Contamination of water with parasite in Iraq

Research project

Submitted to the department of (Biology) in partial fulfillment

of the requirement for the degree of BSc. In (Biology).

By;

Helin Othman Sabr

Supervised by

Asst.Prof. Dr. Khder N. Nooraldeen

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Supervisor's Certification

I certify that this report was prepared under my supervision at the Department of Biology, College of Education, Salahaddin University – Erbil and I do here by recommend it to be accepted in partial fulfillment of the requirements for the Bachelor Degree of Science(BSc.) in Biology

Signature:

Supervisor:

Asst.Prof. Dr. Khder N. Nooraldeen

Date: / April/ 2023

Dedication:

I Dedicate This Work to :-

My Dear Father and Mother who always prayed for me
All whom I appreciate
Finally, My Asst.Prof. Dr. Khder N. Nooraldeen

Helin O.Sabr

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I wish to express my thanks to the most gracious "ALLAH", the facilitator in every step of my life and work.

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Abstract

Water is a vital resource to every living thing on the earth. Once the water is contaminated (physically, chemically, biologically, or radiologically), it brought negative impacts to the living thing. Waterborne parasitic diseases form one of common and important public health and economic problems in low- and middle-income countries, though little is known on the burden and patterns of these diseases in most regions. Pathogenic parasites including helminths and protozoa are responsible for waterborne diseases. Reports of waterborne protozoan infections are very rare. This study was aimed at reviewing on past and present studies on waterborne diseases in Iraq, the risk factors as well as the intervention practices. The unavailability of piped water and dependence of rural dwellers on surface waters which are often contaminated with fecal materials are the major causes of the rising prevalence of waterborne diseases. Poor hygienic practices have also been found to

play significant role in the spread of waterborne diseases. The review found limited number of published studies on waterborne parasitic diseases in Iraq. Focus of studies was mainly on amoebiasis, giardiasis, cryptosporidiosis, cyclosporiasis, toxocariasis hymenolepiasis, ascariasis and enterobiasis.

Key Word: waterborne, helminthes, protozoa, Iraq, amoebiasis, giardiasis, cryptosporidiosis, cyclosporiasis, toxocariasis hymenolepiasis, ascariasis and enterobiasis.

1. Introduction:

Water is the second most vital natural resource after air (Ojha,. 2017).and is essential for the survival of all living things and food production and economic development (Jayaswal et al., 2017) Water plays a role in the transmission and spread of many different pathogens (Fotedar et al., 2007) According to the safe drinking water act, the presence of any physical, chemical, biological or radiological substance or matter in drinking water means water contamination. These contaminants are harmful if their presence in water exceeds the permissible limits and poses a health hazard. The presence of organisms in water means biological contaminants. They may be called microbiological contaminants or microbes contaminants, such as viruses, bacteria and parasite (Cotruvo, 2017)

Pathogens reach the water through human and animal waste. Scientists believe that 80% of diseases in developed and developing countries are caused by polluted water and the lack of procedures that contribute to water sterilization. Consumption of contaminated water is one of the ways of water-borne parasitic agent transmission (Torgerson et al., 2015). Although the prevalence of waterborne diseases is not common in developed countries, waterborne diseases still occur and can lead to serious consequences (craun., 2020). Important water-borne diseases include diarrhoeal diseases, cholera, shigella, typhoid, hepatitis A and E, and poliomyelitis. Diarrhoeal diseases alone account for an estimated 3.6% of the global burden of disease, and were responsible for of 1.5 million deaths in 2012. According to the World Health Organization, 1.4% of people who have suffer from diarrhea caused by contaminated water. Contaminated water (especially groundwater) kills 1.8 million people every year in many countries (Leclerc et al., 2002).

