from 26% to 80% resulted in a 22% reduction of diarrhoea prevalence in children under 3 years of age (Mara et al., 2010). Other studies revealed that the absence of correct body waste material disposal and the lack of drinking water or its inadequate supply are risk factors associated to the presence of intestinal parasites (Basualdo, et al., 2007). In addition to it was found that the *E. histolytica* infection in people who have dry latrine (single or double vault) was higher than water latrine (septic tank, biogas) (Duc, et al., 2011).

The relationship between existence a toilet in the farm and PI was not statistically signification (P=0.634); however, the highest PI was between farmers who didn't have toilet in their farms; this was compatible with studies showed that having access to a sanitation facility reduces the odds of being infected with soil-transmitted helminths regardless of the species (Ziegelbauer et al., 2012).

The relationship between sharing farm toilet and PI was not statistically significant, this result was non- compatible with another study that revealed the sharing or using public latrine statistically associated with intestinal parasitic infection (Tulu, et al., 2014).

The relationship between disposal methods of farm's toilet sanitation and PI was not statistically significant with high PI between participants who use cesspits, chi-square revealed that all of them work in farms far away from their homes and this effect on their access to water and hygiene facilities.

Table 4.28: Relationship between sanitation status and parasitic infection

#	Variable		Parasitic infection (1st phase)				Person chi square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Home's toilet sanitation disposal place	Pumped to the Farm	3	60	2	40	3.25	**0.197**
		Pumped to septic tank	1	12.5	7	87.5		
		Pumped to WW network	13	31	29	69		
	Total		**17**	**30.9**	**38**	**69.1**		
2.	Do you have toilet in the farm	Yes	6	27.3	16	72.7	0.227	**0.634**
		No	11	33.3	22	66.7		
Total			**17**	**30.9**	**38**	**69.1**		
3.	Do other farmers share with you the farm's toilet	Yes	4	22.2	14	77.8		
		No	2	50	2	50	1.273	**0.259**
	Total		**17**	**30.9**	**38**	**69.1**		
4.	Farm's toilet sanitation disposal place	Pumped to the farm	0	0	6	100		
		Pumped to septic tank	6	37.5	10	62.5	3.09	**0.079**
	Total		**6**	**27.3**	**16**	**72.7**		

#	Variable		Farm address						Person chi square	P value
			Home exists inside farm		Farm beside/close from farmer home		Farm is far away from farmer home			
			Freq.	Row %	Freq.	%	Freq.	Row %		
1.	Home's toilet sanitation disposal place	Pumped to the Farm	5	100	0	0	0	0	20.247	0.010*
		Pumped to septic tank	3	37.5	2	25	3	37.5		
		Pumped to WW network	5	11.9	13	31	24	57.1		
	Total									

#	Variable		Home exists inside farm		Farm is far away from farmer home		Person chi square	P value
2.			Freq.	Row %	Freq.	Row %		
	Farm's toilet sanitation disposal place	Pumped to the Farm	3	50	3	50	9.263	0.002*
		Pumped to septic tank	0	0	16	100		
	Total		**3**	**13.6**	**19**	**86.7**		

* The relationship or difference is statistically significant at P value < 0.05

4.6.6. Breeding birds and/or animals:

The relationship between breeding animals/birds, place of breeding, and place situation (closed or non-closed) were not statistically significant with PI. However, the highest PI was between participants who breed animals/bird in non-closed place inside or beside their farm. Studies revealed that the close contact with domestic animals in household increase the *E. histolytica* infection (p=0.003) (Duc, et al., 2011).

Table 4.29: Relation between breeding birds and/or animals and parasitic infection

#	Variable		Parasitic infection (1st phase)				Person chi square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Breeding birds and/or animals	Yes	16	32.7	33	67.3	0.64	0.424
		No	1	16.7	5	83.3		
2.	Place of breeding birds and animals	inside/beside home	13	30.2	30	69.8	0.639	0.333
		inside / beside farm	3	50	3	50		
3.	The breeding birds and animals exist in closed place	Yes	7	29.2	17	70.8	1.47	0.479
		No	7	43.8	9	56.3		
		Sometimes	2	22.2	7	77.8		

* The relationship or difference is statistically significant at P value < 0.05

4.6.7. Hygiene behavior

4.6.7.1 Effect of farmers' hygiene behavior inside home on parasitic infection

There was a statically significant relationship between soap consumption in participants' homes and PI (p=0.041), the PI between participants' families who consumed 4-7 soap peace per week was higher than participants' families who consumed ≤ 3 soap peace per week; chi-square revealed that 86.6% of participants' families who consumed 4-7 soap peace.week were large families (≥ 8 members) and as we mentioned before the PI between them was higher than the PI between the small families (≤ 7 members). Mean of soap consumption per participant per week determined based on family size for each participant and family soap consumption per week; it was found that the average soap consumption is 0.38 peace per week. According to sphere standard, a minimum standards for humanitarian response, at least 250g (2-3 peace) of soap should be available for personal hygiene per person per month, based on that all participants soap consumption were under the standard consumption in emergency (Sphere Project, 2011).

The relationship between cooking place and wearing shoes when participants move around their homes were not statically significant with PI, this was not compatible with study that revealed the not wearing a protective shoes ($p < 0.001$) was significantly associated with PI (Tulu, et al., 2014).

Table 4.30: Effect of farmers hygiene behavior inside home on parasitic infection

#	Variable		Parasitic infection (1st phase)				Person Chi square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Soap consumption in home	≤ 3 peace/family. week	10	23.8	32	76.2	4.19	0.041*
		4-7 peace/family. week	7	53.8	6	46.2		
2.	Cooking place	In the home kitchen	13	37.1	22	62.9	2.41	0.229
		Outside the home	0	0	3	100		
		In the home kitchen and outside the home	4	23.5	13	76.5		
3.	Wearing shoes when going out around home	Always	10	28.6	25	71.4	6.76	0.08
		Almost	2	25	6	75		
		Rarely	4	80	1	20		
		Never	1	14.3	6	85.7		
#	**Variable**		**Family size**				**Person Chi square**	**P value**
			≤ 7 members		≥ 8 members			
			Freq.	**Row %**	**Freq.**	**Row %**		
1.	Soap consumption in home	≤ 3 peace/family. week	22	52.4	20	47.6	5.52	0.019*
		4-7 peace/family. week	2	15.4	11	84.6		

* The relationship or difference is statistically significant at P value < 0.05

4.6.7.1.1 Comparison hygiene behavior inside home between farmer groups:

HB inside home for MWUs was better than the HB for GWUs. It was found a statistically significant difference between GWUs hygiene behavior inside home and MWUs in (1 out of 3) for MWUs benefit.

Table 4.31: Comparison hygiene behavior inside home between MWUs & GWUs

#	Variable		Parasitic infection (1st phase)				Person Chi square	P value
			MWUs		GWUs			
			Freq.	Row %	Freq.	Row %		
1.	Soap consumption in home	≤ 3 peace/family. week	25	59.5	17	40.5		
		4-7 peace/family. week	11	**84.6**	2	15.4		
	Total		**36**	**65.5**	**19**	**34.5**	2.76	0.096
2.	Cooking place	In the home kitchen	26	**74.3**	9	25.7	7.22	0.027*
		Outside the home	3	100	0	0		
		In the home kitchen and outside the home	7	41.2	10	58.8		
	Total		**36**	**65.5**	**19**	**34.5**		
3.	Wearing shoes when going out around home	Always	21	**60**	14	40	2.86	0.413
		Almost	7	**87.5**	1	12.5		
		Rarely	4	80	1	20		
		Never	4	57.1	3	42.9		
	Total		**36**	**65.5**	**19**	**34.5**		

* The relationship or difference is statistically significant at P value < 0.05

4.6.7.2. Effect of farmers' hygiene behavior through harvesting on parasitic infection

Chi-square test revealed there was no statically significant relationship between participant's hygiene behavior through harvesting and parasitic infection.

4.6.7.2.1. Comparison of farmers' hygiene behavior '' through harvesting ''

Chi-square test revealed there is statically significant relationship between MWUs and GWUs in dealing with fruits that fall on the soil if they want to eat it, as (30.6%) of MWUs wash it before eating it directly while (5.3%) of GWUs wash it. Regarding MWUs HB through harvesting when they use TWW; Chi-square test revealed there is statically significant difference between MWUs behavior according to irrigation water type.

Table 4.32: Comparison hygiene behavior through harvesting between the two farmer groups when they use GW

#	Variable	HB through harvesting if participants want to eat fruits that fall on the soil						Person -chi square	P value
		a		b		c			
		Freq.	Row %	Freq.	Row %	Freq.	Row %		
1.	MWUs	8	22.2	17	47.2	11	30.6	7.418	0.025*
	GWUs	2	10.5	16	84.2	1	5.3		
		a		b		**c**		**Person chi square**	**P value**
	(MWUs, GWIP)	(MWUs, TWWIP)							
		Freq.	**Row %**	**Freq.**	**Row %**	**Freq.**	**Row %**		
2.	Eat them	3	24.9	4	57.1	0	0	10.7	0.029*
	Clean them by using my hands or my clothes	2	10.5	10	52.6	7	36.8		
	Wash hem very well	1	20	0	0	4	80		
#	**Variable**	**HB through harvesting if participants want to sell fruits that will fall on the soil**						**Person chi square**	**P value**
		d		e		f			
		Freq.	**Row %**	**Freq.**	**Row %**	**Freq.**	**Row %**		
3.	MWUs	1	3	1	3	31	93.9	3.452	0.178
	GWUs	3	16.7	0	0	15	83.3		
		d		e		f		**Person chi square**	**P value**
	(MWUs, GWIP)	(MWUs, TWWIP)							
		Freq.	**Row %**	**Freq.**	**Row %**	**Freq.**	**Row %**		
4.	collect them	1	100	0	0	0	0	56	0.001*
	Wash hem very well	0	0	1	100	0	0		
	Get rid them	0	0	0	0	26	100		

* The relationship or difference is statistically significant at P value < 0.05

a: Eat them, b: Clean them by using my hands or my clothes, c:Wash hem very well

d: collect them, e: Wash hem very well, f: Get rid them

4.6.7.3. Effect of farmers hygiene behavior inside farm on parasitic infection:

Generally we can say the hygiene behavior mean for participants who were parasitic infected were less than the hygiene behavior mean for participants who were not parasitic infected based on t-test results in the table (4.33).

Table 4.33: Effect of farmers hygiene behavior inside farm on parasitic infection:

Variable	Category	N	Mean	SD	Factor	Value	P value
Hygiene behavior between GWUs	**Parasitic infection** between GWUs (1st)						
	Positive	7	1.78	1.14			
	Negative	12	1.54	0.864	t	0.487	0.637
	Parasitic infection between GWUs (2nd)						
	Positive	8	1.43	0.495			
	Negative	11	1.77	1.19	t	-0.839	0.415
Hygiene behavior between MWUs	**Parasitic infection** between MWUs (1st)						
	Positive	10	1.2	0.421			
	Negative	26	1.62	0.707	t	-2.2	0.036*
	Parasitic infection between MWUs (2nd)						
	Positive	18	1.37	0.494			
	Negative	18	1.63	0.971	t	-1.2	0.239

* The relationship or difference is statistically significant at P value < 0.05

4.6.7.3.1. Comparison hygiene behavior inside farm between farmer groups

Generally the HB inside farm mean for GWUs was higher than the HB inside farm mean for MWUs. It was found a statistically significant difference between GWUs hygiene behavior inside farm and MWUs in (4 out of 12) for GWUs benefit and in (1 out of 12) for MWUs benefit.

Table 4.34: Comparison hygiene behavior inside farm between MWUs & GWUs

#	Variable		Always		Almost		Really		Never		Person Chi square	P value
			F.	Row %	F.	Row %	F.	Row %	F.	Row %		
1.	Existence soap in the farm	MWUs			5	13.9	9	25	22	61.1	16.8	0.001*
		GWUs			13	**68.4**	2	10.5	4	21.1		
2.	Frequency of using farm faucet	MWUs	3	10.3	15	51.7	9	31	2	6.9	26.2	0.001*
		GWUs	16	**84.2**	2	10.5	1	5.3	0	0		
3.	Washing hands by using multiple used water	MWUs			2	5.6			34	94.4	1.09	0.424
		GWUs			0	0			19	**100**		
4.	Washing crops before eating them	MWUs	7	19.4	13	36.1	4	11.1	12	33.3	9.5	0.022*
		GWUs	10	**52.6**	1	5.3	1	5.3	7	36.8		
5.	Washing hands after operating irrigation pump	MWUs	4	**16.7**	3	12.5	0	0	17	70.8	4.17	0.243
		GWUs	2	10.5	0	0	1	5.3	16	84.2		
6.	Washing hands after maintaining any faults in farm	MWUs	7	**29.2**	1	4.2	4	16.7	12	50	1.95	0.582
		GWUs	5	26.3	2	10.5	1	5.3	11	57.9		
7.	Washing hands after touch soil	MWUs	29	80.6			4	11.1	3	8.3	0.554	0.758
		GWUs	16	**84.2**			1	5.3	2	10.5		
8.	Touching irrigation water	MWUs	4	11.1	18	50	5	13.9	9	25	16.7	0.001*
		GWUs	0	0	1	5.3	4	21.1	14	**73.7**		
9.	Washing hands after touching the irrigation water	MWUs	32	88.9	1	2.8			3	8.3	2.27	0.320
		GWUs	19	**100**	0	0			0	0		
10.	Wearing special footwear in the field	MWUs	21	**58.3**	7	19.4	4	11.1	4	11.1	2.82	0.419
		GWUs	7	36.8	7	36.8	2	10.5	3	15.8		
11.	Wearing gloves when you work in the field	MWUs	28	**77.8**	7	19.4			1	2.8	0.626	0.731
		GWUs	13	68.4	5	26.3			1	5.3		
12.	Wearing special clothes when you work in the field	MWUs	23	**63.9**	6	16.7			7	19.4	13.8	0.001*
		GWUs	6	31.6	0	0			13	68.4		

* The relationship or difference is statistically significant at P value < 0.05

Regarding MWUs hygiene behavior inside farm through irrigation by TWW; Paired samples t test revealed there is a statistically significant relationship between HB inside farm for MWUs and irrigation water type, as the mean for HB through irrigation by TWW was higher than the HB mean through irrigation by GW as its found in table (4.35).

Table 4.35: Comparison MWUs hygiene behavior inside farm through irrigation by GW and TWW

Variable	Category	N	Mean	SD	Factor	Value	P value
HB between MWUs	HB between MWUs through (TWWIP)	36	1.70	0.92	t	2.7	0.01*
	HB between MWUs through (GWIP)	36	1.41	0.66			

* The relationship or difference is statistically significant at P value < 0.05

In developing countries the intestinal parasitism was an indicator of substandard sanitation, poor personal hygiene, lack of a convenient, safe water source, overcrowding, and poverty (Glickman et al., 1999). A study in Nigeria revealed the prevalence of infection was significantly higher in children who did not wash fruits before eating when compared to those who did regularly wash (p=0.001), also the infection rate was significantly higher in children who washed fruits irregularly when compared to those who did regularly (p=0.010). In addition to the prevalence of infection was significantly higher in children who did not use foot wear when compared to those who always did (p=0.001) and to those who did occasionally (p=0.001). In addition to, the proportion with hookworm was higher among children who did not use foot wears after school hours compared to consistent foot wear users. Not wearing of foot wears after school was significantly associated with risk of acquisition of intestinal helminthes (p=0.001) (Ilechukwu et al., 2010). A cross-sectional study about associated risk factors of intestinal parasitic infections among primary school revealed that students who had no frequent contact with water during swimming and irrigation activities were found to be protected from intestinal parasitic infections compared to those who were unable to do so (p=0.007) (Tulu, et al., 2014). Using personal protective conditions during field work such as gloves and boots reduced the risk (OR = 0.5, 95% CI: 0.3-1.1) and omitting to bath and shower after field work increased the risk (OR = 2.3, 95% CI: 1.0-5.6) for an infection with *E. histolytica*. However, these associations were not statistically significant. Omitting to wash hands was a significant risk as the people who rarely washed their hands with soap after field work had a large risk increase of an *E. histolytica* infection (OR = 3.0, 95% CI: 1.2-7.4) compared to those who frequently wash their hand with soap after work (Duc, et al., 2011).

