

Prevalence of Giardiasis due to wastewater reuse for agriculture in the suburbs of Asmara City, Eritrea

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A study was undertaken to assess the health impact of utilization of the raw domestic sewage for vegetable cultivation in the suburbs of the capital city of Asmara, Eritrea. Standard techniques were adopted for the analysis of the samples. Results showed heavy contamination of vegetables by faecal coliforms as well as with *Giardia* cysts. Stool samples of 75 farmers who were occupationally exposed revealed that 45% of them were harbouring giardia cysts. The dietary intake of raw salads (lettuce, cabbage) grown on the raw sewage appear to be a causative factor of Giardiasis in the farming community as well as in the town of Tsadachristian located on the suburbs of the capital city of Asmara. The hospital data of the affected town is compared with other towns of Eritrea. The result indicates agriculture reuse of untreated wastewater is a major cause for the increase in Giardiasis.

Keywords: Wastewater reuse; vegetable cultivation and Giardiasis.

Introduction

Eritrea is situated in Northeast Africa; it has a total area of 124,320 km² and a population of about 3.5 million. Ethiopia borders it in the south, Sudan in the West, Djibouti on the southeastern flank and the Red Sea to the east. The capital city of Asmara is located at an elevation of 1,700 metres above sea level with a population of about 0.5 million. Water is a scarce commodity in rural as well as in the urban parts of Eritrea. Hence, untreated urban sewage is utilized for the cultivation of vegetables including salads in the Peri-urban areas of Asmara city. The untreated raw sewage flows through a stream called Maiballa. The wastewater is likely to contain many fold levels of bacteria, parasitic organisms and other pathogenic organisms posing a health risk to the consumers. However, research in this direction carried out in other parts of the world (Linnemann *et al.* 1984; Fattal *et al.* 1986; Esrey *et al.* 1988; Shuval *et al.* 1989; Cifuentes *et al.* 1993; Srikanth *et al.* 1994) reveal various health hazards to the consumers and farming communities involved in this practice. Apart from contamination from direct exposure, the health risk associated is due to under cooked and raw consumption of vegetables. Several epidemiological studies have revealed the health effects associated with the agricultural use of wastewater in the farms (Kowal and Pahren 1980; Dorn *et al.* 1985; Clark 1987; Blumenthal *et al.* 2001).

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Giardiasis, mainly a water-borne disease in many countries has already been attributed to inadequate treatment of water (Chute *et al.* 1987; Kettlewell *et al.* 1998). However, exposure to untreated sewage may potentially result in an increase in giardiasis among consumers and farm workers as reported by Esrey *et al.* 1989 in Lesotho, Southern Africa and Cifuentes *et al.* (2000) in Mexico. Helminthic and Salmonella infections due to wastewater reuse in Morocco was reported by Aiat Melloul and Hassani 1999 and Habbari *et al.* 2000.

However, the health impact due to sewage farming has not been studied in this country and this is a first attempt in this direction. The negative impact arising out of this practice may result in

- (a) Microbial contamination of vegetables.
- (b) Health hazards to community consuming vegetables and raw salads.
- (c) Occupational hazards to farm workers and the consumers.

Considering these issues, a study was designed for the first time to assess the health impact arising from sewage farming in the suburbs of the capital city of Asmara with the following objectives.

- Study the type of pathogens occurring in the sewage utilized for cultivation and to identify the various pathogenic bacteria and parasitic organisms in the vegetables growing in different parts along the Maibela stream.
- To assess the health impacts to farm workers exposed to raw sewage and consumers who are dependent on vegetables and salads raised on farms irrigated with untreated sewage.

Materials and Methods

Study area

The study was carried out around the capital city Asmara and its suburbs. About six sampling sites were selected along the Maibella stream, which carries the sewage load of the capital city of Asmara. The total stretch of sampling sites is around 12 km. The total area investigated was about 100 km². The six sampling sites include the following localities.

