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PARASITIC INFECTIONS OF DRY SEASON FARMERS IN SOME PARTS OF PLATEAU STATE, NIGERIA

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A parasitological survey was conducted among 1080 dry season farmers and controls spread over nine farming locations in the Jos and Barkin-Ladi areas of Plateau State, Nigeria, to provide data or parasitic infections in the area due to waste utilization. Standard laboratory procedures were adopted in the collection, processing and parasite identification in the stool samples. The rates of parasites infections in the farmers were 91.6% for helminthes and 86.4% for protozoa. Helminth infection rates but not those of protozoa, varied significantly between farmers and controls. Average infection rates were. Ancylostoma duodenale 91.9%. Ascaris lumbricoides 84.7%, Trichuris trichiura 74.2%, Strongyloides stercoralis 50.3%, Giardia lamblia 13.3%, Entamoeba coli 28.4%, Chilomastix mesnili 15.4%, Endolimax nana 17.3%, Isospora belli 6.3% and Lodoamoeba butshili 11.5%.

More males than females were infected. The rates of infection varied among farmers in the different locations, but younger farmers had higher prevalences. Significant correlations between infections and their symptoms were observed with diarrhoea and abdominal pains being most common.

INTRODUCTION

One major aspect of development challenges confronting mankind towards the close of the 20th century was how to achieve a cost effective, technologically appropriate and environmentally benign strategies to deal with the waste crisis. The threat of the waste crisis. The threat of the waste on the assimilative and carrying capacities of our land, water air, and the overall environment is enormous. For this reason, waste utilization in agriculture, aquaculture and biogas production has gained prominence. For this reason also, the application of community/municipal refuse, urban and rural soil, animal manure mainly from cows, pigs, goats, sheep, poultry; crop residues, green manures and some aquatic plants to agricultural land has become a better alternative than the costlier chemical fertilizers in many countries of the developing and industrialized world.

However, wastes from all communities contain parasites. These parasites survive to different degrees as the wastes are transported, treated and applied to land (2). The parasites present in such wastes also constitute a health hazard to agricultural workers, waste handlers and consumers of crops so produced (3,4). The presence, prevalence and distribution of intestinal parasites in wastes have been reasonably reported in different parts of the world (4,5-9). The most important of these parasites among others are ***Ascaris lumbricoides, Necator*** americanus ***Ancylostoma duodenale, Trichuris trichiura, Taenia*** spp and some protozoa.

In Nigeria, the parasitic diseases that have been associated with solid wastes include malaria, myiasis, amoebiasis, filariasis, ascariasis and taeniasis (10,11). Ologhbo (12) demonstrated the role of wastes in the transmission of ***Trichuris trichiura*** and ***Ascaris lumbricoides*** in slums and low-income neighbourhoods, of many towns and cities in Nigeria. Okoronkwo and Onwuliri (13,14) documented significantly high prevalence of protozoa cysts and helminth eggs in municipal waste handlers; and from municipal refuse and abattoir wastes respectively in Jos Metropolis of Plateau State, Nigeria.

A number of intestinal parasites of cattle, pigs, ruminants and poultry which are of public health importance have been reported (5) gastrointestinal nematode eggs have also been regularly demonstrated in dung heaps on farms elsewhere (16-19).

Previous studies indicated that there is an increasing use of waste waters human and animal wastes for irrigation agriculture in Plateau States (20) and that as a consequence of this, there is contamination of vegetables and salad crops as produced by helminth eggs (21). Similarly, studies of irrigation water, as well as the stream and pond sediments also revealed the presence of parasitic helminthes (22,23).

The objective of the present study is to describe the parasite impact and the public health importance of waste utilization on dry-season irrigation farmers in some parts of Plateau State, Nigeria.

MATERIALS AND METHODS

The Study Area:

This study was carried out in six Local Government Areas of Plateau State, Nigeria, including Bassa, Jos North, Jos South, Jos East,

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Riyom and Barkin-Ladi, where intensive dry season irrigation farming is going on. Further details of the study area are shown in Figure 1.