4.6.8. Health status:

4.6.8.1. Relationship between farmers' knowledge and other factors:

ANOVA test revealed that the participants who had higher HB mean were more educated or aware about risk of using TWW in agriculture, but the relationship between awareness and HB and PI was not statistically significant as per table (4.36). Another study revealed the prevalence of intestinal parasitic infection was high in communities of some areas however, the knowledge of these communities about intestinal helminths and protozoa is low (Nyantekyi et al., 2014).

Table 4.36: Relationship between farmers' knowledge and other factors

1.	**Relationship between farmers' knowledge by TWW risks and hygiene behavior**							
#	**Variables**		**N**	**Mean**	**SD**	**Factor**	**Value**	**P value**
1.1	**Hygiene behavior**	Using TWW in agriculture increased your diseases infection						
		Yes	19	1.88	0.944			
		No	11	1.29	0.6			
		I do not know	21	1.33	0.639	F	2.46	0.073
		Yes, with conditions*	4	1.81	0.239			

2.	**Difference between farmers' knowledge by TWW risks and farmer group**											
#	Variable		Yes		No		I don't know		Yes, with conditions*		**Person chi-square**	**P value**
			F.	Row %	F.	Row %	F.	Row %	F.	Row %		
2.1	Farmers' group	MWUs	7	19.4	7	19.4	18	50	4	11.1	12.58	0.005*
		GWUs	12	63.2	4	21.2	3	15.8	0	0		
	Total		19	34.5	11	20	21	38.2	4	7.3		
3.	**Relationship between farmers' knowledge by TWW risks and parasitic infection**											
	knowledge	Positive (1st)	6	35.3	2	11.8	7	41.2	2	11.8	1.57	0.664
		Negative	13	34.2	9	23.7	14	36.8	2	5.3		
	Total		19	34.5	11	20	21	38.2	4	7.3		
	knowledge	Positive (2nd)	11	42.3	5	19.2	8	30.8	2	7.7	1.59	0.660
		Negative	8	27.6	6	20.7	13	44.8	2	6.9		
	Total		19	34.5	11	20	21	38.2	4	7.3		

4.6.8.2. Relationship between participants those previously had diagnosed and taken helminthic medicine with parasitic infection:

As illustrated in table (4.37), Chi-square test reveled there is no statistically significant relationship between those previously had diagnosed for helminthic and PI, but the percentage of participants who were not parasitic infected and in the same time who had previously diagnosed for helminthic (76%).

Chi-square test revealed there is a statistically significant relationship between those had taken helminthic medicine and the parasitic infection, as we found (83.3%) of participants who had previously medicine were not infected. Study on four villages inhabitants in Indonesia revealed there is no significant difference in *Ascaris* and *Trichuris* infection were observed between those having received helminthic medicines and those without (Toma, et al., 1999).

Table 4.37: Relationship between participants those previously had diagnosed and had taken helminthic medicine and parasitic infection:

#	Variable		Parasitic infection				Person Chi square	P value
			Positive		Negative			
			Freq.	Row %	Freq.	Row %		
1.	Previously diagnosed for intestinal parasites	Yes	6	24	19	76	1.02	0.311
		No	11	36.7	19	63.3		
2.	Previously had ant-parasitic drugs	Yes	3	16.7	15	83.3	6.9	0.032*
		No	1	20	4	80		
		Sometimes	2	100	0	0		

* The relationship or difference is statistically significant at P value < 0.05

4.6.8.3. Relationship between farmers' self-reported symptoms and parasitic infection and hygiene behavior:

Chi-square test revealed there is no statistically significant relationship between farmers' self-reported symptoms and their infection. As the experimental analysis for stool samples revealed that all detected parasites were cysts, in addition to there are some parasites have no symptoms in some cases; for example, most people who infected with *A. lumbricoides* have no symptoms (CDC, 2017b).

Regarding the relationship between self-reported symptoms and hygiene behavior; Pearson correlation test revealed that there was a statistically significant linear relationship between hygiene behavior and self-reported symptoms; the direction of the relationship is negative meaning that if one variable increase the other variable will decrease (if the participant have high self-reported symptoms score (participant didn't feel much in his/her parasitic infection), his/her hygiene behavior will be less; the magnitude or strength of the association is approximately moderate ($0.3 < | r | < 0.5$). In developing countries, the presence, incidence, and prevalence of intestinal parasitic infections in different regions are indicators of the health status of the population (Gamboa et al., 2003).

Table 4.38: Association between farmers' self-reported symptoms and hygiene behavior

Variable	Mean	SD	Factor	Value	P value
Farmers Hygiene behavior	1.55	0.77	Pearson Correlation	-0.45	0.001*
Parasitic infection symptoms	2.8	0.557			

* The relationship or difference is statistically significant at P value < 0.05

Chapter V

Conclusions and Recommendations

This chapter provides the main conclusions of this study as well as recommendations for decision makers that help to decrease parasitic infection between farmers, protect them, and improve their health status.

5.1 Conclusions

1. PI between MWUs were higher than the PI between GWUs after using TWW for three months.
2. Positive association not statically significant was found between using TWW in irrigation and PI.
3. Six parasites species were identified at farmers in this study at the two phases *Entamoeba histolytica/dispar and coli, Cryptosporidium*, *Microsporidium, Giardia lamblia*, *Strongyloides stercoralis, and Ascaris lumbricoides*.
4. *Cryptosporidium* was the predominant recognized genus followed by *Entamoeba histolytica/dispar*, *Microsporidium*, *and Giardia lamblia in the first phase.*
5. *Entamoeba histolytica/dispar* was the predominant recognized genus followed by *Cryptosporidium*, *Microsporidium*, *and Giardia lamblia* in the second phase.
6. Positive not statically significant association was found between prevalence of *Entamoeba histolytica/dispar and Giardia lamblia* and using TWW in irrigation in the 2^{nd} phase.
7. A statistically significant difference was found between soil parasitic contamination prevalence in the two phases, as the prevalence of soil parasitic contamination increased after using TWW for three months.
8. Negative association not statically significant was found between soil parasitic contamination and irrigation water source.
9. Prevalence of parasitic contamination was higher at GWUs soils.
10. A statically significant relationship was found between soil contamination and PI at participants in the 1^{st} phase.
11. High PI was found between participants who had bad financially status, who had landless areas inside their homes, who work in farm far away from their homes, who is

a new user for TWW and irrigate more agricultural dunums by it, who didn't work mainly in agriculture, who use fertilizers with TWW, who had toilet in their farm, who disposed from their home and farm toilet into the farm and cesspits respectively, who breed animals/birds in places non- closed inside or beside their farms, who previously diagnosed for intestinal parasites, and who had less HB mean.

12. MWUs HB was better than GWUs HB inside home and through harvesting process, but it was less through working in farm. HB for MWUs through using TWW periods increased to be the best.
13. It was found a statically significant relationship (SSR) between gender and financial status with HB.
14. Highest HB mean was found between participants who work mainly in agriculture, who had the farm inside their homes, and who more knowledgeable toward TWW risk.
15. The least HB and highest PI was found between females, participants who had the least academic qualification, participants age ≤ 18 year, participants who were working in agriculture for period of ≤ 10 years, and who work ≤ 6 hours per day in the farm.
16. SSR was found between family size and participants who previously had ant-parasitic drugs with PI, as we found participants who had less family size and who previously had ant-parasitic drugs had less PI.
17. A statically significant linear relationship was found between self-reported parasitic symptoms and HB, as we found if participant feel good and the self-reported parasitic symptoms were less, her/his HB will be worse.
18. Non-drinking water consumption per person per day was least at parasitic infected participants.
19. All participants were depend on desalinated water plants as a source for drinking water, non-drinking water consumption per person per day was least at patristic infected participants, but the relationship was not statistically significant.

5.2 Recommendations

Protection of farmers and their families health can best be achieved by interrupts the flow of pathogens from the environment (wastewater, crops, soil etc.) to them.

5.2.1. Study recommendation:

1. Improving levels of hygiene both occupationally and in the home and enhancing farmers commitment in using protective clothes even if they use GW or TWW in irrigation.
2. Farms should be provided with adequate water for drinking and hygiene purposes, in order to avoid the consumption of, and contact with, wastewater as proper hand washing with soap should be emphasized before eating anything especially when farmers are working in the farm.
3. Reduction using animal and birds manure and replacing it by organic compost to reduce the parasitic infection.
4. Performing regular screening programs for farming communities in parallel with chemotherapy programmes to be reapplied at regular intervals to be effective as many as 2–3 times.
5. A rigorous health education programme that targets consumers, farm workers, produce handlers and vendors is needed.
6. An official licensed institution should be assigned to regular monitor tthr TWWR projects and follow up the TWW quality and commitment of farms in using the protective and barriers that put in order to interrupts the flow of pathogens from the environment to them.
7. All above recommendation should be considered as health protection measures to be used in conjunction with partial wastewater treatment.

5.2.2. Further research recommendations:

1. Conducting studies on the parasitic load in wastewater and effluent of post treatment systems as (filtration and SAT).
2. Support and provide the GS laboratory with the required equipment for detection parasites in water samples.
3. Conducting studies on the parasitic load in animals and birds manure.
4. Assessment WWR projects and farmers commitment by the using treated wastewater in agriculture guidelines.

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Annexes

Annex (1): Wastewater networks in the Gaza Strip, source (CMWU, 2016)

Governorate	Covering %
North	80
Gaza	90
Middle area	70
Khanyounis	40
Rafah	72
The overall ratio of wastewater coverage	72

Annex (2): Pathogens levels and diseases associated with untreated wastewater, source (Ottoson, 2005; Toze, 1997)

Pathogen by Taxon	Disease	Concentration in wastewater	Infectious dose
Protozoans			
Cryptosporidium Parvum	Diarrhoea, fever	10^0-10^5	Low*
Giardia intestinalis	Giardiasis		
Entamoeba histolytica	Amoebiasis (amoebic dysentery)		
Helminths			
Ascaris lumbricoides	Ascarisis	10^0-10^5	Low*
Enterobius vericularis	Enterobiasis		
Taenia saginata	Taeniasis		
Trichuris trichiura	Trichuriasis		
Strongyloides stercoralis	Strongyloidasis		

few*: few particles/cells/cysts/eggs required to cause infection. High*: many required to cause infection.

Annex (3): Survival times of selected excreted pathogens in soil, wastewater and on crop surfaces at 20-30oC, source (Faechem 1983)

Type of pathogen	Survival time (in days unless otherwise stated)		
	In soil	**On crops**	**In wastewater**
Protozoa			
Entamoeba histolytica	<20 but usually <10	<10 but usually <2	<30 but usually <15
Helminths			
Ascaris lumbricoidies eggs.	Many months	<60 but usually <30	Many months
Hookworm larvae	<90 but usually <30	<30 but usually <10	
Taenia saginata eggs	Many months	<60 but usually <30	
Trichuris trichiura eggs	Many months	<60 but usually <30	

Annex (4): Wastewater reuse guidelines

Annex (4.1): Revised 1989 WHO guidelines for wastewater reuse in agriculture, source (Blumenthal & Peasey, 2002)

	Reuse condition	Exposed group		Irrigation method	Helminth egg/L
A	Unrestricted: crops eaten uncooked, sports fields, public parks.	Workers, consumers, and public		Any	≤ 0.1
B	Restricted: cereal crops, industrial crops, fodder crops, pasture and trees	B1	Workers > 15 years	Spray / sprinkler	≤ 1
		B2	Workers > 15 years	Flood/furrow	≤ 1
		B3	Workers including children, nearby communities	Any	≤ 0.1
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None		Trickle, drip, or bubbler	Not applicable

Annex (4.2): Recommended guidelines for water reuse in the Mediterranean region

	Helminth (egg/L)[a]	TSS (mg/L)	Recommended treatment
I	≤ 0.1	≤ 10	Secondary + filtration + disinfection
II	≤ 0.1	≤ 20, ≤ 150[c]	Secondary + filtration + disinfection or secondary + storage/ maturation ponds/infiltration
III	≤ 1	≤ 35, ≤ 150[c]	Secondary + few days storage or oxidation pond system
IV	None	As required by irrigation technology	Minimum primary treatment

a: Does not require routine monitoring.
c: when treating with stabilization ponds.

Annex (4.3a): Criteria recommended by PWA for effluent standards in the Gaza Strip

Criteria	Restricted Use	Unrestricted Use
BOD (mg/l)	10-20	10-20
TSS (mg/l)	15-20	15-20
Total-N (mg/l)	10-15	10-15
F. coliforms	< 1000	< 200
Helminthes eggs	< 1	< 1
Intestinal nematoda	< 1 ova/liter	< 0.1 ova/liter

Notes:

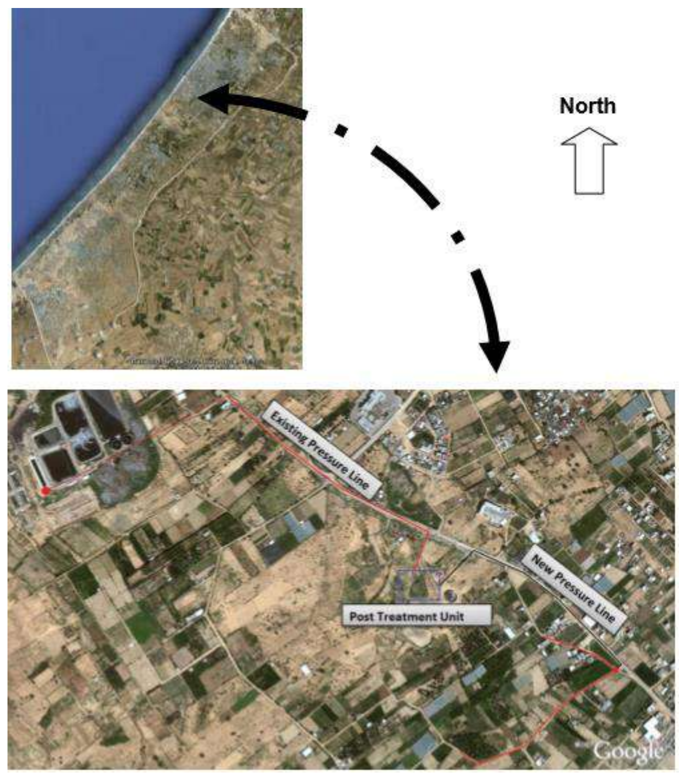
Restricted crops: Cereal crops, industrial crops, fodder crops, crops normally eaten cooked and trees, etc.