- (a) Sembel
- (b) Barjima
- (c) Paradizo
- (d) Adsagadu
- (e) Unagudu
- (f) Tsadachristian

The main crops that are grown here are green vegetables and these localities falls under peri-urban areas of Asmara city. The vegetables cultivated using sewage constitutes the only source for local consumption for the community living in the town of Tsadachristian (Fig. 1).

Predominantly leafy vegetables are grown in the wastewater. The type of vegetables cultivated includes lettuce, cabbage, tomatoes and carrots. The total area under cultivation though runs into hundreds of hectares. However, there is no correct estimate about the total area under sewage farming. The number of farm workers exposed to wastewater is more than 500. The socioeconomic and hygienic condition of farm workers is generally poor. This includes

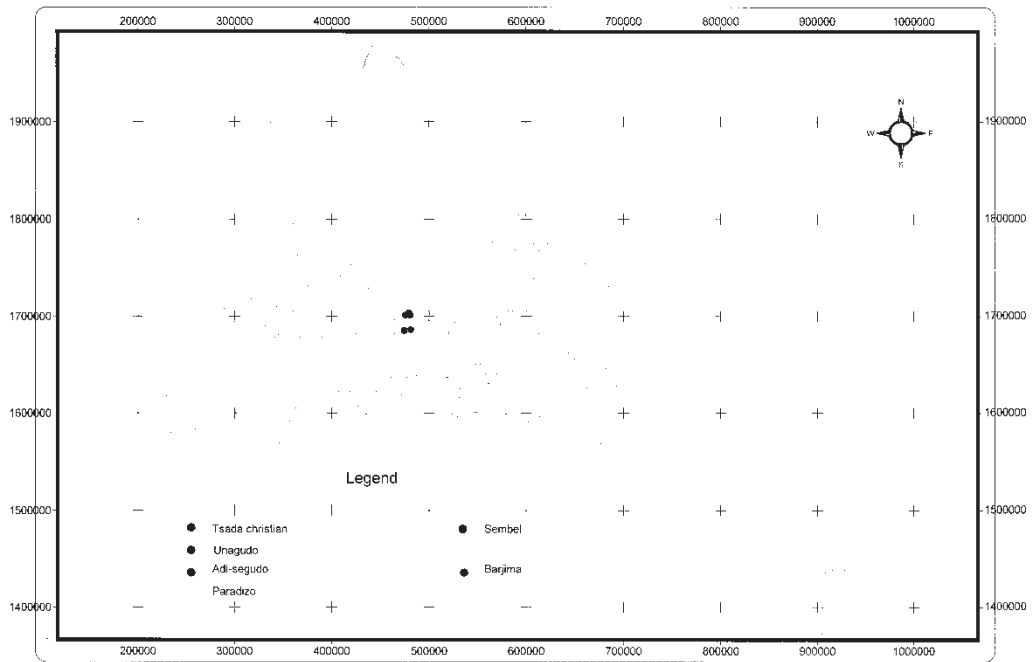


Fig. 1. Map of Eritrea showing sampling sites.

overcrowding, acute water shortage, lack of adequate sanitation, low income, and inadequate disposal of wastes.

Sampling methods

Samples of wastewater used for irrigation and vegetables were collected on a weekly basis for 4 months (May–August) from selected sampling sites. Vegetable samples were collected in clean polyethylene bags. Steps were taken to avoid soil contamination. Water samples were collected in sterilized bottles. All the samples were immediately sent to the central laboratory in Asmara within 2 h for analysis. Samples were collected in triplicate to avoid sampling error.

Faecal samples of farm workers were collected in sterile sample containers. The farm workers were instructed through local administration on how to provide samples. The stool sample bottles were collected the following morning and were examined for intestinal parasites and pathogens in the central health laboratory of Asmara. Central Health Laboratory is also the National Reference Laboratory for Eritrea.

Analytical procedures

Wastewater analysis For identification of coliforms and faecal coliforms the (thermo tolerant *E. coli*) standard method (WHO 1997) was adopted for bacteriological analysis. MPN (most probable number) technique and filtration technique was adopted for analysis. For presumptive test Lauryl tryptose sulphate broth was used. Incubation was carried out at 35°C for coliforms and 44°C for thermo tolerant faecal coliforms. MacConkey agar was used to isolate the pathogens. Identification of colonies was done by biochemical tests. For identification of

Salmonella and Shigella, tryptone Soya and selenate F enrichment method was followed. Suspected colonies were identified by biochemical tests and confirmed by serotyping.