Helminth and Protozoa parasites are found in varied water sources. Additionally, waterborne outbreaks of protozoan parasites are far more common than outbreaks due to helminths because of the smaller sizes of their transmissible stages. *Giardia* and *Cryptosporidium* have become significant waterborne pathogens in the developed world for three reasons. Firstly, giardiasis and cryptosporidiosis are indigenous infections in many animals; secondly, the densities of environmental contamination with infective cysts and oocysts are sufficient to pollute the aquatic environment; and thirdly, the cysts and oocysts which penetrate water treatment processes are insensitive to the disinfectants commonly used in water treatment (Slifko et al., 2000).*Giardia* cysts and *Cryptosporidium* oocysts are also small enough to pose a threat to ground waters .the water samples have unknown interfering factors that affect the diagnostic method, which are generally expensive. Parasitic diseases are quite common in third world countries. In Iraq the parasitic infection is widely prevalent with variable distribution in different areas. (Jarallah et al., 2022)

The aim of this review article is to study the prevalence of water contamination with parasites in Iraq through collecting and analyzing the data of previous studies accomplished in Iraq.

2. Water-Borne Diseases

Waterborne diseases are those diseases that are transmitted through the direct drinking of contaminated water with human or animal excreta (Hikal,.2020).

Contaminated drinking water when used in the preparation of food can be the source of food borne disease through consumption of the same microorganisms. Most waterborne diseases are characterized by diarrhoea, which involves excessive stooling, often resulting to dehydration and possibly death. According to approximately 4 billion cases of diarrhoea reported each year cause at least 1.8 million deaths with 90% of the cases being children under the age of five years. These deaths represent approximately 4% of all deaths, and 18% of children under-five years' deaths in developing countries, diarrheal disease accounts for an estimated 4.1% of the total daily global burden of disease and is responsible for the deaths of 1.8 million people every year and mostly concentrated on children below 5 years in developing countries. Most waterborne diseases are often transmitted via the fecal-oral route, and this occurs when human fecal material is ingested through drinking contaminated water or eating contaminated food which mainly arises from poor sewage management and improper sanitation. In rural African regions, fecal contamination of water arises from runoffs from nearby bushes and forest which serve as defecation sites for rural dwellers. Waterborne disease can be caused by protozoa, viruses, bacteria, and intestinal parasites. (manetu.2021)

Waterborne diseases are highly attributable to lack of clean and safe drinking water, poor sanitation and hygiene practices. Additionally, research indicates that more than half of acute illnesses are attributable to water, sanitation and hygiene-related across all age groups. Water related diseases are commonly reported in low-income countries as provision of safe water, sanitation and hygiene is sub-optimal as compared to developed countries which has more water resources. As well, even with more resources in developed countries, pumps, pipes and purification facilities could fail leaving people susceptible to waterborne diseases. (Emmanuel.2012)

3. Water contamination mechanism

The transmission routes of parasite are complex and diverse, including contact transmission, water transmission, food transmission, and respiratory transmission Among them, water transmission is the most important route. Interestingly, a few studies have shown that unclean sex is also a transmission route (Escobedo et al. 2014).

First, parasite have a wide transmission route. Although countries with comprehensive water treatment technology can guarantee drinking water quality, other ways such as vegetable pollution and contact with livestock and pets still pose greater risks. Some studies have shown that raw vegetables play a role in spreading parasitic food-borne diseases. Several studies have also shown that people are more susceptible to intestinal worms and protozoa by eating fruits or vegetables. Researches have revealed that the reason for this phenomenon may be that vegetables are polluted by wastewater during irrigation or directly contaminated by animals and humans during harvesting, packaging, transportation, processing, distribution, and sales). The increase in the number of pets raised has also increased the infection rate of humans with parasite. In particular, common pets in most areas are likely to be infected with parasite, which increases the risk of infection by human contact. A summary of reports on pet infections and some foreign countries is shown in figure1. (Feng,2021).