Unrestricted crops: Crops normally eaten uncooked (vegetables), Sport fields, parks

Annex (4.3b): Limit Values for Effluent Reuse (PS 742/2003)

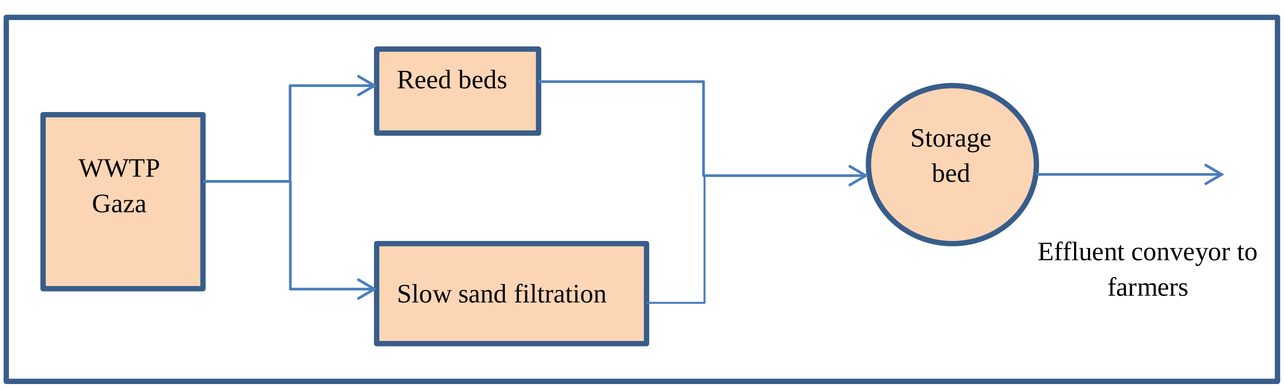
<table>
<tr><th>Parameter (mg/l)</th><th>Discharge to sea (500 m)</th><th>Recharge</th><th>Dry fodder</th><th>Fresh fodder</th><th>Parks and gardens</th><th>Industrial and cereal crops</th><th>Trees and forests</th><th>Fruit trees</th></tr>
<tr><td>COD</td><td>200</td><td>150</td><td>200</td><td colspan="2">150</td><td>200</td><td>200</td><td>150</td></tr>
<tr><td>DO</td><td colspan="2">>1</td><td colspan="6">>0.5</td></tr>
<tr><td>TDS</td><td>-</td><td colspan="3">1500</td><td>1200</td><td colspan="3">1500</td></tr>
<tr><td>pH</td><td colspan="8">6-9</td></tr>
<tr><td>FOG</td><td>10</td><td>0</td><td colspan="6">5</td></tr>
<tr><td>Phenol</td><td>1</td><td colspan="7">0.002</td></tr>
<tr><td>MBAS</td><td>25</td><td>5</td><td colspan="6">15</td></tr>
<tr><td>NO_3-N</td><td>25</td><td>15</td><td colspan="6">50</td></tr>
<tr><td>NH_4-N</td><td>5</td><td>10</td><td colspan="2">-</td><td>50</td><td colspan="3">-</td></tr>
<tr><td>Organic N</td><td>10</td><td>10</td><td colspan="6">50</td></tr>
<tr><td>Cl</td><td>-</td><td>600</td><td colspan="2">500</td><td>350</td><td colspan="2">500</td><td>400</td></tr>
<tr><td>SO_4</td><td colspan="2">1000</td><td colspan="6">500</td></tr>
<tr><td>Na</td><td>-</td><td>230</td><td colspan="6">200</td></tr>
<tr><td>Mg</td><td>-</td><td>150</td><td colspan="6">60</td></tr>
<tr><td>Ca</td><td>-</td><td>400</td><td colspan="6">400</td></tr>
<tr><td>SAR</td><td>-</td><td colspan="3">9</td><td>10</td><td colspan="3">9</td></tr>
<tr><td>PO_4-P</td><td>5</td><td>15</td><td colspan="6">30</td></tr>
<tr><td>Al</td><td>5</td><td>1</td><td colspan="6">5</td></tr>
<tr><td>Ar</td><td colspan="2">0.05</td><td colspan="6">0.1</td></tr>
<tr><td>Cu</td><td colspan="8">0.2</td></tr>
<tr><td>Fe</td><td colspan="2">2</td><td colspan="6">5</td></tr>
<tr><td>Mn</td><td colspan="8">0.2</td></tr>
<tr><td>Ni</td><td colspan="8">0.2</td></tr>
<tr><td>Pb</td><td colspan="8">0.1</td></tr>
<tr><td>Se</td><td colspan="8">0.02</td></tr>
<tr><td>Cd</td><td colspan="8">0.01</td></tr>
<tr><td>Zn</td><td colspan="2">5</td><td colspan="6">2</td></tr>
<tr><td>CN</td><td colspan="2">0.1</td><td colspan="6">0.05</td></tr>
<tr><td>Cr</td><td>0.5</td><td>0.05</td><td colspan="6">0.1</td></tr>
<tr><td>Hg</td><td colspan="8">0.001</td></tr>
<tr><td>Co</td><td>1</td><td colspan="7">0.05</td></tr>
<tr><td>B</td><td>2</td><td>1</td><td colspan="6">0.7</td></tr>
<tr><td>Pathogens</td><td>Free</td><td colspan="7"></td></tr>
<tr><td>Protozoa(1) (cyst/l)</td><td colspan="2">Free</td><td colspan="2">-</td><td>Free</td><td colspan="3">-</td></tr>
<tr><td>Nematodes (eggs/l)</td><td colspan="8"><1</td></tr>
</table>

Annex (5): Location of Sheikh-ejleen pilot project area



Figure(2.1): Location of Sheikh-ejleen pilot project area, source (Austrian Development Cooperation and Palestinian National Authority, 2013)

Annex (6): Post wastewater treatment system layout, source



Figure(2.2): Post wastewater treatment system layout, source (Austrian Development Cooperation and Palestinian National Authority, 2013)

Annex (7): Interview questionnaire with consent form

Annex 7a: Interview questionnaire with consent form (English version)

AL-QUDS UNIVERSITY

Consent Form for participation in scientific thesis

My Brother Farmer:

I'm the researcher: Haneen Nabil Al-Sbaihi, I'm studying at Al-Quds University (Abu Dees) in Public Health collage –I'm preparing Research about Parasitic Infection between Farmer dealing with Treated Wastewater in Azaitoun Area – Gaza City (Comparative Study).

As a prerequisite for my Graduation and obtaining on the Master degree in Public Health – Epidemiology.

The research mainly aims to identify the parasitic infection between farmer dealing with Treated Wastewater by comparison it with the infection between farmer dealing with groundwater.

To perform this research, farmers who use the treated wastewater in agriculture in Azaitoun area beside Gaza car shop (west of Salah El-Deen street) and farmers who use the ground water in Johur El-Deek area (east of Salah El-Deen Street) are chosen as sample for this research.

This research require from each farmer to fill one questionnaire (20 min) , and provide stool, hand washing water, soil, and irrigation water (GW/TWW) samples.

Your participation is voluntary, In case of you approved to participate, we prefer to commit in answering the questionnaire and providing the required samples.

You can refused to answer any question in the questionnaire, and I would like to confirm that all information you mentioned will be secret, and will be used for scientific research purposes only without mention your names, since the results will not spread in special form, will spread in general, and there is no anything will related to you.

Research possibly will put the necessary recommendation that will contribute in providing sufficient safely degree for farmers.

This research obtained on Helsinki approval, the approval copy attached in the end of the questionnaire.

Your cooperation are highly appreciated

Researcher: Haneen Al-Sbaihi

Based on the previous I confess: The researcher Haneen Nabil Al-Sbaihi from Al-Quds University, informed me about the research and answered on my questions and enquires completely.

And based on that, I accept to participate in the research , by filling the questionnaire and providing the required samples through the previous coordination, in addition to I know I'm free and I have the right to withdrw in anytime, without clarify the reasons and without my withdrawal effect on my right to benefit from the research results; even if this withdraw happened after this written approval, but it's better to commit in order to contribute in performing the research successfully and obtaining on recommendation contribute in providing sufficient safely degree for me and other farmers.

Farmer Name: Signature: Date: / /

Date: ……………………….

Time:……………………….

Questionnaire No..……………….

1. General Information about Farmer

1.1	Farmer's name: ……………………….	Phone number:……………………
1.2	Farmer's address	……………………………………….
1.3	Gender	☐ Male ☐ Female
1.4	Age (Years)	....
1.5	Academic qualification	☐Primary or less ☐Preparatory - General secondary ☐Bachelors/Diploma ☐High studies
1.6	Family size	....
1.7	Is farming your main job	☐Yes ☐ No
	1.7.1 If No, What's your main job: …………………………………………….	
1.8	Years of working in agriculture	....
1.9	Do any one assist/ share you working in agriculture	☐Yes ☐ No
1.9.1	If yes, Who are those people	☐Father ☐Mother ☐Wife ☐Sons ☐Brothers/Sisters ☐Others(Identify)…….
1.10	How do you describe your financial and economic status	☐ Excellent ☐ Very good ☐ Good ☐Bad

2. Farmer's home:

2.1	What's the type of your home	☐ Concrete ☐ Asbestos ☐ Other (Identify) ………………
2.2	What's the distance between your home and the closest home of your neighbors	.... meter
2.3	What's the type of your home land	☐Concrete ☐Court ☐ Soil ☐wood ☐ Other (Identify)
2.4	What's the type of the land around your home	☐Concrete ☐Grass ☐Soil ☐ Other (Identify)

3. Agriculture:

3.1	What's the address of the farm that you work or have	……………………….…………
	☐Home exists inside farm ☐Farm beside/close from farmer home ☐ Farm is far away from farmer home	
3.2	How much time do you spent in the farm	.... hour/day
3.3	What are the area of your agri. land	……………………….. dounm
	Mention the cultivated plants in you farm	☐Trees (specify types)………… ☐Fodders (specify types)………… ☐Vegetables (specify types)………… ☐Other (specify types)…………
3.4	Do you fertilize your farm	☐Yes ☐No
	3.4.1 If the answer is Yes, what's the type of fertilizers that you use	☐ Animal manure ☐ birds manure ☐ chemical fertilizers ☐ Sludge ☐more than one type (specify) …..
3.5	What's the source of the used fertilizers	……………………………..

The following questions are for farmers who use TWW in Agriculture

3.6	How many donums do you irrigate by TWW	…………………………………. dounm		
3.7	How long have you been using TWW in Agriculture	.... year		
	Mention the cultivated plants in you farm	☐Fruits trees (specify types)………… ☐Olive ☐Fodders (specify types)………… ☐Other (specify types)…………		
3.9	Do you eat from Crops irrigated be TWW	☐Yes	☐ No	☐ Sometimes
3.10	Do you fertilize your farm when you use TWW in irrigation	☐ Yes	☐ No	☐ Sometimes , at need
	3.10.1 If the answer is Yes, what's the type of fertilizer that you use	☐ Birds manure ☐ Chemical Fertilizers	☐ Animal manure ☐ More than one type (Identify) …………………….	
	3.10.2 What's the source of the used fertilizers	……………………………..		

4. Water

4.1	What are the sources of drinking water you supply your home with	□Municipality water □Private water plants (Desalination water plant) □Private well □Agricultural well □Rain water
4.2	What are the sources of non- drinking water that supply your home	□Municipality water □Private well □Agricultural well □Rain water
4.3	Do you do anything before drinking water in order to improve its quality	□ Yes □No □Sometimes
4.3.1	If your answer is Yes, mention the methods you use	□Chlorination □Boiling □Chlorination + Boiling □ filtration □ other
4.4	What's the amount of daily consumed water for purposes other than drinking water	.... (Liter/Family)

5. Sanitation

5.1	Where do you get rid of sanitation in your home	□Pumped for farm □Pumped to WW network	□Pumped for septic tanks □Other (identify) ………
5.2	Do you have toilet in the farm	□Yes	□No

If your answer is Yes:

5.2.1	Do other farmers share the toilet with you	□ Yes Number: …………….	□ No
5.2.2	where do you get rid of sanitation in the farm toilet	□Pumped for farm □Pumped to WW network	□Pumped for septic tanks □Other (identify) ………

If your answer is No:

5.2.3	where do you go to Urinating while you are at the farm	□On the edge of the farm □ In home toilet	□Between plants □Other (identify) …..

6. Birds and Animals Breeding

6.1 Do you breed birds and/or animals ☐ Yes ☐No

If the answer is yes,

6.1.1	Where do you breed brides and animals	☐ Inside the home ☐In the farm ☐ outside home garden ☐Other (identify):……….
6.1.2	If your previous answer are inside home or in the farm, Do the birds and animals exist in closed place	☐ Yes ☐ No
6.1.3	Do the birds and animals that you breed eat the agricultural remaining	☐ Yes ☐ No
6.1.4	What are the birds and animals that you breed	☐ Cats ☐ Dogs ☐ Birds ☐Cattle ☐Other (Identify) ……..

7. Farmer health behavior

7.1	What's the quantity of soap consumption in your house per week	………………………………(Peace/week)
7.2	where often do you cook Where is most of the cooking done	☐inside the home ☐outside home but is not in assigned room ☐in home kitchen
7.3	Do you wear shoes when going out	☐Always ☐ Almost ☐ rarely ☐ Never
7.4	Is there a faucet in or around there the house	☐ Yes ☐ No
7.5	How often do use this faucet	☐Always ☐ Almost ☐ rarely ☐ Never
7.6	Is there a soap in your farm?	☐Always ☐ Almost ☐ rarely ☐ Never

The below questions (7.6-7.16) enquired about the irrigation period with using groundwater and then about the irrigation period with using treated wastewater

7.7	When you are in the farm , How often do you wash fruit and vegetables before eating them?	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.8	How often do you wash your hands after you operate the water/ TWW pump to irrigate the farm	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.9	How often do you wash your hands after you maintain any faults in irrigation network	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.10	How often do you wash your hands when they had touch soil	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.11	How often do you had touch with the irrigation water	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.12	When you are in the farm , do you use water for washing hands used multiple times?	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.13	Do you use special footwear when you work in the field	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.14	Do you use special gloves when you work in the field	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.15	Do you use special clothes when you work in the field	☐Always	☐ Almost	☐ rarely	☐ Never
		☐Always	☐ Almost	☐ rarely	☐ Never
7.16	At harvest , how do you deal with the fruits that fall to the soil if you want to eat them	☐eat them directly	☐clean them by my clothes then I eat them	☐wash them very well	☐get rid them
		☐ collect them	☐clean them by my clothes then I eat it	☐wash them very well	☐get rid them

7.17	At harvest for selling purposes , how do you deal with the fruits that fall to the soil	□eat them directly	□clean them by my clothes then I eat them	□wash them very well	□get rid them
		□ collect them	□clean them by my clothes then I eat it	□wash them very well	□get rid them

The following question are for farmers who use TWW in agriculture

7.18	is groundwater used for irrigation two weeks before harvest	□ Yes	□ No

8. Health

8.1	Have you ever been diagnosed with intestinal parasites?	□ Yes		□ No	
8.1.1	If yes, when was the diagnosis made?	□ Within the last month	□ Within the 2 last month	□ Within the 3 last month	□ Other, specify ……….
8.1.2	Do you previously had Anti-parasitic drugs	□ Yes		□ No	
8.1.3	Mention the type of parasites that you had ?				

Some of the questions are for treated wastewater users only:

8.2	In General, How do you evaluate your Health status now	□Excellent	□ Good	□Accepted	□ Bad
8.3	How do you evaluate your health status before using TWW in agriculture	□ Not differ about previous		□Bad than previous	□I can't evaluate that
8.4	How do you evaluate your children health status	□ Not differ about previous	□Bad than previous		□I can't evaluate that
8.5	How do you evaluate your children health status after using TWW in agriculture	□ Not differ about previous	□Bad than previous		□I can't evaluate that
8.6	Do you think using TWW in agriculture increased your diseases infection	□ Yes		□ No	
8.7	If your answer is yes, mention these diseases	………………………………….			

