Health effect of urban wastewater reuse in a peri-urban area in Morocco

Omar Amahmid and Khadija Bouhoum

University of Marrakesh, Morocco

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Abstract Describes a study designed to assess the health effect of the agricultural reuse of urban wastewater in a peri-urban area of Marrakesh, by evaluating the impact of this practice on the transmission of two pathogenic protozoan infections – giardiasis and amoebiasis. The study was carried out on two child populations (608 individuals). The exposed group (321 children) came from the wastewater spreading area, while the non-exposed group (287 children) came from a control peri-urban area where surface water is used in irrigation. Results showed that, of the exposed group, 67 per cent of the examined persons were infected by giardiasis and/or amoebiasis, versus 26 per cent in the control zone. Concludes that the risk of infection rate attributable to reuse of waste water is about 41 per cent. This excess of parasitic infestation in the spreading zone may be related to wastewater reuse in agriculture, which creates a polluted environment.

Introduction

The growing urbanisation in many areas of Morocco resulted in a significant increase of generated amounts of urban wastewater. Indeed, the volume of produced wastewater increased from 129 to 470 million m³ per year from 1970 to 1994 with an annual increase rate of 5.3 per cent. In Marrakesh, water supplies are very scarce and this fact has encouraged many rural families to migrate and settle in peri-urban areas where urban wastewater is poured out. At present, raw wastewater is being used to irrigate about 3,000ha, and irrigated crops comprise trees, fodder and vegetables which are either consumed by farmer families or sold at the city markets (Water and Climate National Council, 1994). Application of urban wastewater on agricultural land has many benefits. Wastewater represents primarily a source of water and its nutrient content has been shown to have a fertiliser value for many crops and contributes to the improvement of the soil properties. However, the benefits of urban wastewater reuse may be limited by its potential health hazards associated essentially with the danger of transmission of pathogenic organisms to human beings (Korentajer, 1991).

In fact, untreated wastewater may contain many pathogens depending upon the incidence of disease in the indigenous animal and human population that discharge to the municipal sewer. To date, a limited number of epidemiological studies have been conducted in the exposed peri-urban areas to evaluate the...
extent of the incurred risk. As a result, the World Health Organisation (1989) has stated that further studies are necessary to determine whether or not an association exists between first, infection rate and wastewater reuse in irrigating crops and second, the onset of infections between farm workers and their family.

An epidemiological study was carried out to determine the impact of the urban wastewater reuse in agriculture on the transmission of two protozoan infections, giardiasis and amoebiasis, to children in a peri-urban area of Marrakesh. These two infections are pathogenic and recently giardiasis has been recognised as the most frequent protozoan infection and is becoming a major public health concern. An increase in the incidence of waterborne outbreaks of giardiasis is reported in many parts of the world, yet the role sewage reuse has played in the transmission of these parasites is not established.

**Material and methods**

*Study populations*

Children were chosen to be the subjects of the present study since they have been reported to constitute the most vulnerable and exposed group to parasitic infections (Savioli *et al.*, 1992). The study was carried out on two child populations, totalling 608 individuals, comprising males (51 per cent) and females (49 per cent), from two to 14 years old (Table I). The first population constitutes the exposed group (321 children), living in the wastewater spreading area of Marrakesh, a peri-urban zone where urban wastewater is used for irrigation purposes. The second population is a control group (287 children) issued from a peri-urban area with similar social living standards, in general, but surface water is used for irrigation (control zone). Data on individual exposure and on potential confounding factors (water supply, sanitation, hygiene etc.) were collected by suitable questionnaires developed and tested prior to use.

<table>
<thead>
<tr>
<th>Group</th>
<th>Children from sewage farming</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-8</td>
<td>97</td>
<td>79</td>
</tr>
<tr>
<td>9-14</td>
<td>77</td>
<td>68</td>
</tr>
<tr>
<td>Father’s job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer</td>
<td>89</td>
<td>79</td>
</tr>
<tr>
<td>Other occupation</td>
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<td>68</td>
</tr>
<tr>
<td>Total/sex</td>
<td>174</td>
<td>147</td>
</tr>
<tr>
<td>Total/area</td>
<td></td>
<td>321</td>
</tr>
<tr>
<td>Total number</td>
<td></td>
<td>608</td>
</tr>
</tbody>
</table>

Table I.

Distribution of investigated children by sex, age and father’s occupation.
Stool samples
As a subject may not be declared non-infected by a single stool examination, because of the existence of negative phases in which no cyst is eliminated in faeces, the repetition of examinations was necessary. So, three samples were taken from each subject at one week intervals. A subject is considered non-infected if the three examinations appear negative. The study took place over an extended period (several months) working in both exposure groups at the same rate.

Stool samples were collected in sterile faecal containers. The stools were concentrated by formalin-ether technique (Beaver et al., 1984) and the sediment was visualised microscopically at 100× and 400× magnification. Protozoan cysts were identified following iodine staining using a Thoma counting chamber.

For each group of children, the prevalence of infection was determined. The attributable risk designates the risk of infection related to raw wastewater reuse in irrigation (attributable risk = prevalence in exposed group – prevalence in the non-exposed group).

Results
Protozoan infections in exposed and control children
Results showed that there were more protozoan infections in the exposed group with a prevalence of 67 per cent against 26 per cent for the control group ($p < 0.001$).

Giardiasis was observed in 39 per cent of the exposed group against 20 per cent in the control group; while amoebiasis was observed with respective prevalences of 28 per cent and 6 per cent (Figure 1). The difference noticed was statistically significant ($p < 0.001$).

The overall risk of pathogenic protozoan infections attributable to wastewater reuse in the spreading peri-urban area of Marrakesh was approximately 41 per cent (19 per cent and 22 per cent for giardiasis and amoebiasis, respectively).