The main cause of waterborne and water-washed diseases is fecal material in the water supply and lack of hygiene. Feces can enter the water in various ways such as .wastewater overflow, nonfunctioning sewage systems, contaminated storm drains, and agricultural effluent. Causative agents of protozoan disease along with liquid sewage from improperly-arranged toilets, cesspools, and livestock farms penetrate into the soil and aquifers. Untreated livestock wastes from facilities located in close proximity to settlements that use the upper aquifers for water supply are especially dangerous. Melt and rain water on the ground can penetrate the groundwater aquifers and pollute the quality of water used for drinking. Confined water constitutes an underground reservoir between the confining strata with a time-constant level and relatively high-water quality. Confined water is the most reliable in sanitary and parasitological terms. However, cysts and oocysts seeding even of confined water can occur if the integrity of the confining strata is violated or there is no supervision over old wells (Omarova, A. *et al.* 2018)

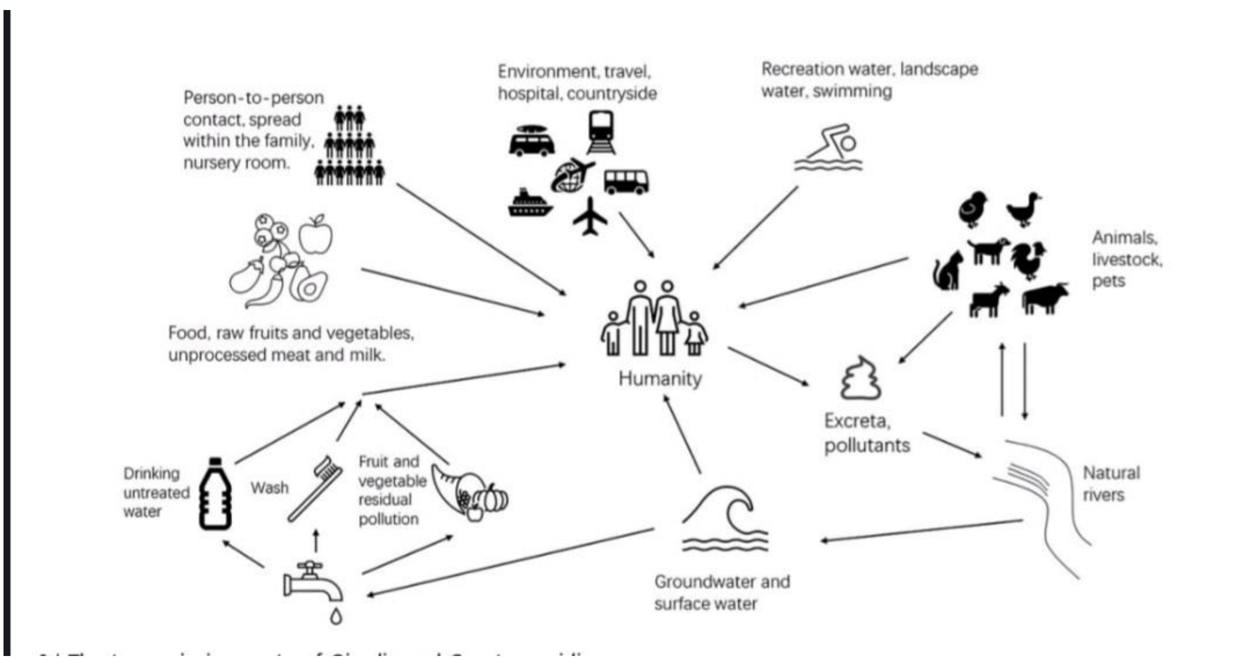

Figure 1

4. Global situation on waterborne parasites

In 2015, the World Health Organization estimated that 91% of the global population had access to an improved drinking water source through piped connection or other improved sources including public taps, protected wells and boreholes. Despite this achievement, at least 1.8 billion people are still using faecal contaminated drinking water sources which are causing an estimated 500,000 diarrhoeal deaths, each year (Lim & Nissapatorn, 2017).