8.8	Did you have abnormal diarrhea	□ Yes	□ Sometimes	□ No
8.9	Did you have abnormal constipation	□ Yes	□ Sometimes	□ No
8.10	Did you have abnormal abdominal pain	□ Yes	□ Sometimes	□ No
8.11	Did you have abnormal stool with blood	□ Yes	□ Sometimes	□ No
8.12	Did you have abnormal vomiting	□ Yes	□ Sometimes	□ No
8.13	Did you have abnormal fever	□ Yes	□ Sometimes	□ No
8.14	Did you have abnormal weakness	□ Yes	□ Sometimes	□ No
8.15	Did you have abnormal headache	□ Yes	□ Sometimes	□ No
8.16	Did you have abnormal loss of appetite	□ Yes	□ Sometimes	□ No

Annex 7.b: Interview questionnaire with consent form (Arabic version)

إقرار موافقة بالمشاركة في بحث علمي "أطروحة علميه"

أخي المزارع, أنا الباحثة: حنين نبيل الصبيحي أدرس في جامعة القدس (أبو ديس) , كلية الصحة العامة, أقوم بإعداد بحث بعنوان:

العدوى الطفيلية بين المزارعين المستخدمين للمياه العادمة المعالجة في منطقة الزيتون – مدينة غزة- , "دراسة مقارنة"

باعتباره متطلب للتخرج والحصول على درجة الماجستير في الصحة العامة – علم الأوبئة

يهدف هذا البحث إلى تحديد العدوى الطفيلية بين المزارعين مستخدمين المياه العادمة المعالجة عن طريق مقارنتها بالعدوى الطفيلية بين المزارعين المستخدمين للمياه الجوفية

لإجراء هذا البحث تم اختيار المزارعين المستخدمين للمياه العادمة المعالجة في منطقة الزيتون – بالقرب من سوق سيارات غزة (غرب شارع صلاح الدين) والمزارعين المستخدمين للمياه الجوفية في منطقة جحر الديك (شرق شارع صلاح الدين)

البحث يتطلب من كل مزارع تعبئة استبيان (20 دقيقة) و تقديم عينات براز, عينات من مياه غسيل يديه "أثناء عمله في المزرعة" , عينات تربة, و عينات مياه ري(مياه عادمة معالجة/ مياه جوفية).

مشاركتك تطوعية , و في حال موافقتك على المشاركة يفضل الالتزام بإجابة الاستبيان وتقديم العينات المطلوبة.

يمنك رفض الإجابة عن أي سؤال في الاستبيان و أرغب أن أؤكد لك أن المعلومات التي تذكرها ستكون مصدر ثقة وسرية وستستخدم فقط لغرض البحث العلمي وبدون ذكر الأسماء فالنتائج لن تنشر بشكل خاص و انما سوف تنشر بشكل جماعي ولن ينسب أي شيء اليك,

علماً بأن نتائج البحث سوف تساهم في وضع التوصيات اللازمة من أجل الوصول الى درجة كافية من السلامة للمزارعين.

وقد تم حصول البحث على موافقة لجنة هلسنكي, وقد أرفقت الموافقة في نهاية الاستبيان.

وشكرا لك على حسن تعاونك.

الباحثة / حنين نبيل الصبيحي

بناءً على ما سبق,

أقر أنا الموقع أدناه: ....
بأن الباحثة حنين نبيل الصبيحي من جامعة القدس , قد أطلعتني على طبيعة البحث الذى تقوم به ومجرياته وفوائده المحتملة, وقد أجابت عن كل استفساراتي وأسئلتي بوضوح وعلى أكمل وجه.
وبناءً عليه فإنني باختياري أوافق على المشاركة في البحث وذلك بتعبئة استبانة ومنح الباحثة العينات المطلوبة من خلال التنسيق المسبق, كما أعلم تماما بأنى حر في المشاركة والانسحاب من هذا البحث متى شئت ولو بعد الموافقة التحريرية بدون ابداء الاسباب ومن دون ان يؤثر على حقي في الاستفادة من نتائج البحث, الا انه يفضل الالتزام التام من أجل المساهمة في انجاح تنفيذ البحث والحصول على نتائج تساهم في وضع التوصيات الازمة للوصول الى درجة كافية من السلامة لي ولغيرى من المزارعين.

اسم المشارك : التاريخ: / /

التوقيع:

التاريخ: ....

الوقت: ....

1. معلومات عامة عن المزارع :

1.1 اسم المزارع: .... رقم الجوال: ....

1.2 عنوان المزارع ....

1.3 الجنس □ ذكر □ أنثى

1.4 العمر (بالسنوات) ....

1.5 المؤهلات العلمية □ابتدائي فأقل □إعدادي – ثانويه عامه □ دبلوم /بكالوريوس □ دراسات عليا

1.6 عدد أفراد الأسرة ....

1.7 هل تعد الزراعة مهنتك الرئيسية □ نعم □ لا

1.7.1 اذا كانت الإجابة لا, ما هي وظيفتك الرئيسية : ....

1.8 عدد سنوات العمل في الزراعة ....

1.9 هل يقدم لك المساعدة/يشارك العمل في الزراعة أشخاص آخرين □ نعم □ لا

1.9.1 اذا كانت الإجابة نعم , اذكر الأشخاص الذين يشاركونك العمل □ الأب □ الأم □ الزوجة □ الأبناء □ الأخوة □ أخرى, حدد........

1.10 كيف توصف الوضع المادي لعائلتك □ ممتاز □جيد جداً □ جيد □ سيء

2. السكن / المنزل:

2.1 نوع المنزل □ منزل (باطون) □ منزل (اسبست) □ أخرى (حدد) ....

2.2 ما هي المسافة التي يبعدها اقرب منزل من منزلك .... متر

2.3 ما هي طبيعة أرضية منزلك □اسمنت □ بلاط □ تربة □خشب □ أخرى(حدد).........

2.4 ما هي نوعية الارض حول المنزل □اسفلت □عشب □ تربة □ أخرى (حدد).......................

3. الزراعة:

3.1 ما هي عنوان المزرعة التي تمتلكها/ تعمل فيها المنطقة:..................

☐ يقع البيت بداخل المزرعة ☐ المزرعة قريبه من المنزل ☐ المزرعة بعيدة جداً عن المنزل

3.2 الزمن الذى تقضيه في المزرعة .... ساعه/يوم

3.3 مساحة المزرعة .... دونم

3.4 اذكر المزروعات التي تقوم بزراعتها ☐ أشجار (حدد الأنواع):......................

☐ أعلاف (حدد الأنواع):......................

☐ خضراوات (حدد الأنواع):.....................

☐ أخرى (حدد) ....

3.5 هل تستخدم الروث كسماد لتسميد أرضك الزراعية ☐ نعم ☐ لا

3.5.1 اذا كانت الإجابة بنعم, ما هو نوع الروث التي تستخدمها ☐ روث طيور ☐ روث حيوانات ☐ حمأة ☐ سماد كيميائي ☐ أكثر من نوع, (حدد).....................

3.5.2 ما هو مصدر الروث الذى تستخدمه ....

الأسئلة التالية للمزارعين الذين يستخدمون المياه العادمة المعالجة في الزراعة

3.6 المساحة التي ترويها بالمياه العادمة المعالجة .... دونم

3.7 المدة الزمنية لاستخدامك المياه العادمة المعالجة في الزراعة .... سنه

3.8 اذكر المزروعات التي يتم ريها بالمياه العادمة المعالجة ☐ أشجار فواكه (حدد الأنواع):...................

☐ أشجار زيتون

☐ أعلاف (حدد الأنواع):......................

☐ أخرى (حدد) ....

3.9 هل تتناول المحاصيل المروية بالمياه العادمة المعالجة ☐ نعم ☐ لا ☐ أحيانا

3.10 هل تستخدم الروث كسماد لتسميد المساحات الزراعية المروية بالمياه العادمة المعالجة ☐نعم ☐ لا ☐ أحيانا عند الحاجه

3.10.1 اذا كانت الإجابة بنعم, ما هو نوع الروث التي تستخدمها ☐ روث الطيور ☐ روث الحيوانات ☐ سماد كيميائي ☐ أكثر من نوع, حدد (......)

3.10.2 ما هو مصدر الروث الذى تستخدمه ....

4. المياه

4.1 مصادر تزويد المنزل بالمياه الصالحة للشرب ☐ البلدية ☐ محطات تحلية المياه الخاصة ☐ بئر خاص ☐ بئر زراعي ☐ مياه الأمطار

4.2 مصادر تزويد المنزل بمياه أغراض غير الشرب ☐ البلدية ☐ بئر خاص ☐ بئر زراعي ☐ مياه الأمطار

4.3 هل تقوم بعمل أي شيء من اجل تحسين جودة المياه قبل استخدامها لأغراض الشرب ☐ نعم ☐ لا ☐ أحيانا

4.3.1 إذا كانت الإجابة بنعم , ما هي الطرق المستخدمة ☐ كلورة ☐ غلي ☐ فلترة ☐ أخرى, حدد ....

4.4 كمية المياه المستهلكة يوميا لأغراض غير الشرب .... (لتر/عائلة)

5. الصرف الصحي

5.1 أين يتم التخلص من مياه الصرف الصحي لمنزلك ☐ تضخ للمزرعة ☐ تضخ الى حفر امتصاصية ☐ تضخ الى شبكة الصرف الصحي ☐ أخرى (حدد)............

5.2 هل يوجد مرحاض في المزرعة ☐نعم ☐لا

اذا كانت الاجابة نعم:

5.2.1 هل يشاركك في استخدام المرحاض مزارعين اخرين ☐نعم ☐لا
العدد: ....

5.2.2 أين يتم التخلص من مياه مرحاض المزرعة ☐ تضخ للمزرعة ☐ تضخ الى حفر امتصاصية ☐ تضخ الى شبكة الصرف الصحي ☐ أخرى (حدد)....

اذا كانت الاجابة لا

5.2.3 اين تقضى احتياجاتك من التبول وغيره اثناء العمل في المزرعة ☐ في اطراف المزرعة ☐ في وسط المزروعات ☐في مرحاض المنزل ☐ أخرى (حدد).........

6. تربية الحيوانات و الطيور

6.1 هل تربى حيوانات وطيور ☐ نعم ☐ لا

اذا كانت الإجابة نعم:

6.1.1 اين تربى الحيوانات والطيور ☐ داخل البيت ☐ فى الحديقة الخارجية للبيت ☐ في المزرعة للبيت ☐ أخرى (حدد) ....

6.1.2 إذا كانت الاجابة السابقة المزرعة أو داخل البيت , فهل تتواجد الحيوانات والطيور في مكان مغلق خاص فيها في المزرعة أو داخل المنزل ☐ نعم ☐ لا ☐ أحياناً

6.1.3 هل بقايا وخلفات الزراعة تتناولها الحيوانات والطيور ☐ نعم ☐ لا

6.1.4 ما هى الحيوانات والطيور التي تربيها ☐ القطط ☐ الكلاب ☐الطيور ☐ الماشية ☐ أخرى, حدد ....

7. السلوك الصحي:

7.1 ما هي كمية استهلاك الصابون في المنزل .... (قطعة / اسبوع)

7.2 اين تحدث معظم عمليات الطهى في منزلك ☐ في داخل السكن (ليس فى غرفة محددة) ☐ في مطبخ السكن ☐ في خارج السكن

7.3 هل تلبس حذاء عادة عند التنقل في محيط منزلك ☐ دائماً ☐ غالباً ☐ نادراً ☐ أبداً

7.4 هل لديك صنبور مياه في المزرعة لغسيل يديك/طعامك عند الحاجه ☐ نعم ☐لا

7.4.1 اذا كانت الإجابة نعم, ما هو مصدر هذا الصنبور ....

7.4.2 مدى استعمالك لصنبور المياه ☐ دائماً ☐غالباً ☐ نادراً ☐ أبداً

7.5 هل لديك صابون في المزرعة ☐ دائما ☐غالباً ☐نادراً ☐ أبداً

الأسئلة التالية من 7.6 – 7.16 تتضمن السؤال عن فترات الري باستخدام المياه الجوفية / مياه الآبار وفترات الرى باستخدام المياه العادمة المعالجة

7.6 أثناء تواجدك في المزرعة تغسل الفواكه والخضروات قبل تناولها ☐ دائماً ☐غالباً ☐ نادراً ☐ أبداً

☐ دائماً ☐غالباً ☐ نادراً ☐ أبداً

7.7 تغسل يديك بعد تشغيل مضخة ضخ المياه العادمة المعالجة/ المياه الجوفية لري المزروعات ☐ دائماً ☐غالباً ☐ نادراً ☐ أبداً

☐ دائماً ☐غالباً ☐ نادراً ☐ أبداً

7.8	تغسل يديك بعد صيانه أي عطل في شبكة ري المزروعات	□ دائماً	□غالباً	□ نادراً	□ أبداً
		□ دائماً	□غالباً	□ نادراً	□ أبداً
7.9	تغسل يديك بعد ملامستهم للتربة	□ دائماً	□غالباً	□ نادراً	□ أبداً
		□ دائماً	□غالباً	□ نادراً	□ أبداً
7.10	يحدث تلامس مع مياه الري	□ دائماً	□غالباً	□ نادراً	□ أبداً
		□ دائماً	□غالباً	□ نادراً	□ أبداً
7.11	تغسل يديك بعد ملامستهم للمياه الري	□ دائماً	□غالباً	□ نادراً	□ أبداً
		□ دائماً	□غالباً	□ نادراً	□ أبداً
7.12	اثناء تواجد في المزرعة تغسل يديك باستخدام ماء سبق استخدامه عدة مرات	□ دائماً	□غالباً	□ نادراً	□ أبداً
7.13	أثناء عملك في المزرعة تستخدم حذاء خاص / حذاء مغلق	□ دائماً	□غالباً	□ نادراً	□ أبداً
		□ دائماً	□غالباً	□ نادراً	□ أبداً
7.14	ترتدى قفازات عند العمل في الحقل	□ دائماً	□غالباً	□ نادراً	□ أبداً
		□ دائماً	□غالباً	□ نادراً	□ أبداً
7.15	ترتدى ملابس خاصة عند العمل في الحقل	□ دائماً	□غالباً	□ نادراً	□ أبداً
		□ دائماً	□غالباً	□ نادراً	□ أبداً
7.16	عند الحصاد, كيف تتعامل مع الثمار التي تسقط على التربة اذا كنت ترغب بتناولها	□ اتناولها مباشرة	□ امسحها بملابسي ثم أتناولها	□ اغسلها جيدا	□ اتخلص منها
		□ اجمعها	□ امسحها بملابسي ثم أتناولها	□ اغسلها جيدا	□ اتخلص منها
7.17	عند الحصاد من أجل البيع, كيف تتعامل مع الثمار التي تسقط على التربة	□ اتناولها مباشرة	□ امسحها بملابسي ثم أتناولها	□ اغسلها جيدا	□ اتخلص منها
		□ اجمعها	□ امسحها بملابسي ثم أتناولها	□ اغسلها جيدا	□ اتخلص منها

السؤال التالي للمزارعين مستخدمي المياه العادمة المعالجة في الزراعة

7.18 هل يتم الري بالمياه الجوفية قبل الحصاد بأسبوعين □ نعم □ لا

8. الصحة

8.1 هل سبق وأن اجريت فحصاً للطفيليات المعوية □ نعم □ لا

اذا كانت الاجابة نعم,

8.1.1 متى قمت بإجراء هذا الفحص □خلال الشهر الماضي □خلال الشهرين الماضية □خلال الثلاث أشهر الماضية □أخرى, حدد ....

8.1.2	هل تعالجت بأدوية مضادة للطفيليات	□ نعم	□ لا	□ أحياناً	
8.1.3	اذكر نوع الطفيليات التي تم الكشف عنها خلال الفحص الذى اجريته	....			