Vegetables analysis Wash method was adopted for microbiological analysis of vegetables following the standard procedure adopted by Feenstra *et al.* (2000). A vegetable of known weight free from soil contamination was washed with 1 litre of sterile water and the wash water was screened for faecal coliforms, *E. Coli*, Salmonella and Shigella.

Stool examination for parasites For screening for intestinal parasites, the direct smear method was adopted followed by microscopic method.

Socio-economic cum health survey A cross sectional Socio-economic cum health survey was carried out by administering questionnaires in Tigrinia (local African dialect) to assess the health risk for the residents of the town, Tsadachristian. The residents of this town belong to the farming class and depend solely on the vegetables raised on the farms irrigated with sewage. The health questionnaire included close-ended questions about the occupation, family size, source of drinking water, source of vegetable, intake of raw salads, disease pattern etc. The questionnaire was administered at random to a target population of 20% of the population (200 households) i.e. approximately 1,000 population out of an estimated population of 5,025 in the town.

Results and discussions

The distribution of pathogenic and parasitic organisms in the vegetable sample is given in Table 1 and their range of distribution in the wastewater and in the vegetable samples is presented in Table 2. Tables 1 and 2 reveal heavy contamination of the vegetable samples all along the sampling sites. The source of contamination is untreated sewage. Faecal coliform is an indicator organism of sewage contamination. The number of colonies of faecal coliform in the wastewater is several folds higher than the WHO permissible limit (Table 2).

Giardia cysts were detected in considerable amounts in samples of lettuce, tomatoes and cabbage. At least one sample of lettuce obtained from the sampling sites revealed the presence of Shigella.

Prevalence of intestinal parasites among farmers exposed to wastewater

To study the prevalence of intestinal parasites, stools samples of adult farmers were screened for the presence of parasites. The samples were obtained from farmers from different localities at random all along the stream where sewage is utilized for cultivation. The result of the study is presented in Table 3.

The study shows that among the intestinal parasites, giardia is most significant. At least 45.33% farmers were found to be harbouring giardia cyst, however other helminthes infection was negligible, except for the presence of Taenia (tapeworms) in two cases. No cases of hookworms or roundworm were detected.

Stool samples of the farmers revealed the level of infection among farmers is very much higher when compared with the consumers of the affected area. This results correlate with other studies carried out in similar lines in Pakistan by Feenstra *et al.* 2001 and also elsewhere in Paris, where sewage treatment workers revealed higher risks of giardiasis when compared with

Table 1. Contamination of vegetables with pathogenic bacteria and giardia cysts along the sampling sites

Types of vegetables grown	Sampling sites	No. of sample	Faecal coliform		E. Coli		Giardia	
			No. + ve	% + ve	No. + ve	% + ve	No. + ve	% + ve
Cabbage	4	8	6	75	6	75	4	50
Lettuce	4	12	11	96.6	6	96.6	6	50
G.vegetable	4	12	12	100	11	100	3	25
Tomatoes	3	9	9	100	12	100	2	22.0
Carrots	3	9	6	66.6	9	66.6	ND	–
Cucurbits	3	6	6	100	6	100	ND	–
Total	16	62						

* ND indicates not detected.

Note: No Salmonella was detected, Shigella was however detected in one lettuce sample.