Waterborne outbreaks reported worldwide in this period, 2011-2014, were heavily skewed to two regions, North America and Australasia,. The majority of the reported outbreaks (63%, or 151 240 outbreaks) had *Cryptosporidium* spp. as their etiological agent, while *Giardia* spp. was the cause of 40% of them. No other protozoa were reported as the causative agents of 153 parasitic protozoan waterborne outbreaks between the years 2011-2016. A single outbreak due to 154 contamination of drinking water by *Cyclospora cayetanensis* took place in Puerto Rico in 2008 but 155 was not reported until later and is included here as it was not reported in time 156 for the previous reviews. Surprisingly, nearly a half of the reported worldwide waterborne outbreaks caused by parasitic protozoa were reported in Australia and New Zealand. A total of 185 (47%) 160 outbreaks were reported in New Zealand alone, with 3 (1%) in Australia. The waterborne outbreaks on the American continent amount to almost 40% of the worldwide waterborne outbreaks, all but one of which occurred in the USA. Europe contributed with 10% of worldwide waterborne outbreak reports. The distribution within the European countries was: Ireland 2.4% (9) of worldwide waterborne outbreaks, the UK 2.4% (9) and at least 8% (7) in continental Europe (Norway 1, Sweden 2, France 2, Belgium and Germany, 1 each). In Asia, only three (1%) waterborne parasitic protozoan disease outbreaks were reported, two from the Republic of Korea and one in China. (Efstratiou et al., 2017)

In contrast, limited outbreak data were recorded for developing countries, for example parts of Asia, Africa and Latin America. This was mainly due to the apparent lack of an organised and standardised documentation systems coupled with inadequately sensitive detection methods for protozoan infections or waterborne diseases, rather than it being a reflection of the actual scenario. (Lim & Nissapatorn, 2017)

5. Pathogenic parasite from water in Iraq

1. Giardia *Giardia intestinalis* also known as *G. duodenalis* or *G. lambia* is the only species that infects human. In the environment, *G. lambia* exists as a pear-shaped cyst approximately 8- 12 µm in size The cyst wall contains a chitin-like substance that acts as a protective layer and makes the wall resistant to environmental conditions.. Giardiasis results in diarrhea like symptoms in symptomatic (90%) patients, which are usually self-resolvable in two to six weeks' time in healthy individuals. (Samuelson et al., 2013)

Figure 2. Trophozoite of Giardia lamblia

2. Cryptosporidium Several species of Cryptosporidium have been described; however human infections are more frequently caused by *C. parvum* or *C. hominis*. *C. parvum* results in gastrointestinal infection which can get fatal in new born and immunosuppressed patients, and may also result in respiratory and gallbladder infections. In environment, Cryptosporidium exists as a spherical oocyst about 5 µm in diameter. Oocysts are tough and durable structures resistant to various chlorine-based disinfectants used for water treatment systems. (Leitch,. 2011)