بعض الاسئلة التالية لمستخدمين المياه العادمة المعالجة في الزارعة فقط:

8.2	بشكل عام , كيف تقيم وضعك الصحي الان	□ ممتاز	□ جيد	□ مقبول	□ سيء
8.3	كيف تقيم وضعك الصحي قبل استخدام المياه العادمة المعالجة	□ لم يختلف عن السابق	□ أسوأ من السابق	□ لا أستطيع التحديد	
8.4	كيف تقيم الوضع الصحي لأطفالك	□ ممتاز	□ جيد	□ مقبول	□ سيء
8.5	كيف تقيم الوضع الصحي لأطفالك بعد استخدام المياه العادمة المعالجة	□ لم يختلف عن السابق	□ أسوأ من السابق	□ لا أستطيع التحديد	
8.6	هل تعتقد ان استخدام المياه العادمة المعالجة في الزراعة يساهم في زيادة الإصابة بالأمراض	□ نعم	□ لا		
8.7	اذا كانت الاجابة نعم, فما هي هذه الامراض	....			
8.8	هل يحدث معك اسهال	□ نعم	□ أحياناً	□ لا	
8.9	هل يحدث معك امساك	□ نعم	□ أحياناً	□ لا	
8.10	هل يحدث معك الم في البطن	□ نعم	□ أحياناً	□ لا	
8.11	هل يحدث معك نزول دم مع البراز	□ نعم	□ أحياناً	□ لا	
8.12	هل يحدث معك استفراغ	□ نعم	□ أحياناً	□ لا	
8.13	هل يحدث معك حمى	□ نعم	□ أحياناً	□ لا	
8.14	هل يحدث معك هزال/ضعف	□ نعم	□ أحياناً	□ لا	
8.15	هل يحدث معك صداع	□ نعم	□ أحياناً	□ لا	
8.16	هل يحدث معك فقدان شهيه	□ نعم	□ أحياناً	□ لا	

Annex (8): Expert Names who validated the interview questionnaire

#	Name	Position
1.	Dr. Nahed Al Laham	Associate Professor - Al Azhar University Gaza
2.	Dr. Bassam El-Zain	Associate Professor - Al Quds University Gaza
3.	Dr. Jehad El-Hissi	PHD - Al Azhar University Gaza
4.	Dr. Yousef Abu Safia	PHD - Al Quds University Gaza
5.	Dr. Abood El-Qeshawi	Associate Professor – Islamic University of Gaza
6.	Dr. Abdelfatah Abdrabou	Associate Professor - Islamic University of Gaza
7.	Dr. Thaer Abu Sbak	PHD - Al Azhar University Gaza
8.	Dr. Khitam Abu Hamad	PHD - Al Quds University Gaza
9.	Dr. Basam Abu Hamad	Associate Professor - Al Quds University Gaza
10.	Dr. Yehia Abd	PHD - Al Quds University Gaza
11.	Dr. Amal Sarsor	Environmental Health Consultant - Earth and Human Center for Researches and studies
12.	Dr. Mohammed Abu Hashish	PHD - Al Quds University Gaza
13.	Dr. Yosef El-Jesh	Associate Professor - Islamic University of Gaza
14.	Dr. Adnan Ayesh	PHD - Al Azhar University Gaza
15.	Dr. Reyad Jaber	Assistant Professor - Islamic University of Gaza
16.	Prof. Abdelraouf A. Elmanama	Professor - Islamic University of Gaza

Annex (9): Helsinki Committee Approval Letter

المجلس الفلسطيني للبحث الصحي

Palestinian Health Research Council

تعزيز النظام الصحي الفلسطيني من خلال مأسسة استخدام المعلومات البحثية في صنع القرار

"Developing the Palestinian health system through institutionalizing the use of information in decision making"

Helsinki Committee

For Ethical Approval

Date: 04/04/2016 **Number:** PHRC/HC/107/16

Name: Haneen N. Al-Sbaihi

الاسم: حنين الصبيحي

We would like to inform you that the committee had discussed the proposal of your study about:

نفيدكم علماً بأن اللجنة قد ناقشت مقترح دراستكم حول:

Parasitic Infection among Farmers dealing with Treated Wastewater in Azaitoun Area, Gaza City

The committee has decided to approve the above mentioned research. Approval number PHRC/HC/107/16 in its meeting on 04/04/2016

و قد قررت الموافقة على البحث المذكور عاليه بالرقم والتاريخ المذكوران عاليه

Signature

Member **Member**

Chairman

4/4/2016

Genral Conditions:-

1. Valid for 2 years from the date of approval.
2. It is necessary to notify the committee of any change in the approved study protocol.
3. The committee appreciates receiving a copy of your final research when completed.

Specific Conditions:-

E-Mail:pal.phrc@gmail.com

Gaza - Palestine غزة - فلسطين

Annex (10) : Stool analysis report for medical treatment

مختبرات قسم العلوم الطبية المخبرية	الاسم : الجنس : ذكر العنوان: مدينة غزه- حي الزيتون

تحليل براز

Stool Analysis

مواصفات العينة: تم استلام ثلاث عينات أخذت على مدار ثلاث أيام متتابعه محفوظة باستخدام فورمالين 10%

نتيجة الفحص:

Consistency: L

Abnormal features:-

Parasite:

The sample is positive for :

-***Strongyloides setercoralis*** **larvae**

-Cryptosporidium sp. (Oocyst)

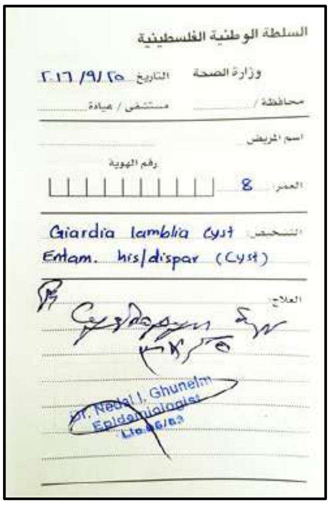
تم إجراء هذا الفحص كمتطلب لإجراء رسالة ماجستير للباحثة حنين الصبيحي بعنوان " دراسة العدوي الطفيلية بين المزارعين المستخدمين للمياه العادمة المعالجة في منطقة الزيتون – مدينة غزة"

إشراف : د. خالد قحمان أ.د. عدنان الهندي

التوقيع: أ. د. عدنان الهندي *I recommend to give the patient the suitable treatment based on the above result.*	التاريخ: 2016/07/30

عزيزي الدكتور في حال مواجهتك أي مشكلة أو لديك استفسار , رجاءاً تواصل مع د. مجدى ضهير – مدير الطب الوقائي , جوال رقم: 0599832983

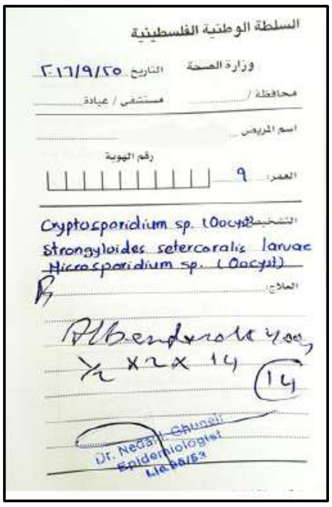
Annex (11) : Medicine prescriptions

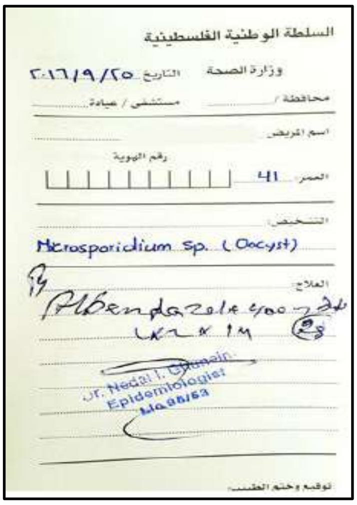

السلطة الوطنية الفلسطينية
وزارة الصحة التاريخ ٢٥/٩/٢٠١٦
محافظة / مستشفى / عيادة
اسم المريض
رقم الهوية
العمر: 8
التشخيص: Giardia lamblia Cyst
Entam. his/dispar (Cyst)
العلاج:
Dr. Nedal I. Ghuneim
Epidemiologist


وزارة الصحة التاريخ ٢٥/٩/٢٠١٦
محافظة / مستشفى / عيادة
اسم المريض
رقم الهوية
العمر: 50
التشخيص: Giardia lamblia (Cyst)
Entam. his/ dispar (Cyst)
العلاج:
Dr. Nedal I. Ghuneim
Epidemiologist
توقيع وختم الطبيب:

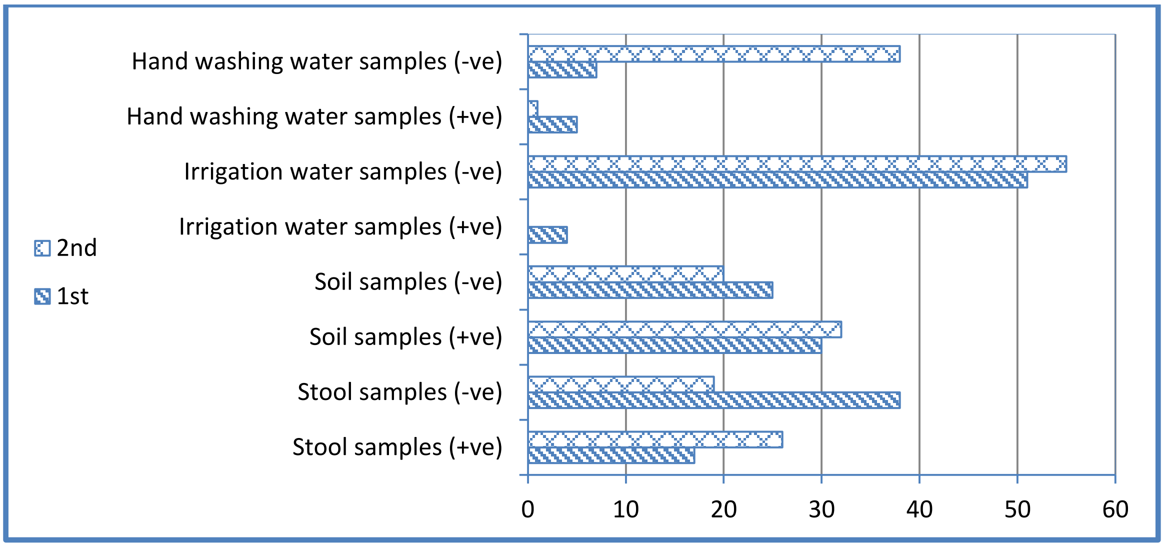

السلطة الوطنية الفلسطينية
وزارة الصحة التاريخ ٢٥/٩/٢٠١٦
محافظة / مستشفى / عيادة
اسم المريض
رقم الهوية
العمر: 8
التشخيص:
Cryptosporidium sp. (Oocyst)
العلاج:
Dr. Nedal I. Ghuneim
Epidemiologist


السلطة الوطنية الفلسطينية
وزارة الصحة التاريخ ٢٥/٩/٢٠١٦
محافظة / مستشفى / عيادة
اسم المريض
رقم الهوية
العمر: 48
التشخيص:
Cryptosporidium sp. (Oocyst)
العلاج:
Dr. Nedal I. Ghuneim
Epidemiologist

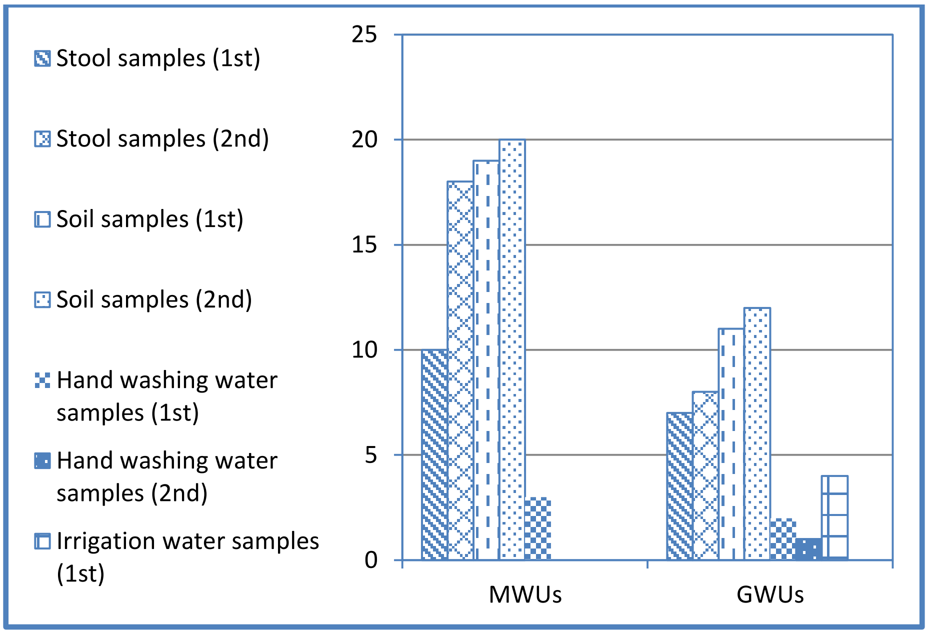

السلطة الوطنية الفلسطينية
وزارة الصحة التاريخ ٢٥/٩/٢٠١٦
محافظة / مستشفى / عيادة
اسم المريض
رقم الهوية
العمر: 9
التشخيص: Cryptosporidium sp. (Oocyst)
Strongyloides stercoralis larvae
Microsporidium sp. (Oocyst)
العلاج:
Albendazole 400 mg
½ x2x 14 (14)
Dr. Nedal I. Ghuneim
Epidemiologist


السلطة الوطنية الفلسطينية
وزارة الصحة التاريخ ٢٥/٩/٢٠١٦
محافظة / مستشفى / عيادة
اسم المريض
رقم الهوية
العمر: 41
التشخيص:
Microsporidium sp. (Oocyst)
العلاج:
Albendazole 400 mg
Dr. Nedal I. Ghuneim
Epidemiologist
توقيع وختم الطبيب:

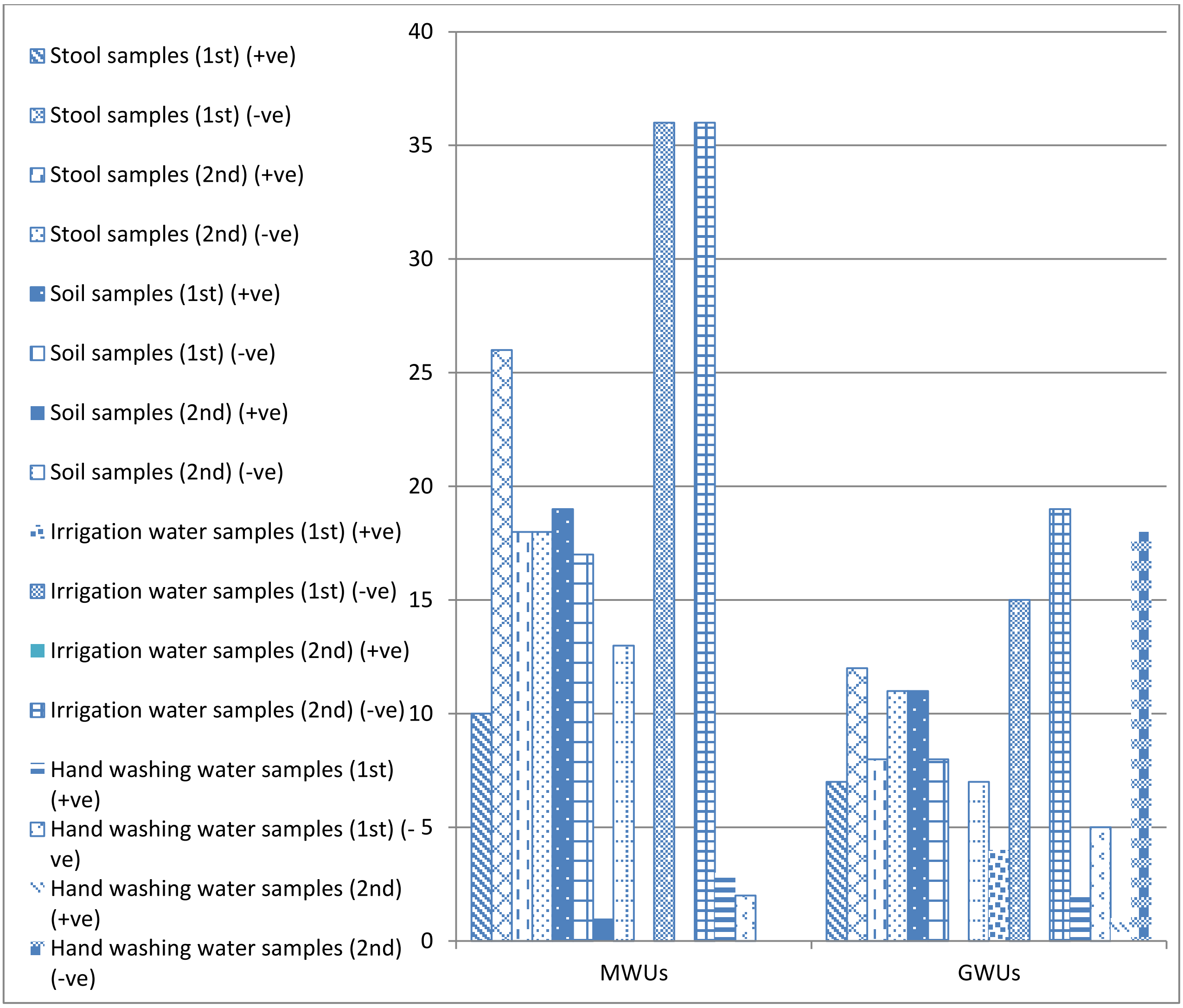
Annex (12): Comparison between parasitic infection and contamination by figures