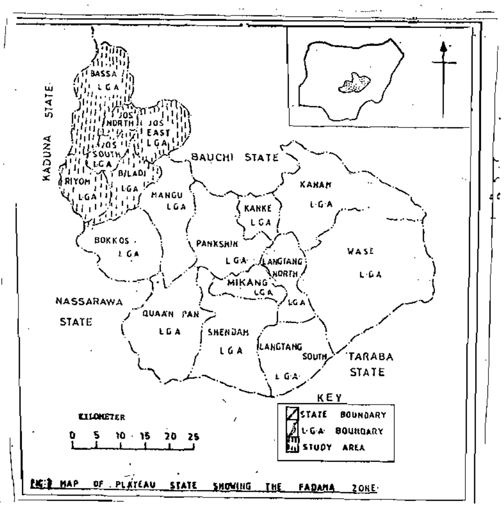

Figure 1: Map of **Plateau State** Showing the Fadama Zone.

The Dilimi River and its tributaries as well as five other rivers and eight abandoned mine ponds were the major sources of water for crop irrigation in the study area. These water bodies received numerous discharges of raw sewage, animals slurries, night soil, municipal/community refuse from the municipality with some diversions, from where the wastewater laden river water was transported to cultivation areas through irrigation canals.

In the dry season, the irrigation farmers make substantial investments towards the building of canals and appurtenances. The farmer produce a variety of exotic crops, which include tomatoes, carrots, lettuce, cabbage, cucumber, onions and other such vegetable and salad crops meant for the Nigerian market.

In this cross-sectional comparative study, the cluster sampling technique was adopted in the random selection of one hundred and twenty farmers from each of the nine sampling stations (giving a total of 1080 samples). One hundred and thirty five other farmers who used only chemicals fertilizers and matched for age and sex were similarly selected as controls (24).

Stool samples were collected from each of the 1080 dry-season farmers and 135 controls. The samples were quickly preserved in 10% formal-saline and transferred to the Public Health Laboratory of the Department of Community Health University of Jos, for examination for the presence of protozoal cysts and helminthic eggs. Stool concentration was done using the formal-ether concentration technique modified by Allen and Ridley (25). Parasite eggs were quantified by the Stoll egg count technique modified by Fleck and Moody (26) in all the positive stool samples.

The type of cysts and eggs of parasite encountered in the samples were identified to reference to Muller (27) and Soulsby (28).

The results were fed into the computer (Epi Info version 5) and the chi-squared test was used for comparative analysis.

RESULTS

Out of a total 1080 dry-season farmers spread over nine locations in the study area, 989 (91.6%) were infected with one type of helminthic parasite or the other, while 633 (86.4%) were infected with different types of protozoa (Table 1). Similarly, of the 135 farmers in the control group, 104 (76.5%) had helminth infections, while 77 (56.6%) had protozoal infections. There was a significant difference in the combined rates of infection with both helminths and protozoa between the control group and the rest of the farmers (Chi-square=16; df=8 $p<0.05$). There was however, no significant difference between the infection rates of the control and the rest of the farmers at the different locations.

Infection rates between the farmers and control were however, significantly different with ***Schistosoma mansoni*** (476 (44.1%) versus (32 (23.7%); ***Ascaris lumbricoides*** 915 (84.7%) and ***Trichuris trichiura*** 801 (74.2%) versus 66 (48.9%) (Chi-square = 8.7; df = 3 $p<0.05$). ***Enterobius vermicularis*** infection in the two groups was not significantly different. ***Strongyloides stercoralis*** infection however, was significantly different between the farmers 543 (50.3%) and control 24 (17.8%) (Chi-square = 1.6; df = 1 $p<0.05$).

Table 2 shows the prevalence of different parasitic species among the farmers at the different locations. The results show that there was no significant variation between infection rates by protozoa in the farmers and the control. But between locations, ***Entamoeba histolytica*** infection was highest in farmers at Anglo Jos (41.7%) and Zaramaganda (41.7%). Farmers at Anguldi had 50.0% of them infected with ***Entamoeba coli***, The table 2 further indicated that among the helminths, infection rates with ***Taenia*** spp; ***Hymenolepis nana, Hymenolepis diminuta, Dipylidium caninum*** and ***Enterobius vermiculariliis*** were very low in all the nine locations and even within the control group. The greatest problem of the farmers seemed to be from ***Schistosoma mansoni,*** which infected 81.7% of farmers at Farin-gada, 50.0% at Anglo-Jos, 47.5% at Zaramaganda and 44.2% at Mai-Adiko; ***Ascaris lumbricoides*** infection was high among farmers at all locations, but highest at Mai-Adiko (99.2%), Farin-Gada (90.8%), Korot (89.2%) and Zaramaganda (89.2%). Both ***Necator americanus and Ancylostoma duadenale*** appear to have been evenly distributed at the various farming locations with values ranging from 41.3% to 56.3%. Infection with ***Trichuris trichiura*** was somewhat higher than the hookworms. Thus, farmers at Farin-Gada (82.5%), Mai-Adiko (80.0%), and Anguldi (79.2%) were the worst affected infection rates of farmers at Gada-Biu and Foron/Bisichi can be gleaned from Table2.