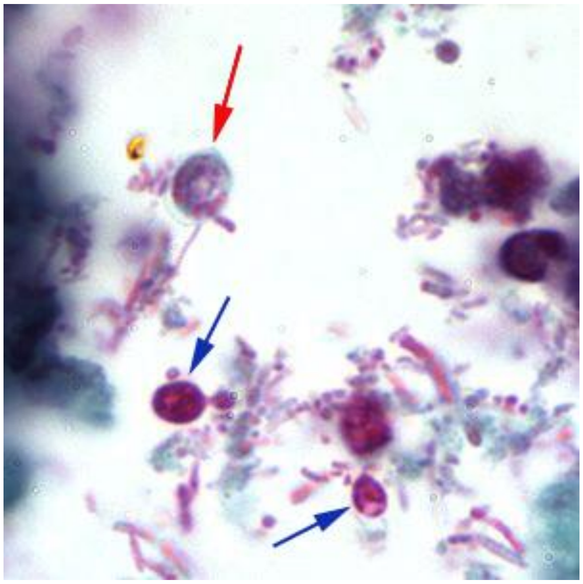

Figure 3. Oocyst of Cryptosporidium Parvum

3. Entamoeba Out of the six *Entamoeba* species that infect humans, only *E. histolytica* is known to cause disease. *E. histolytica* causes amoebic dysentery and liver abscess. Both cysts and trophozoites are passed in feces. Cysts are typically found in formed stool, whereas trophozoites are typically found in diarrheal stool. Infection however occurs by ingestion of mature cysts. Cyst is thus both the diagnostic and infectious form. It contains four nuclei and is surrounded by cyst wall containing chitin and chitin-binding lectins. (Dumètre,2013)

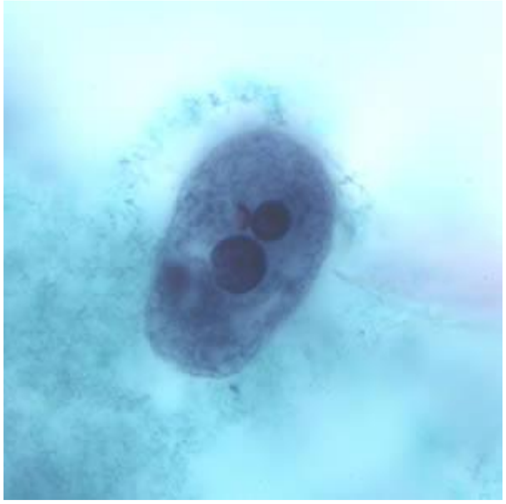

Figure 4. Trophozoite of Entamoeba histolytica

4. Balantidium *coli Balantidium* coli is a species of protozoan parasite that is pathogenic in humans. Balantidium coli is localized in the caecum and colon. *Balantidium coli* has two developmental stages; trophozoite and cyst. Trophozoites proliferate and become cysts in the intestines.. If the balance develops between the parasite and host, clinical signs may not be seen in infected humans. The infection is most likely to occur in people who are malnourished, with low stomach acid, or in people with weakened immune systems .Common symptoms of infection; chronic diarrhea, nausea, occasional dysentery (diarrhea with the passage of blood and mucus), halitosis, colitis, abdominal pain, weight loss, deep intestinal ulcers and possibly intestinal perforation. Bleeding may occur in fulminant acute balantidiasis, which can lead to shock and death. (Dinç,.2021)

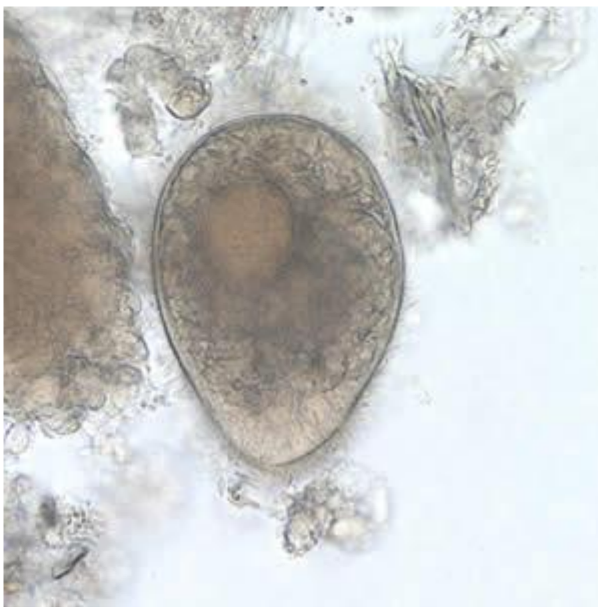

Figure 5. Trophozoite of Balantidium coli

5. Acanthamoeba spp. The life cycle of *Acanthamoeba* consists of two stages: an actively feeding, dividing trophozoite and a dormant cyst. The trophozoites Both the trophozoite and cyst usually possess a single nucleus. The trophozoite converts into a double-walled cyst when conditions become adverse. *Acanthamoeba* species can act as both opportunistic and non-opportunistic pathogens and may cause blinding keratitis and fatal granulomatous encephalitis (GAE) involving the central nervous system. Symptoms of keratitis are intense pain, lacrimation and photophobia of eye and headache; fever and abnormal behaviour are the symptoms of GAE. (Visvesvara,.2013)

Figure 6. Cysts of Acanthamoeba spp.