Parasitic infection/load (No. of positive and negative) in stool, soil, irrigation water, and hand washing water samples at the two rounds



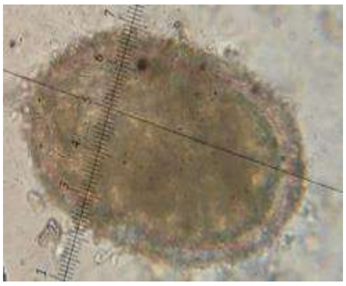
Comparison of parasitic infection/load in stool, soil, irrigation water, and hand washing water samples between the two groups at the two rounds, (only for positive samples)



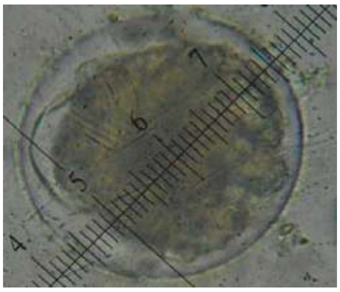
Comparison of parasitic infection/load in stool, soil, irrigation water, and hand washing water samples between the two groups at the two rounds, (positive and negative samples)

Annex (13): Parasities detected in the collected samples

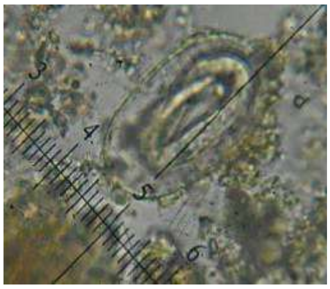
Parasites were found in soil samples



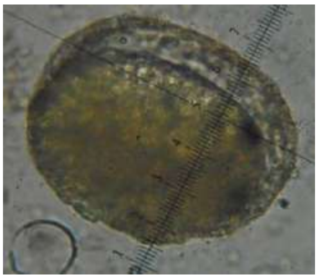
Size (X40): L*W (18.25*12) µm



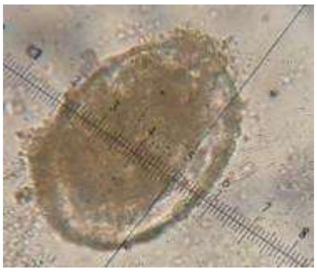
Size (X40): L*W (8*8) µm



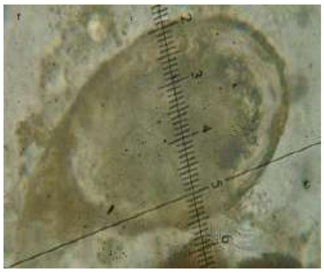
Size (X40): L*W (6.25*4) µm



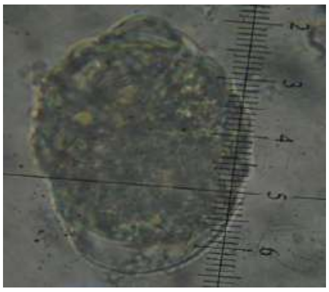
Size (X40): L*W (16.25*11.75) µm



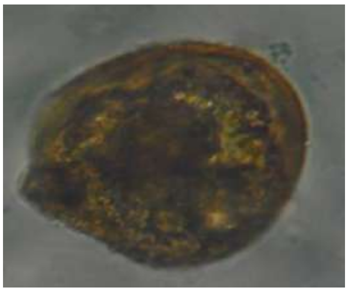
Size (X40): L*W (13.25*9.25) µm

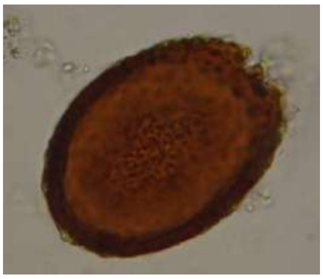


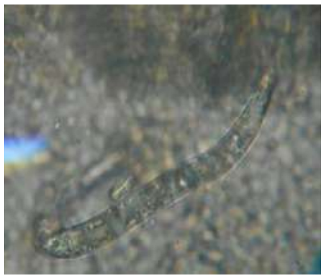
Size (X40): L*W (15*8.75) µm