![Prevalences of giardiasis (Giar.) and amoebiasis (Amoe.) in exposed and control groups](image-url)
Parasites distribution by sex, age and father’s occupation
To determine the children most exposed to parasitic infections in the wastewater spreading peri-urban zone, infection rates were analysed according to sex, age and father’s occupation.

With respect to the sex of the children, 30 per cent of males were infected with amoebiasis versus 26 per cent of females. For giardiasis, the respective prevalences for the two sexes were 44 per cent and 33.3 per cent (Figure 2). More males than females seem to be infected; however, no statistically significant difference was noticed ($p > 0.05$).

The prevalence of intestinal protozoa in the children in the spreading area varies according to age (Figure 3). The prevalence of giardiasis reached 47 per cent among children of two to eight years, versus 30 per cent for children of nine to 14 years. The difference is statistically significant ($p < 0.001$). The respective prevalences of amoebiasis in the two age groups were 33 per cent and 23 per cent and there is no statistically significant difference ($p > 0.05$).

With regard to the father’s occupation, pathogenic protozoan infections (giardiasis and amoebiasis) were observed in 78 per cent of the farmers’ children against 56 per cent for the other occupations ($p < 0.05$). Higher prevalences were recorded even for giardiasis and amoebiasis among the children of farmers in the spreading area (Figure 4).

Figure 2.
Prevalence of childhood giardiasis (Giar.) and amoebiasis (Amoe.) according to sex in the spreading area

Figure 3.
Prevalence of childhood giardiasis (Giar.) and amoebiasis (Amoe.) according to age in the spreading area
Discussion

The role urban wastewater reuse has played in the dissemination of parasitic infestations is not well established and available epidemiological data are very scarce especially for protozoa infections (Ayres et al., 1992; Mara and Cairncross, 1994; Bouhoum and Schwartzbrod, 1998). This fact limits the degree to which accurate comparisons between studies can be made. The current study showed that children living in the peri-urban area where urban wastewater is poured out are more likely to have protozoa infections than a control group issued from a control peri-urban area of the same socio-economic characteristics. A higher prevalence of amoebiasis and giardiasis in children of the farming area than in the control group was observed. The higher frequency of recorded infections among children in the wastewater spreading area may be related to activities which tend to place them in direct contact with contaminated sources (wastewater irrigation, field upkeep, harvest, etc.), in addition to the role played by the consumption of contaminated agricultural products. In fact, although raw wastewater reuse for vegetable irrigation is forbidden by Moroccan law, in the wastewater spreading area of Marrakesh some fields are planted with various types of vegetables (marrow, turnip, radish, eggplant, squash, etc.) and analysis undertaken on crop samples showed that they were contaminated by protozoan cysts (Amahmid et al., 1999). Pound and Crites (1973) demonstrated that the incidence of parasitic diseases in consumers of sewage irrigated crops was higher than that of controls. Bryan (1974) reported two outbreaks of amoebiasis in the USA, both associated with food contaminated by wastewater.

The results of the present study corroborate those reported in the literature on protozoan and helminthic infections in the wastewater spreading areas (Strauss and Blumenthal, 1990; Srivastava and Pandey, 1986). In Mexico, Cifuentes et al. (1992) reported that *Entamoeba histolytica* was more frequent in children of farmers using wastewater, compared to a control group. In Aleppo (Syria), Bradely and Hadidy (1981) found that 60 per cent of the population was infected with intestinal parasites. They concluded that use of untreated sewage for irrigation was the main causative agent of the high parasitic infestation.

![Figure 4. Prevalence of childhood giardiasis (Giar.) and amoebiasis (Amoe.) according to father’s occupation in the spreading area](image-url)
among the population. A study from Germany (Anders, 1954) showed that 37 per cent of sewage farm workers were infected with *Trichuris trichiura* compared to 5 per cent of sewer workers. Strauss and Blumenthal (1990) recorded a significantly greater incidence of Ascaris infection in farm workers (50 per cent) than in controls (16 per cent). Shuval *et al.* (1986) indicated that the risk due to wastewater reuse varies from 30 to 60 per cent. Blumenthal *et al.* (1994) showed that exposure to raw sewage is associated with increased Ascaris infection in workers in all age groups, but particularly in the children of farm workers. This observation has been made by other researchers (Healy, 1979; Bradely and Hadidy, 1981; Estevez *et al.*, 1983) and is related to imprudence and non-hygienic practices of the children (Feachem *et al.*, 1983). In fact, during the visits undertaken to the peri-urban area receiving urban wastewater, young children have been frequently observed playing near irrigation canals and in irrigated fields, without taking any precautions, in addition to the ingestion of soil particles from putting fingers into their mouths.

**Conclusion**

The present study has raised a situation in which urban wastewater reuse in agriculture is the main causative agent of the high protozoan infestations (giardiasis and amoebiasis) among the infantile population in a peri-urban area where raw urban wastewater is reused for irrigation. The uncontrolled reuse of raw wastewater in agriculture in this peri-urban area would be a real threat for urban population health as it provides the adjacent urban markets with contaminated agricultural products. The prevention of these risks can be achieved by an integrated set of measures which may include wastewater treatment, crop restriction, appropriate wastewater application techniques and human exposure control. This would contribute to the improvement of the socio-economic and sanitary level of peri-urban populations and provide urban markets with agricultural products of the best hygienic quality.

In perspectives, after description of the attributable risk of infection to wastewater reuse in the child populations, further studies, including adults, have to be carried out in order to be able to generalise what the effect of an equivalent practice would be on other similar communities in other parts of Morocco. On the other hand, the occurrence and removal of pathogens in wastewater treatment processes and assessment of their viability on crops, soil and water would be of interest.

**References**