6. Naegleria fowleri has three stages in its life cycle: a trophozoite, a cyst, and a flagellate; hence, it is also called an amoeboflagellate. The trophozoite is a slug-like amoeba that feeds on Gram-negative bacteria and reproduces by binary fission. It exhibits rapid sinusoid movement by producing anteriorly hemispherical bulges called lobopodia. The posterior end (the uroid) is sticky and often has several trailing filaments. The trophozoite differentiates into a pear-shaped biflagellate stage in response to sudden changes in the environment and transforms into the resistant cyst during adverse conditions when the food supply becomes scarce or the environmental niche dries. The cyst is usually spherical, , and is doublewalled with a thick endocyst and a closely apposed thinner ectocyst. *N. fowleri* causes an acute and fulminating infection called primary amoebic meningoencephalitis (PAM) in persons who have had contact with contaminated water a few days preceding the infection. PAM usually occurs during the summer months when the ambient temperature is high and almost always leads to death within a week to 10 days .PAM symptoms are similar to GAE caused by *Acanthamoeba* species: headache, fever, nausea, stiff neck, confusion, seizures, and hallucinations. (Visvesvara,.2013)

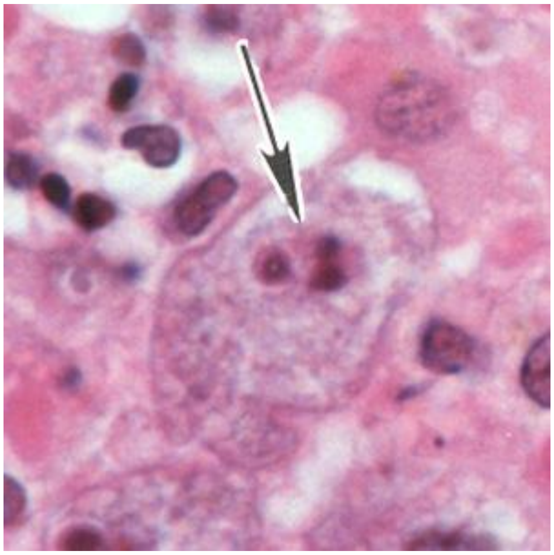

Figure 7. Trophozoite of Naegleria fowleri

Table 1. Some of the most important protozoan parasites transmitted through water and their clinical symptoms (Hoseinzadeh et al., 2021)