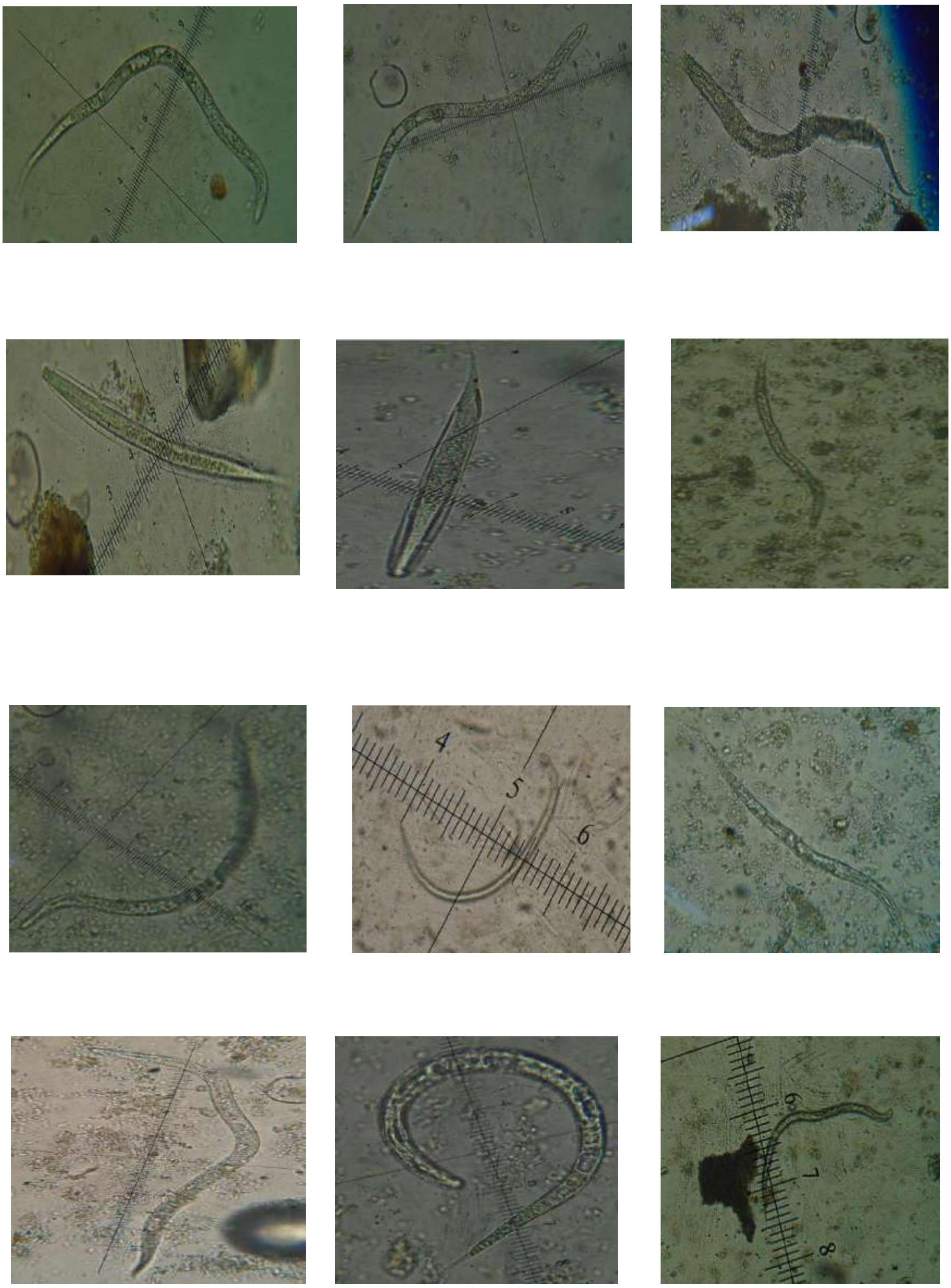
Size (X40): L*W (11.25*7) µm





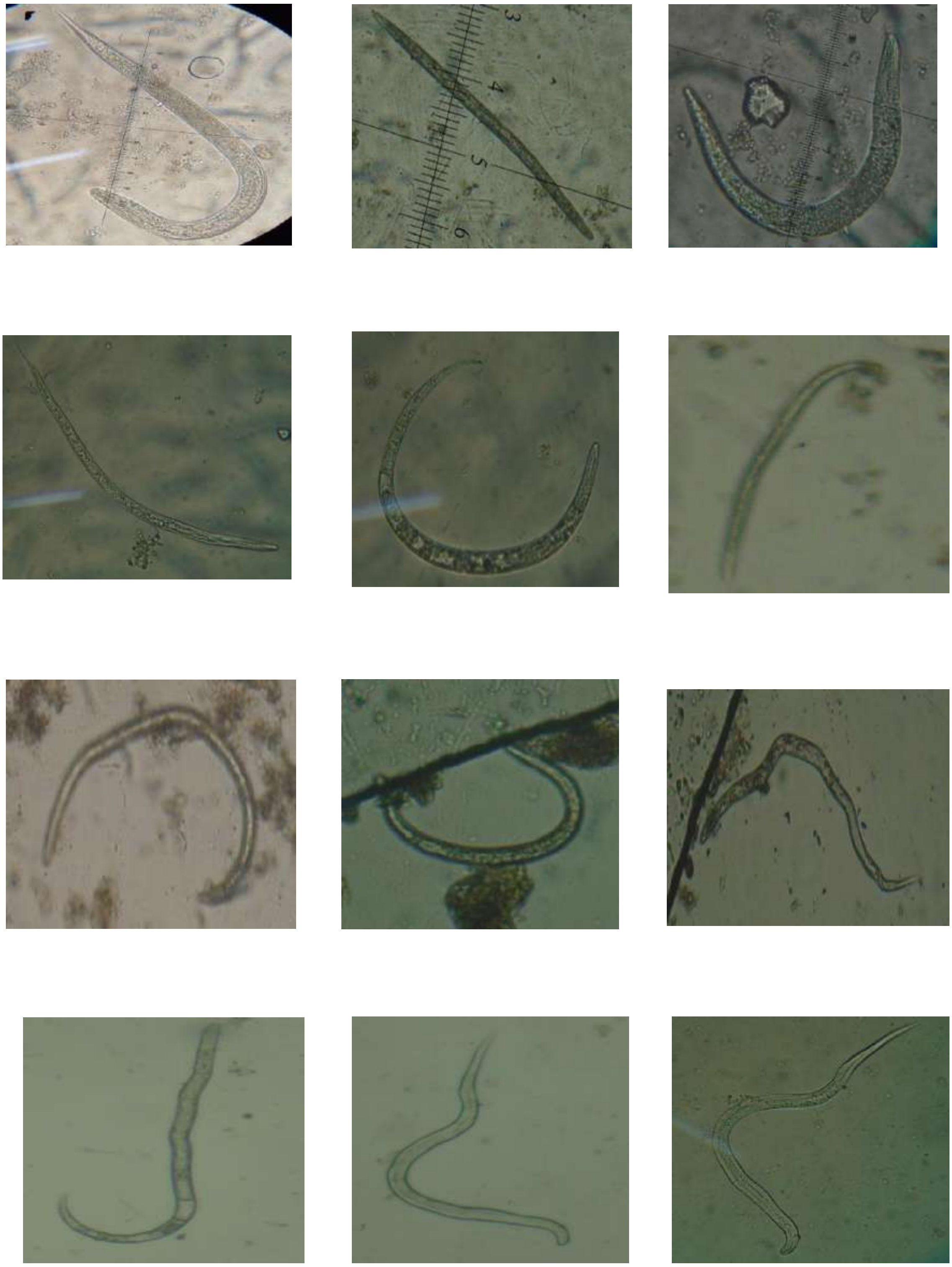


Parasites were found in soil samples

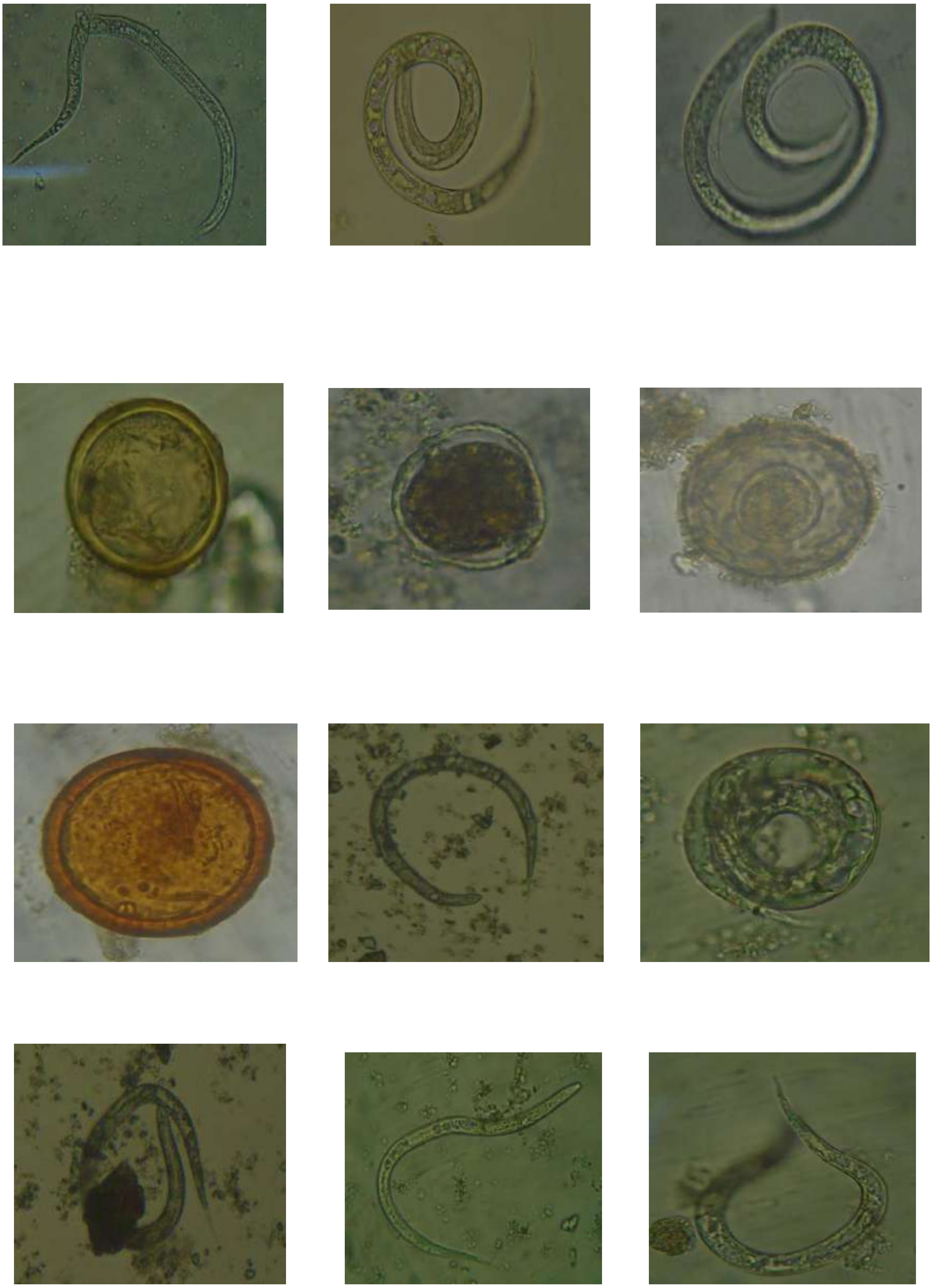


Parasites were found in soil samples

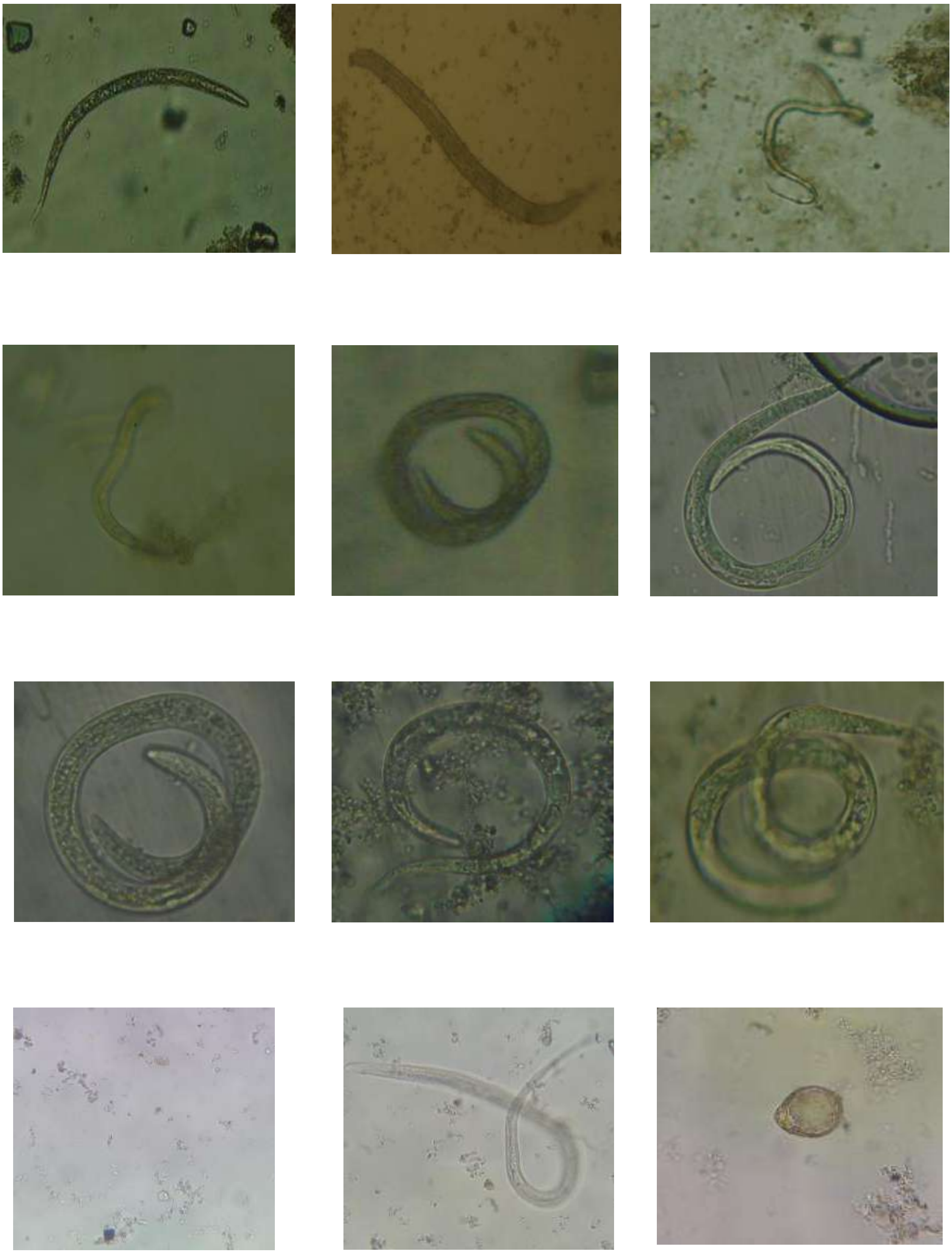
Parasites were found in soil samples

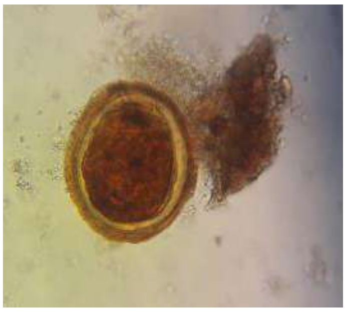
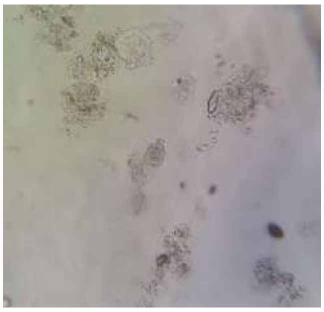


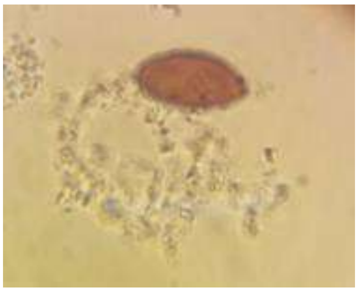
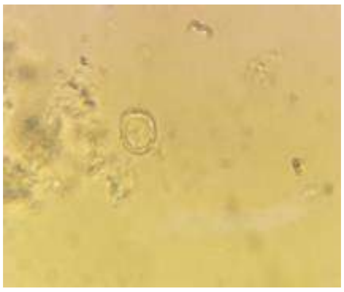
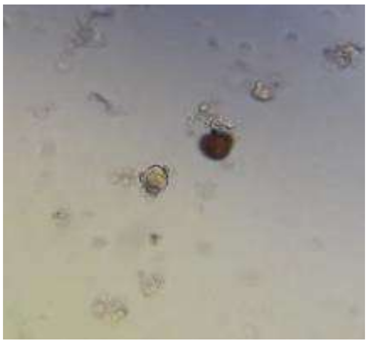
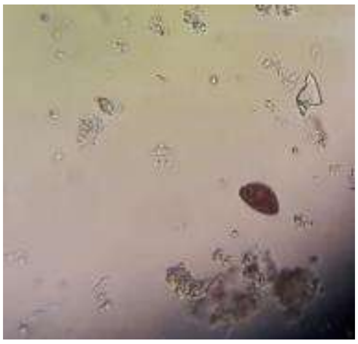
Parasites were found in soil samples

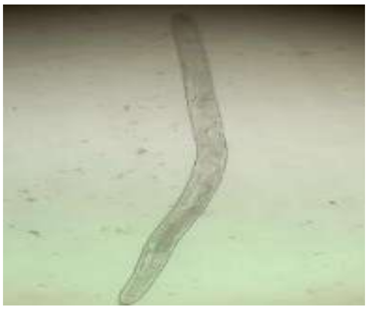


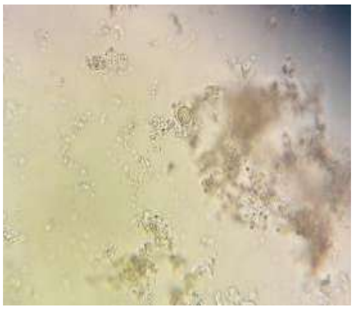
Parasites were found in soil samples



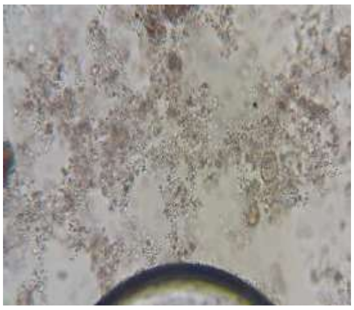
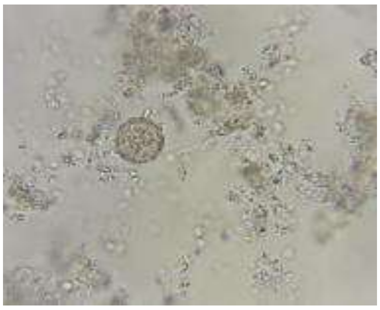




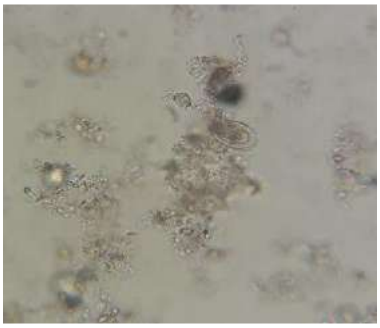
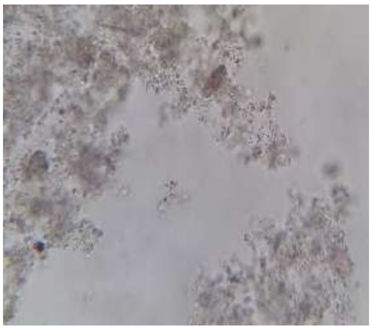
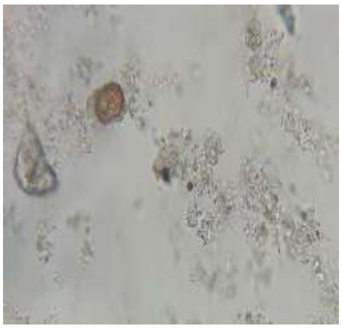





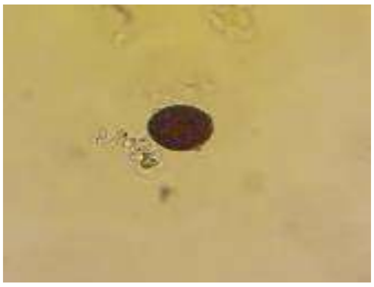


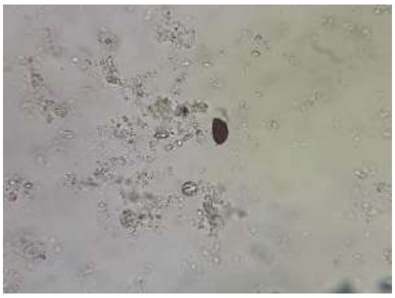




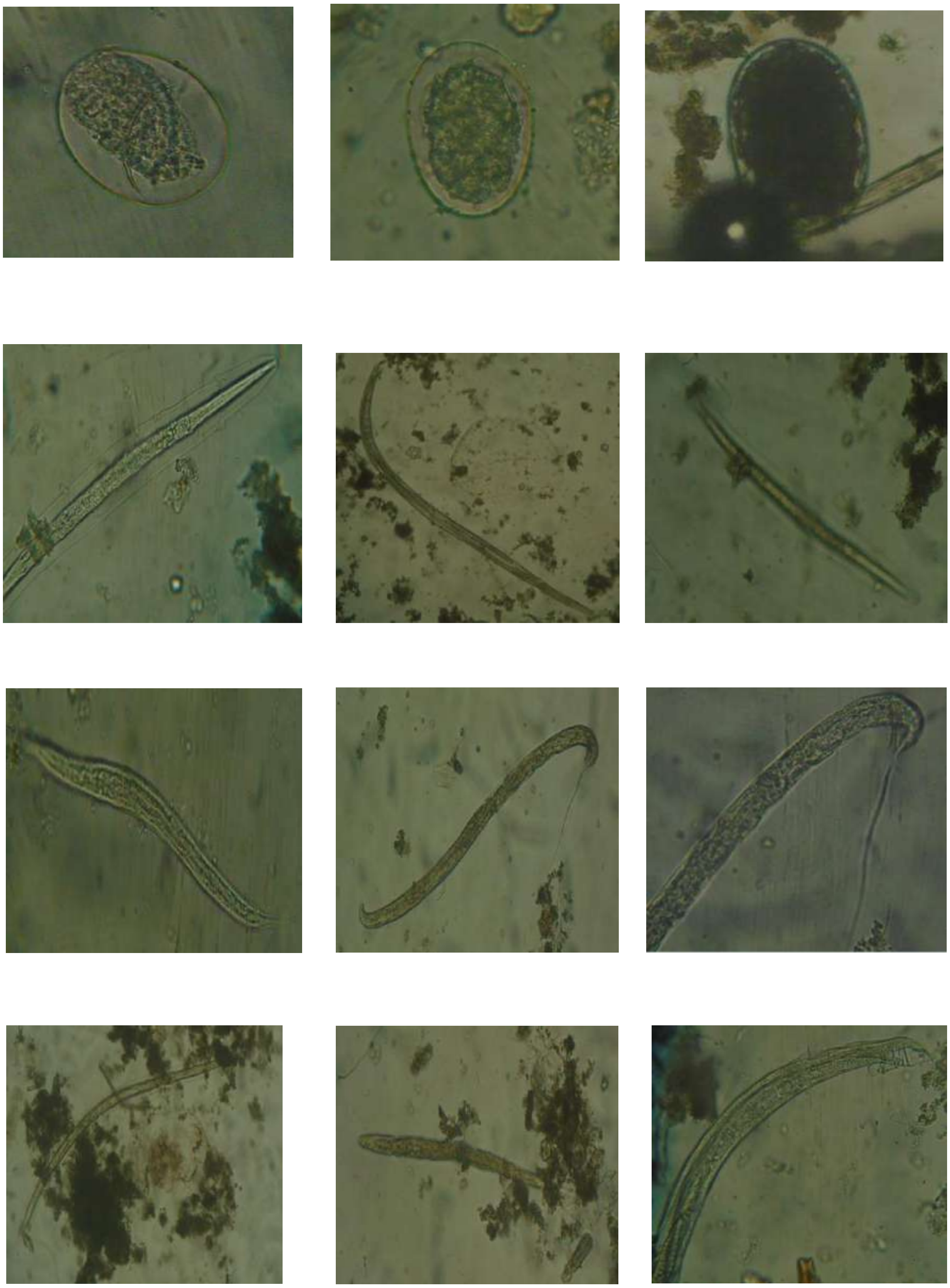





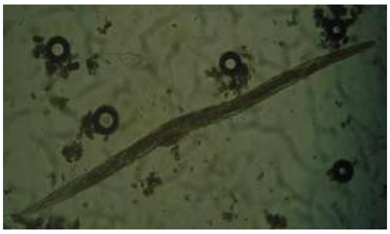


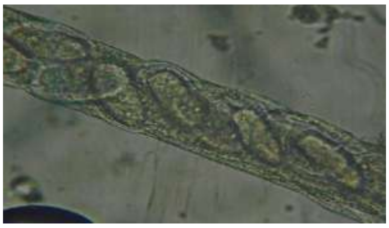
Parasites were found in wastewater samples