The prevalence rates of intestinal parasites in different age groups and in both sexes are presented in Table3 ***Entamoeba histolytica, Entamoeba coli, and Endolimax*** nana were more prevalent in the older age groups. ***Giardia lambia, Iodoamoeba butschlii, Chilomastix mesnili, Isospora belli and balantifium coli*** were highest in the younger age groups (19-39 years olds).

Similarly, ***Ascaris lumibricoides and Tricuris trichiura*** were more prevalent in the younger farmers, while ***Strongyloides stercaralis*** and ***Taenia*** spp were more commonly found in the older age groups. Hookworm and Schistosoma masoni were highly prevalent in all age groups. ***Enterobius vermicularis, Hymenolepsis nana, H. dimunita and Dipylidium caminium*** were too few to be analysed by age and sex.

However, the frequency of infection increased with age to a peak value in the 30 39 and 40 49 year age groups. The farmers in this subpopulation includes young farmers of 30 39, and 40 49 years who constitute up to 60% of farmers harbouring the intestinal parasites encountered at Farin-Gada/Dilimi, Anglo-Jos and Zaramangada. Generally, males had higher worm burdens than females, but there were also differences in sex prevalence rates of the various parasites. Hookworm infection did not show any sex-related differences in prevalence rates, but more females were infected with ***Ascaris, Trichuris and Entamoeba histolytica.*** Infection with ***Taenia*** species was rather diffuse and did not show any sex related differences as well.

Both the farmers and the control group expressed some symptoms during sampling 617 (57.1%) of the farmers compared with 19 (14.1%) of the control group had diarrhoea; 202 (18.7%) of the farmers compared with (1 (5.2%) of the control group complained of fever; 168 (15.6%) of the farmers compared with 4 (3.0%) of the controls said they were having skin itch; while 397 (36.8%) of the farms compared with 12 (8.9%) of the controls reported abdominal discomfort at sampling time.

Location of Farmers	Helminths No examined	Helminths No Positive	Helminths Infection Rate (%)	Protozoa No examined	Protozoa No Positive	Protozoa Infection Rate (%)
Control	135*	104*	(76.5)	135	77*	(56.6)
Yelwa Mista Bow	120	104	(86.7)	120	62	(51.7)
Farin-Gada/Dilimi	120	120	(100.0)	120	83	(69.2)
Anglo-Jos	120	112	(93.3)	120	81	(67.5)
Zaramaganda	120	117	(97.5)	120	103	(85.8)
Mai-Adiko	120	106	(88.3)	120	92	(76.7)
Anguldi	120	99	(82.5)	120	67	(55.8)
Gada-Biu (B/Ladi)	120	109	(90.8)	120	57	(47.5)
Foron/Bisichi	120	103	(85.8)	120	71	(59.2)
Korot	120	119	(99.2)	120	74	(61.7)
Total	1080	989	(91.58)	1080	633	(86.39)

*Figures for the Control were taken separately.

Table 1 : Prevalence of Helminths and Protozoa among Farmers at Different Locations in the Study Area