Table 2. Range of bacterial and parasites in wastewater and vegetables grown along Maibella stream

<i>Sources</i>	<i>Faecal coliform range</i>	<i>Parasite load (Giardia lamblia)</i>
Sewage water used for irrigation	$4 \times 10^4 - 13 \times 10^9 \text{ lt}^{-1}$	5–10 organism/field
Vegetables (including lettuce, cabbage, tomatoes)	$2 \times 10^3 - 4 \times 10^6 \text{ kg}^{-1}$	10–50 cyst/kg
WHO guideline for wastewater irrigation	1,000 lt^{-1}	–

Table 3. Number of positive samples for intestinal parasites in 75 stool samples examined in the farmers exposed to untreated wastewater

<i>Sampling sites</i>	<i>No of sample</i>	<i>Giardia lamblia</i>	<i>Hymenolepis nana</i>	<i>Taenia sp</i>	<i>Round worm/ hookworm</i>	<i>Salmonella/ Shigella</i>
Adisagadu	40	18	–	–	–	–
Tsadachristian	15	7	2	1	–	–
Paradizo	15	9	1	1	–	–
Semebel	5	–	–	–	–	–
Total	75	34	3	2	–	–

the general population (Doby *et al.* 1980). The major cause of the intestinal infection among the farmers is due to very poor personal hygiene and frequent exposure to wastewater.

Impact of vegetable contamination on the health of the consumers

Results from socio-economic cum health survey questionnaire revealed that the impact of contaminated vegetables cultivated along the wastewater stream is considerable, since the entire population comprising of 5,025 residents of the town of Tsadachristian, about 8 km west of Asmara city are solely dependent on the vegetables grown on untreated wastewater.

The household data revealed that the majority of the family size was more than seven. Approximately 60% of the households were found to be farmers. Half the population in the survey was using groundwater for drinking water purposes while others were dependent on tank water supplies from the municipalities. The dietary intake of all the households revealed consumption of raw salad was a common feature. The dietary intake among the Eritrean population includes regular intake of raw salad chiefly comprising of lettuce, cabbage and tomatoes (Table 4).

The age distribution of communities exposed to raw sewage revealed that a majority of the population were under 19 years (52%) and rest of them (46.9%) was adults. The complaints of diarrhoea and fever is predominant among children and adults from the families. The study showed that diarrhoea is a frequent complaint in children (48.9%) in adults (38.8%) this followed by diarrhoea complicated with fever 10% and 5% suffered from respiratory/cold ailments.

Morbidity pattern was studied based on hospital data obtained from the affected town of Tsadachristian for 3 years (1998–2001) and this was compared with other major towns of Eritrea such as Dakamare and Keran. These two towns have a population of more than 76,000 and 23,000 respectively. The socioeconomic conditions, diet and nutrition conditions of the people residing in these towns are almost similar to those of the affected town of Tsadachristian and ground water is the sole source of drinking water in these towns. However, unlike Tsadachristian town, the residents of these two major towns are free from the impact of sewage grown vegetables in their diet. This is reflected in the number of giardia cases recorded in the hospital records in these towns which was considerably less compared with Tsadachristian (Fig. 2). The number of reported cases of giardiasis is disproportionately higher in the affected town of Tsadachristian, i.e., 1998–2001 where raw salads raised on untreated sewage forms the basis of a regular diet.

Figure 3 shows the comparison of percentage of Giardiasis in Tsadachristian town, the other major towns of Eritrea and that of the national average. The percentage of Giardiasis during 1998–2000 in the two towns and at national level was less than 1% in adult populations when

Table 4. Dietary intake of three commonly consumed food among Eritrean adults

<i>Major food items</i>	<i>Approximate daily intake among adults (grams/day)</i>	<i>Total population at risk from pathogens due to consumption of contaminated vegetables</i>
Raw salad (constituting lettuce, cabbage and tomatoes)	50	Approximately 5,025
Local bread (Injera)	400	
Lentils	50	