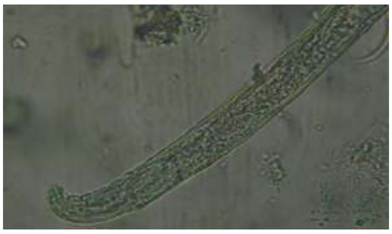


Parasites were found in wastewater samples

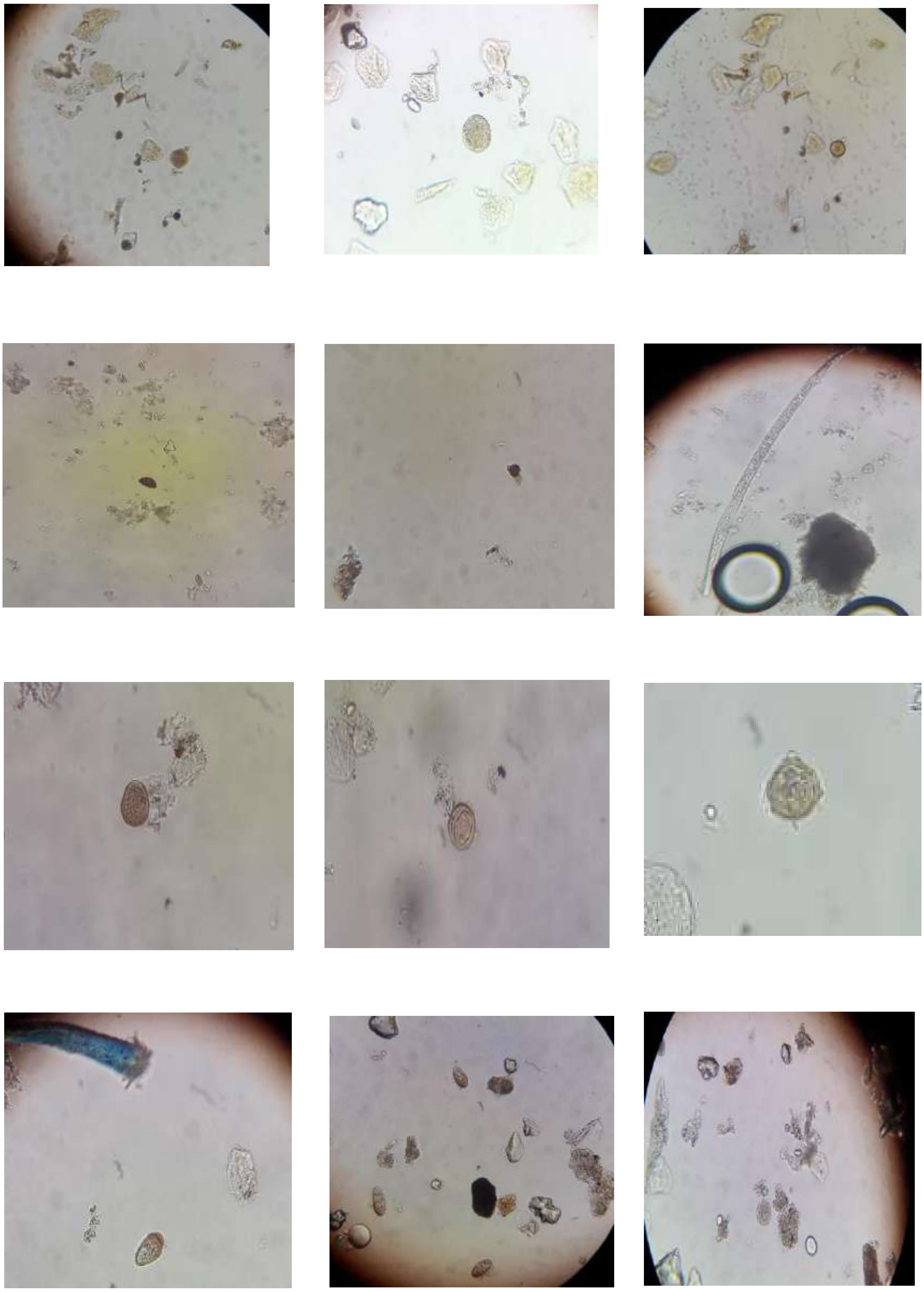
All photos for the same female adult



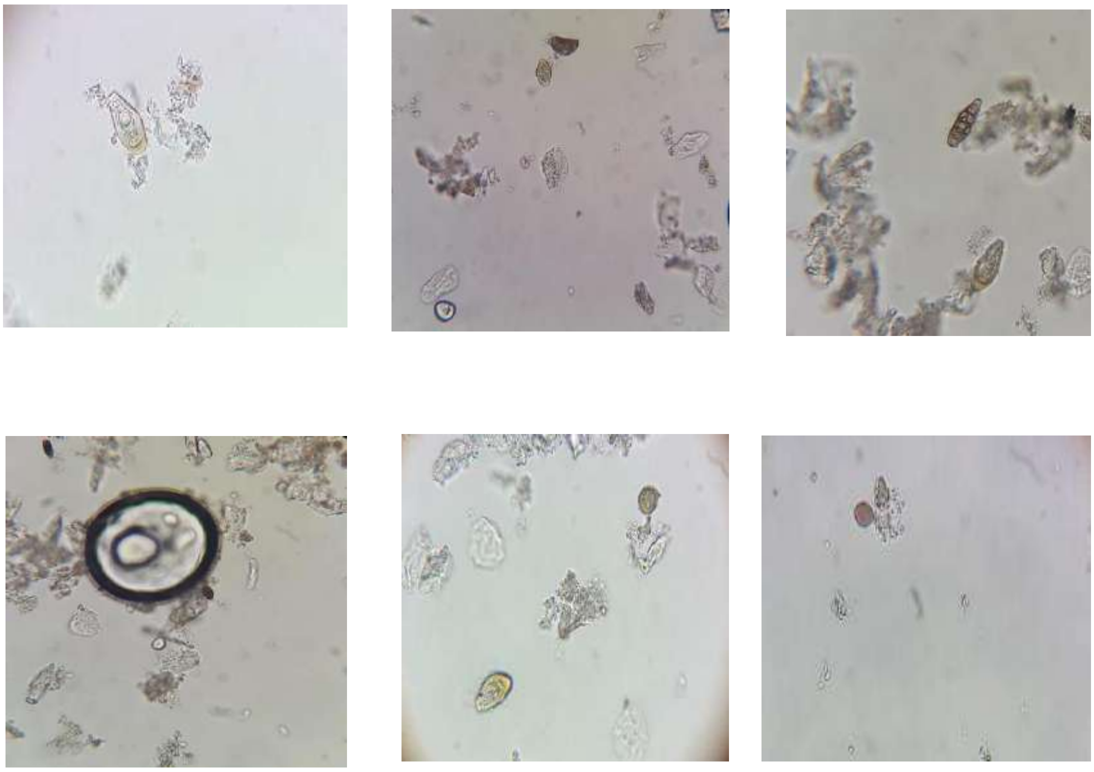




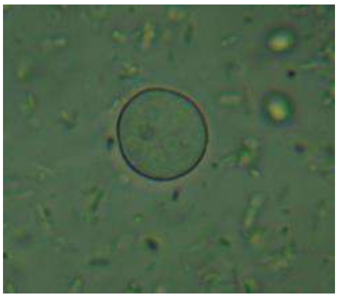
Parasites were found in Hand washing water samples



Parasites were found in hand washing water samples

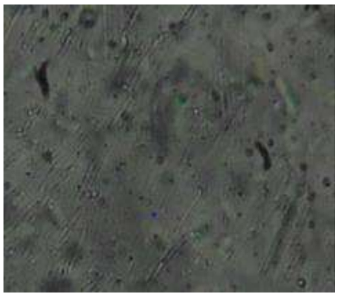


Parasites were found in stool samples



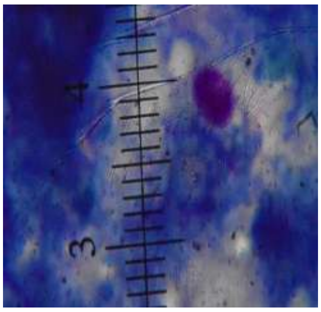
Entamoeba coil cyst

Entamoeba histolytica/dispar cyst

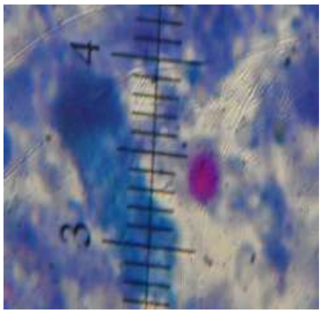


Giardia lamblia cyst

Ascaris lumbricoides egg



Cryptosporidium sp. occyst



Microsporidia sp. oocyst

Annex (14): Relation between Age variable and other variables

Annex 14.1: Relation between Age variable and agricultural factors

#	Variable		Age ≤ 18 year Freq.	%	19-46 year Freq.	%	≥ 46 year Freq.	%	Pearson Chi-square	P value
1.	Is farming your main job	Yes	2	6.9	15	51.7	12	41.4	26.8	**0.001***
		No	19	73.1	6	23.1	1	3.8		
	Total		**21**	**38.2**	**21**	**38.2**	**13**	**23.6**		
2.	Time of working in agriculture per day		18	52.9	11	32.4	5	14.7	8.87	**0.012***
			3	14.3	10	47.6	8	38.1		
	Total		**21**	**38.2**	**21**	**38.2**	**13**	**23.6**		
3.	Years of working in agriculture	2 – 5 years	19	82.6	4	17.4	0	0	34.2	**0.001***
		≥ 6 years	2	6.3	17	53.1	13	40.6		
	Total		**21**	**38.2**	**21**	**38.2**	**13**	**23.6**		
4.	Years of using TWW in Agriculture	2 – 5 years	13	56.5	7	30.4	3	13	1.55	**0.212**
		≥ 6 years	4	30.8	6	46.2	3	23.1		
	Total		**17**	**47.2**	**13**	**36.1**	**6**	**16.7**		
5.	Soil contamination (1st)	positive	13	43.3	10	33.3	7	23.3	0.868	**0.648**
		Negative	8	32	11	44	6	24		
	Total		**21**	**38.2**	**21**	**38.2**	**13**	**23.6**		
6.	Soil contamination (2nd)	positive	10	31.3	14	43.8	8	25	1.004	**0.605**
		Negative	9	45	7	35	4	20		
	Total		**19**	**36.5**	**21**	**40.4**	**12**	**23.1**		

Annex 14.2: Relation between Age variable and farmers' group

Variable		Parasitic Infection MWUs Freq.	%	GWUs Freq.	%	Pearson Chi-square	P value
Age	≤18 years	17	81	4	19	4.48	**0.106**
	19-45 years	13	61.9	8	38.1		
	≥ 46 years	6	46.2	7	53.8		
Total		**36**	**65.5**	**19**	**34.5**		

Abstract (Arabic language)

العنوان : العدوى الطفيلية بين المزارعين المستخدمين للمياه العادمة المعالجة في منطقة الزيتون – مدينة غزة
اعداد : حنين نبيل الصبيحي
اشراف: د. خالد قحمان أ.د. عدنان الهندي

ملخص: يرتبط الري باستخدام المياه العادمة المعالجة بفوائد متعددة ولكنه قد يؤدي إلى مخاطر صحية. يتمثل الهدف الرئيسي من هذه الدراسة في الاستقصاء عن العدوى الطفيلية بين المزارعين الذين يستخدمون المياه العادمة المعالجة في منطقة الزيتون، مدينة غزة. شملت هذه الدراسة مجموعتين من المزارعين: المزارعون الذين يستخدمون المياه العادمة المعالجة، والمزارعون الذين يستخدمون المياه الجوفية في ري المزروعات. وقد تطلب من كل مزارع تعبئة استبيان, تقديم عينات براز, تربة, مياه ري, و مياه غسل اليدين على مرحلتين.

تهدف العينات في المرحلة الأولى إلى ضمان أن يكون المزارعون غير مصابين بالطفيليات قبل البدء بالمرحلة الثانية للدارسة, وإنشاء معلومات أساسية حول مدى تلوث التربة, مياه الري, ومياه غسيل اليدين بالطفيليات. كانت المرحلة الثانية تهدف لمقارنة انتشار العدوى الطفيلية عند مستخدمي المياه العادمة المعالجة بعد استخدمهم للمياه العادمة المعالجة لمدة ثلاثة أشهر مع مراعاة نسبة الطفيليات في التربة وفي مياه الري عند كل مزارع وفقا المعلومات الأساسية.

كان معدل انتشار العدوى الطفيلية فى المرحلة الاولى بين المشاركين 30.9% وزاد في المرحلة الثانية ليصل 47.3%. وجدت علاقة طردية ذات دلالة احصائية معنوية بين استخدام المياه العادمة المعالجة والعدوى الطفيلية في المرحلة الثانية (OR=1.37, CI 0.448-4.21). وقد تم التعرف على ستة أنواع من الطفيليات لدى المزارعين في هذه الدراسة المُتَحَوِّلَة الحالَّةُ للنُّسُج/ المتحولة المُتَغَيِّرَة/ المتحولة القولونية/أميبا داخلية معوية، خَفِيَّةُ الأَبْواغ, والفطريات البويغية, والجِيارْدِيَّةُ اللَّمْبلِيَّة، الاسطوانية البرازية / الدودة الخيطية، و الصَّفَرُ الخَراطينِيّ.

كان انتشار التلوث بالطفيليات في التربة في المرحلة الاولى 54.5% وزاد في المرحلة الثانية ليصل 61.5%, وجدت علاقة عكسية ليست ذات دلالة احصائية معنوية بين تلوث التربة بالطفليات ومصدر الري حيث كانت قيمة OR في المرحتين على التوالي (OR^{1st} =0.813, CI 0.265-2.495) and (OR^{2nd} =0.897, CI 0.28-2.876)

توصلت الدراسة الى أن أعلى نسبة عدوى طفيلية كانت بين الإناث، المشاركين الذين لديهم أدنى مؤهل علمي, المشاركون الذين يقعون في الفئة العمرية $\geq$ 18 سنة، والمشاركون الذين كانوا يعملون في الزراعة لمدة $\geq$10 سنوات, والذين يعملون في الزارعة لمدة $\geq$ 6 ساعات يوميا.

تبين وجود علاقة ذات دلالة إحصائية بين حجم الأسرة والمشاركين الذين استخدموا العقاقير المضادة للطفيليات سابقا، حيث كانت العدوى الطفيلية اقل لدى المشاركين الذين لديهم حجم الأسرة أقل والمشاركين الذين كانوا في السابق يتناولون العقاقير المضادة للطفيليات.

وقد أظهرت الدراسة أيضا ارتفاع نسبة العدوى الطفيلية بين المشاركين الذين يعانون من سوء الوضع المالي, الذين لا يمتلكون مناطق رملية داخل منازلهم، يعملون في مزارع بعيدة عن منازلهم، المستخدمون الجدد لمياه العادمة المعالجة والذين يرون دونمات زراعية أكثر بمياه الصرف الصحي, الذين لا يعملون بشكل أساسي في الزراعة، الذين يستخدمون الأسمدة مع مياه الصرف المعالجة، و الذين ليس لديهم مرحاض في مزرعتهم، الذين يتخلصوا من مياه الصرف الصحي لبيوتهم ومرحاض المزرعة بضخها الى المزرعة و إلى الحفر الامتصاصية على التوالي، الذين يربون الحيوانات أو الطيور في أماكن غير مغلقة داخل أو بجانب مزارعهم، والذين سبق تشخيصهم بالإصابة بالطفيليات المعوية, و الذين لديهم سلوك نظافة شخصية أقل.

كان استهلاك المياه غير الصالحة للشرب لكل شخص في اليوم أقل عند المشاركين المصابين بالطفيلية و بشكل عام كان سلوك النظافة الشخصيةأفضل لدى الأشخاص الذين يستخدمون مياه الصرف الصحي المعالجة في المنزل و خلال عملية الحصاد و أسوأ خلال العمل في المزرعة. وجد ان معدل سلوك النظافة الشخصيةيزيد للمستويات الأفضل خلال فترات استخدام المياه العادمة في الزراعة.

توصلت الدراسة إلى أنه توجد علاقة طردية ليست ذات دلالة إحصائية معنوية بين العدوى الطفيلية بين استخدام مياه الصرف المعالجة في الري. و لوحظ أن زيادة العدوى الطفيلية زيادة ذات دلالة احصائية اقترنت فقط بمستخدمي المياه العادمة وقد يعزى زيادة فرص العدوى بينهم رغم زيادة سلوك النظافة الشخصية لديهم خلال استخدام المياه العادمة, عملهم في ترب زراعية أقل تلوث بالطفليات, واستخدامهم لنظام الري بالتنقيط إلى زيادة نشاط ونمو الكائنات الحية الدقيقة في التربة بزيادة المواد العضوية من تأثير استخدام مياه الصرف المعالجة، والى وجود 80% من المشاركين الذين يقعون ضمن الفئة العمرية $\geq$ 18 سنه ضمن المزارعين المستخدمين للمياه العادمة المعالجة .

كلمات هامة: مياه الصرف الصحي، المياه الجوفية، مياه الصرف الصحي المعالجة، سلوك النظافة الشخصية، العدوى الطفيلية.