Parasite	Yewa Mista Bow	Farin-Gada	Angio-Jos	Zaramaganda	Ma-Adiko	Anguldi	Gada-Biu	Foron /Bisichi	Forol	Control Group
PROTOZOA	No Pos (%)	No Pos (%)	No Pos (%)	No Pos (%)	No Pos (%)	No Pos (%)	No Pos (%)	No Pos (%)	No Pos (%)	No Pos (%)
Entamoeba histolytica	12 (10.0)	18 (15.0)	50 (41.7)	38 (31.7)	18 (15.0)	16 (13.3)	11 (9.2)	16 (13.3)	21 (17.5)	26 (19.3)
Entamoeba coli	15 (12.5)	34 (28.3)	31 (25.8)	32 (26.7)	36 (30.0)	60 (50.0)	17 (14.2)	15 (12.5)	31 (25.8)	36 (26.7)
Endolimax nana	13 (10.8)	10 (8.3)	19 (15.8)	24 (20.0)	6 (5.1)	69 (57.5)	5 (4.2)	12 (10.0)	18 (15.0)	10 (7.4)
Iodoamoeba butschli	3 (2.5)	13 (10.8)	11 (9.2)	17 (14.2)	11 (9.2)	9 (7.5)	10 (8.3)	3 (2.5)	18 (15.0)	15 (11.1)
Giardia lamblia	12 (10.0)	14 (11.7)	29 (24.2)	28 (23.3)	14 (11.7)	16 (13.3)	10 (8.3)	7 (5.8)	7 (5.8)	12 (8.9)
Chilomastix mesnili	8 (6.7)	10 (8.3)	25 (20.8)	25 (20.8)	11 (9.2)	31 (25.8)	10 (8.3)	15 (12.5)	15 (12.5)	16 (11.9)
Balantidium coli	4 3.3	0 (0.0)	1 (0.8)	3 (2.5)	2 (1.7)	1 (0.8)	4 (3.3)	5 (4.2)	0 (0.0)	0 (0.0)
Isospora belli	7 5.8	2 (1.7)	0 (0.0)	1 (0.8)	0 (0.0)	47 (39.2)	3 (2.5)	3 (2.5)	2 (1.7)	3 (2.2)
HELMINTHS										
Taenia spp	8 6.6	11 (9.2)	9 (7.5)	7 (5.8)	15 (12.2)	4 (3.3)	2 (1.7)	10 (8.3)	9 (7.5)	11 (8.1)
Hymenolepis nana	7 5.8	8 (6.7)	5 (4.2)	5 (4.2)	1 (0.8)	5 (4.2)	9 (7.5)	10 (8.3)	4 (3.3)	7 (5.2)
Hymenolepis diminuta	4 3.3	1 (0.8)	2 (1.7)	2 (1.7)	3 (2.5)	3 (2.5)	7 (5.8)	6 (5.0)	12 (10.0)	2 (1.5)
Dipylidium caninum	3 2.5	6 (5.0)	3 (2.5)	2 (1.7)	1 0.8	2 (1.7)	0 (0.0)	2 (1.7)	7 (5.8)	9 (6.7)
Schistosoma mansoni	28 23.3	98 (81.7)	60 (50.0)	57 (47.5)	53 (44.2)	45 (37.5)	42 (35.0)	49 (40.8)	46 (38.3)	32 (23.7)
Ascaris lumbricoides	89 74.2	109 (90.8)	100 (83.3)	107 (89.2)	119 (99.2)	104 (86.7)	88 (73.3)	92 (76.7)	107 (89.2)	71 (52.6)
Ancylostoma duodenale	61 50.8	66 (54.6)	71 (59.3)	54 (45.0)	57 (47.1)	63 (52.0)	55 (45.5)	61 (50.9)	64 (53.4)	35 (30.9)
Necator americanus	54 45.0	57 (47.1)	59 (48.8)	61 (52.8)	59 (49.1)	58 (47.9)	50 (41.3)	55 (45.9)	55 (45.9)	30 (22.0)
Trichuris trichiura	72 60.0	99 (82.5)	92 (76.7)	90 (75.0)	96 (80.0)	95 (79.2)	90 (75.0)	84 (70.0)	83 (69.2)	66 (48.9)
Enterobius vermicularis	3 2.5	0 (0.0)	0 (0.0)	4 (3.3)	3 (2.5)	6 (5.0)	2 (1.7)	0 (0.0)	2 (1.7)	5 (3.7)
Strongylo stercoralis	19 15.8	79 (65.8)	47 (39.2)	69 (57.5)	65 (54.2)	54 (45.0)	57 (47.5)	74 (61.7)	69 (57.5)	23 (17.6)

TABLE 2: Prevalence of Intestinal Parasites Among Dry Season Irrigation Farmers Using Human and Animal Wastes and Control Farmers Using Chemical Fertilizers