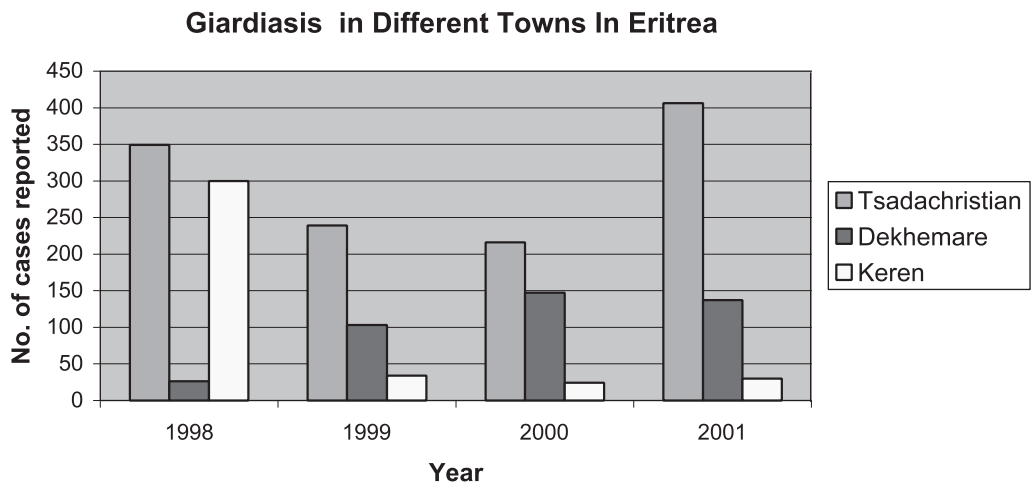


Fig. 2. Showing Giardiasis in different towns in Eritrea.

compared with the town of Tsadachristian, which was in the range between 4.78–8.12% during the period of the study.

Study elsewhere in the world suggests drinking water as a major route for giardia infection (Jephcott *et al.* 1986; Omar *et al.* 1995; Hoque *et al.* 2000) however the water quality of the town did not reveal the presence of giardia cysts, however, high coliform counts were detected in drinking water samples (Table 5). This shows that the contribution of drinking water for Giardiasis may be less significant when compared to consumption of raw vegetables contaminated with sewage in this geographical area.

Conclusions

The study conclusively reveals the impact of sewage contamination and raw consumption of vegetables in the form of salads is major causative factor in the occurrence of Giardiasis among farmers and communities. This is the first report from this geographical area and therefore, calls for urgent remedial measures in evolving strategies for health risk management. Detailed research need to be initiated on the disinfection of vegetables as a means of adopting immediate short term measures to prevent periodic reoccurrence of Giardiasis diseases in both consumers

Percentage of Giardiasis in Different Towns In Eritrea

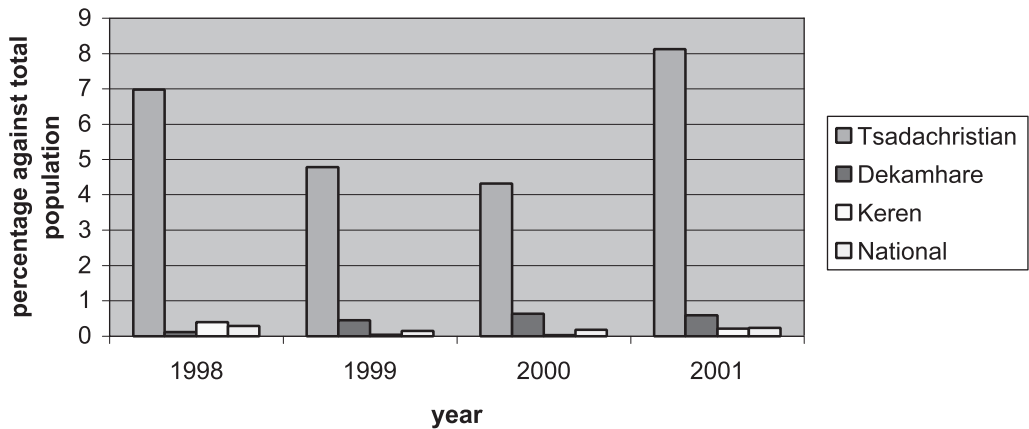


Fig. 3. Showing percentage of Giardiasis in different towns of Eritrea.

Table 5. Water quality in Tsadachristian town in Eritrea

Source	Consumption pattern	Water quality
Borehole inside hospital	80% of the population	No Faecal coliform detected
Hand dug well	20% of the population	250 Faecal coliform colonies found in 100 ml/water sample, no giardia cysts was detected

and among the farming communities. Comprehensive health education programmes should also be initiated regarding risk involved in the use of untreated wastewater for agricultural crops.

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