Parasite	Disease	Transmission route(s)	Stage of transmission and pathogenesis
Giardia duodenalis	Giardiasis	Drinking water and contaminated food, pool water, contaminated surfaces in public places.	*Giardia* spp. is transmitted to humans through fecal-oral route, so swallowing a *Giardia* spp. trophozoites can cause the parasite to settle in the small bowel and develop giardiasis.
Cryptosporidium Parvum	Cryptosporidiosis	Water amusement parks, swimming pools, eating contaminated food, contact with infected animals, people, or solid surface.	The oocysts are transmitted to humans through contaminated drinking water.
Entamoeba histolytica	Amebiasis	Contaminated water or food, surface stagnant water (river).	The disease is caused by the mature cysts, through water, or contaminated food. The parasite's cysts are very resistant and can survive for weeks in moist soil. After the cyst enters the gastrointestinal tract, it becomes active and causes disease.
Balantidium coli	balantidiasis		The disease is caused by the cyst through water or contaminated food. After digestion, the cyst becomes vacuolar or granular or remains the same.
Acanthamoeba	Acanthambiasis	The opportunistic parasite is found in soil, dust, fresh water, seawater, stagnant surface water, swimming pools, dental units, air conditioners and hospital spaces.	The first step in acanthambiasis is to stick to the cell surface. In these cases, the amoeba may enter the bloodstream through the olfactory epithelium, lungs, skin lesions, or mucosa and spread to the brain.
Naegleria fowleri	Primary amoebic meningoencephalitis (PAM)	This amoeba is abundant in lakes, rivers, and hot springs, ponds, swimming pools and even urban water sources that are not well-disinfected. Although it is "thermophile", but also identifies in the natural waters of tropical climate and is more likely to be affected during the warm seasons.	It never leads to disease by "drinking" contaminated water. When *Naegleria fowleri* enters the nasal cavity, it passes through the nasal mucosa and the cribriform plate in the ethmoid bone through the skull and enters the brain. It first affects the frontal lobe and the olfactory bulb, causing extensive damage in those areas. It then spreads to the base of the brain, the brainstem and cerebellum, possibly damaging these areas by secreting enzymes. Finding trophozoites in biopsy confirm diagnosis.

6. Prevalence of parasitic pathogens in water resources in Iraq

Table 2. Prevalence of parasitic pathogens in water resources in Iraq

Province	Type of water	Parasite species	Percentage of contamination with parasites	Total	Reference
Samara	drinking water	Entamoeba histolytica Giardia lamblia Cryptosporidium parvum	36% 23% 21%	80%	(Mohammed, S.A., 2022)
Basrah	Drinking water	Entamoeba histolytica Giardia lamblia	8% 7.2%		(Mahdi,H.J., 2016)
Baghdad	tap water	Giardia lamblia Cysts Entamoeba histolytica/E. dispar cysts Cryptosporidium spp. Cyclospora cayetanensis	3.47% 2.08% 1.38% 1.38%		Ihsan M. Al-Sagur(2015)
Babylon	Drinking water	Cyclospora Entamoeba. histolytica Entamoeba. coli Giardia. lamblia H. diminuta Taenia sp. A. lumbricoides E. vermicularis	1.9% 14.4% 1.9% 4 1.9% 0.96% 0.96% 1.9%. 0.96%		Kassim A.H.(2015)
Al-Diwaniyah	wastewater	Enterobius. vermicularis Ascaris. lumbricoids Giardia. lamblia Entamoeba. Coli	75% 41.176% 45% 0%		(Khah KH and Abbas A 2020)
Saladdin	water wells	Ova of Toxocara canis Cyste of Entamoeba coli Ova of Toxocara canis Cyste of Entamoeba histolytica Ova of Ascaris lumbricoides	6% 11% 13% 23% 7%		(Jamal Zangana & Ahmad Erdeni, 2019)

7. International standard of drinking water

The World Health Organization (WHO) has been active in issuing and developing water quality standards through its guidance. The first published report of drinking water quality guidelines and testing methods in 1958 and European drinking water standards in 1961. Guidelines for drinking water quality were issued in 1963 by WHO, followed by several guidelines for drinking water quality and development. In 1974, the United States established the US Environmental Protection Agency (EPA), which is responsible for setting drinking water standards as a result of growing concern about water-borne desise. (Frisbie,.2022)

The drinking water quality guidelines of the World Health Organization (WHO) cover various aspects that cause harm to health, including physical, chemical, biological and radiological aspects. The World Health Organization (WHO) provides guidance to all the international community for use by governments to set their own national standards. Consumption of drinking water contaminated with microbes is one of the biggest threats to public health. WHO has identified several properties that characterize pathogens transmitted by drinking water which are called waterborne pathogens. There are several characteristics to judge water-borne pathogens: 1) Have the ability to grow in the environment—Cause acute and chronic diseases; 2) They oftenس stick to suspended solids in water, and their concentration changes so that the risk of injury cannot be predicted from their average concentration in water; 3) The disease caused by exposure to the pathogens depends on the dose, invasion and virulence of the pathogen, and the immune status of person; 4) Have the ability to reproduce/multiply inside the host and can reproduce in foods, beverages, drinks or warm water systems, and this increases the risk of infection; 5) Pathogens do not show a cumulative effect unlike many chemical agents. (Hikal,.2020)