Study Locations

	Age in Years							Sex		
	10-19	20-29	30-39	40-49	50-59	60-69	Above 70	Male	Female	Total
PROTOZOA	n=124	n=156	n=265	n=259	n=197	n=98	n=59	n=810	270	n=1080
Entamoeba histolytica	27(21.4%)	46(29.6%)	99(37.4%)	59(22.9%)	80(40.7%)	53(54.5%)	32(54.5%)	286(35.3%)	95(35.3%)	381(35.3%)
Entamoeba coli	9(7.1)	30(19.0%)	54(20.4%)	51(19.5%)	54(27.5%)	35(35.4%)	27(45.4%)	194(24.0%)	54(20.0%)	261(24.2%)
Endolimax nana	0(0.0%)	0(0.0%)	17(6.6%)	34(13.2%)	58(29.4%)	16(16.3%)	5(9.1%)	16(2.0%)	5(1.7%)	132(12.2%)
Iodoamoeba butschlii	18(14.2%)	11(7.1%)	23(8.2%)	18(6.9%)	23(11.7%)	9(9.1%)	13(21.2%)	79(9.7%)	22(8.0%)	102(9.4%)
Chilomastix mesnili	53(42.8%)	14(9.1%)	46(17.3%)	27(10.4%)	36(18.4%)	14(14.5%)	7(12.2%)	100(12.4%)	43(16.0%)	144(13.3%)
Giardia lamblia	81(65.7%)	67(42.8%)	65(24.4%)	45(17.3%)	11(5.5%)	5(5.5%)	5(9.0%)	167(20.0%)	61(20.6%)	222(20.6%)
Balantidium coli	5(4.0%)	9(5.8%)	0(0.0%)	5(1.9%)	0(0.0%)	0(0.0%)	0(0.0%)	8(1.0%)	11(4.1%)	19(1.8%)
Isospora belli	10(8.1%)	4(2.6%)	0(0.0%)	0(0.0%)	2(1.0%)	6(6.1%)	0(0.0%)	17(2.1%)	5(1.7%)	22(2.0%)
HELMINTHS										
Taenia spp	18(14.2%)	16(10.2%)	23(8.2%)	20(7.6%)	22(11.0%)	0(0.0%)	0(0.0%)	71(8.8%)	29(10.7)	97(9.0%)
Hymenolepis nana	21(16.9%)	12(7.7%)	7(2.6%)	16(6.2%)	0(0.0%)	0(0.0%)	0(0.0%)	42(5.2%)	14(5.2%)	56(5.2%)
Hymenolepis diminuta	0(0.0%)	0(0.0%)	15(5.7%)	3(1.2%)	0(0.0%)	0(0.0%)	0(0.0%)	10(1.2%)	8(3.0%)	18(1.7%)
Dipylidium caninum	19(15.3%)	0(0.0%)	5(3.2%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	19(2.3%)	5(1.9%)	24(2.2%)
Schistosoma mansoni	53(42.8%)	85(56.2%)	129(48.8%)	122(47.7%)	94(47.7%)	53(54.5%)	20(33.3%)	78(46.7%)	151(56.0%)	529(49.0%)
Ascaris lumbricoides	89(71.4%)	88(81.6%)	213(80.2%)	218(84.2%)	177(89.9%)	93(94.5%)	54(90.9%)	761(94.0%)	228(84.5%)	943(87.3%)
Ancylostoma duodenale	106(85.7%)	140(89.8%)	251(94.6%)	252(97.2%)	179(90.4%)	94(96.4%)	48(81.9%)	634(78.3%)	261(96.8%)	1017(94.2%)
Trichuris trichiura	106(85.7%)	112(71.5%)	254(96.0%)	233(90.0%)	152(77.0%)	87(89.1%)	45(75.8%)	486(60.0%)	173(64.0%)	808(74.8%)

Table 3:- Distribution of Intestinal Parasites in Different Groups and Sexes of Dry Season Irrigation Farmers in Jos and Barkin-ladi Areas of Plateau State, Nigeria

DISCUSSION

Parasitic infections of the dry0season farmers and the controls were comparatively high. Among the helminthic parasites, the results show that the most highly prevalent species found in the farmers were the hookworm, ***Ascaris lumbricoides, Trichuris trichiura, Strongyloides stercoralis and Schistosoma mansoni.*** Among the protozoa, ***Entamoeba histolytica, Entamoeba coli, Endolimax nana, Giardia lambia, Chilomastix mesnil and Iodoamoeba butshili*** constitute the major spectrum. These results confirm earlier reports that these same range of intestinal helminthic and protozoa constitute the greatest transmission potential waste re-use schemes (3,6,29,30). These findings also indicate that the use of untreated river or pond water for irrigation can lead to a qualification excess of the parasites listed above among dry season farmers irrespective of their farming location.