Protecting public health is the main objective of the World Health Organization through its guidance that is useful in providing documented basics that are useful in setting national standards for drinking water quality, health risks and impacts associated with drinking water contaminants, best options for managing drinking water and disease prevention and control. International standards drinking-water (1958) is the oldest edition, followed by the second edition in 1963, the WHO did not established guidelines for parasites. WHO recommended guidelines for parasites starting in 1971 with the development of the following editions. In 1998, the WHO did not establish any new guidelines for the parasites. (WHO,.2017)

8. Personal hygiene

World Health Organization (2007) estimates that 94% of waterborne diarrhoeal cases are preventable through changes to the environment which includes interventions to increase the availability of clean water for drinking and to improve sanitation and hygiene practices. In addition, a 2005 systematic review concluded that diarrhoeal episodes are reduced by 25% through improving water supply, 32% by improving sanitation, 45% through hand washing, and by 39% via household water treatment and safe storage other interventions to reduce waterborne diseases are improvements in drinking water, hygiene practices and sanitation facilities and in less developed countries. (Manetu, W.M. and Karanja, A.M. 2021)

The main factors that reduce the relevance and impact of protozoal infections in the field of public health are education in sanitation and hygiene, abundant availability of good quality water, good sanitary conditions and adequate disposal of human and animal excrements. Education and motivation to change people hygienic behavior should take place in the context of the family (Newson et al., 2013).

People can protect themselves and others from water-related protozoan diseases by practicing good personal hygiene, which includes washing their hands before preparing and eating food, after going to the bathroom, after changing diapers, and before and after tending to someone who is sick. Therefore, the water tanks must be clean and closed, it is necessary to clean and disinfect them on a regular basis. When collecting or storing water, it is not allowed for anyone to put one’s hands into the water and drink directly from the water tank. If possible, water tanks should have a narrow neck and a stopper to avoid contact of water with hands, otherwise water must be taken from the tank with a ladle or a mug. In addition, it is necessary to use the available water to the end, and then rinse the tank thoroughly with clean water before next filling. Moreover, water for domestic purposes should be kept in tanks for as short a time as possible. (Bloomfield et al., 2017)

9. Conclusions

In this review, we have focused on waterborne parasites in Iraq and on the occurrence of waterborne protozoa in different water supplies sources in Iraq in last year's period. This serves to highlight the deficiency in our knowledge regarding the frequency and extent of waterborne parasites in Iraq. The establishment of surveillance systems in Iraq would be the first step in combating parasitic protozoa and improving the health of the population.

This literature review has found limited number of published studies on waterborne parasitic diseases in Iraq. Nevertheless, available studies reveal prevalence of amoebiasis, giardiasis, cryptosporidiosis, cyclosporiasis, toxocariasis hymenolepiasis, ascariasis and enterobiasis in the country in recent years. This is compounded by the fact that there are massive gaps of knowledge in the occurrence, morbidity and mortality associated with parasitic diseases.

Control of waterborne parasitic diseases should include improvement of drinking water sources and sanitation facilities. Introduction and strengthening of water sanitation and hygiene programmes in communities advocated. We must remember the clear benefits of developing sustainable access to safe drinking water and basic sanitation so that debilitating outcomes of parasitic infections and the poverty trap can be addressed.

Also, guidelines on wastewater usage are needed to minimize human exposure to these pathogens. Contaminated wastewaters used for irrigation pose a serious human infection risk and enhancing the re-circulation of these parasites.

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