The explanation for the observed distribution of infection in this study is not certain, but it is probable that several transmission routes are involved, with dry-season irrigation as only one factor. Principal among the multifactoral reasons for the high prevalence of parasitic diseases in both farmers and control are poor environmental sanitation, poor hygiene habits and lack of health education. In the study area, excreta disposal is practiced on-site i.e. mainly through open defecation and therefore, there is no organised sanitation infrastructure particularly in the metropolitan slums of Kobang, Angwan-Rogo, Dilimi, Nasarawa-Gom, Angwan-Rukuba, Congo-Rissa and Tudun-Wada (20). The habit of the farmers of working barefoot in their farms, and the agricultural practice of using bare hands to construct earth dams for crop irrigation can also be a contributory factor to the high prevalence of intestinal parasites in the dry-season farmers. This creates room for the broken skin of their hands and feet to be penetrated readily by the motile hookworm larvae, ***Schistosoma mansoni*** cercariae and perhaps ***Strongyloides stercoralis.*** A parallel view has similarly been expressed by Krishnomoothi et al (31) and Shuval (32) who noted that sewage farm workers in India exposed to raw wastewater had much higher levels of infection with nematode eggs than other agricultural workers.

As is common with most cultures, several aspects of the farmers culture influence sanitary practice and thereby also the impact of the use of wastes. First, most of the farmers studied were Moslems (61%) from Katsina, Kano and Borno States (20). Anal cleansing is performed with water, applied by hand, and there is no tradition of washing the hands after wards with soap. It would seem likely therefore, for excreta-related diseases to be higher in this group. Any consideration of the impact on health of the use of waste wastewaters in irrigation must take into account other social and cultural factors, which have an influence on the occurrence or transmission of gastro-intestinal infections.

The spectrum and intensity of infections varied according to age and sex; thus the result showed that most infections increased with age up to the age of 50 years, except for ***Giardia lamblia.*** This finding is in agreement with the observations of Yakubu and Bello (33). The higher prevalence rates of ***Ascaris, Trichuris*** and other nematodes in the younger age groups (i.e. 19-39, 30-39, 40-49 age groups) suggests that this age group spent more time in their farms thereby having more frequent contact with the wastes. This pattern of frequency distribution of parasites is widely recognised, and according to Nwosu (34) it is the younger age group that falls within the negative binomial sub-population whose behaviour underlies the maintenance of parasitic infections at high levels.

Males had higher parasite rates for the various intestinal parasites than females. However, females were infected with ***Ascaris lumbricoides, Trichuris Trichiura and Entamoeba histolytica*** than males, but hookworm, and ***Schistosoma mansoni*** did not reveal any sex related differences. These results are similar to those of Nwosu(34).

Diarrhoea disease, abdominal discomfort, skin itch and fever were the major symptoms causing morbidities among the farmers. The result has confirmed earlier reports that gastrointestinal infections are endemic in Plateau State, Nigeria (35,36). Our results further showed that 59% and 42% of the dry-season farmers showed symptoms of diarrhoea and abdominal discomfort respectively. This is in agreement with the work of Krishnonmoorthi et al (31); who correlated the symptoms with exposure to untreated sewage in five farming locations in India. At Yelwa-Mista Bow, Farin-Gada, Dilimi and Anglo-Jos, more farmers showed symptoms of diarrhoea, abdominal discomfort and skin itch than farmers at Anguldi, Ga-Biu, Fom/Bisichi and Korot. As shown in Table 3, the varying degrees of parasitic infections associated with diarrhoea, are consistent with the work of Yakubu and Bello (33) who observed diarrhoea as a common symptom in amoebiasis, giardiasis, trichuriasis and strongyloidiasis.

In nearly all the irrigation farms, the main crops are vegetable and salad crops. The detection of helminth eggs (***Ascaris, Trichuris***, hookworm and ***Toxocara eggs***) from the irrigation water (24) and even from the vegetable and salad crops grown by irrigation (21) means that thousands of dry-season farmers are at increased risk of intestinal nematode infections, and possibly other parasitic and bacterial infections. In addition, many consumers of vegetable crops may also be at risk. The most effective way to control these risks would be to institute some form of partial wastewater treatment prior to use. A waste stabilisation pond system capable of reducing the concentration of nematode eggs would be most suitable. Alternatively, the risk to irrigation farmers could be reduced by control of human exposure and modification of waste management practices.

Although there is a law prohibiting the application of raw wastewater on salad vegetable, this practice is still going on in Plateau State. Apparently, there is little or no enforcement of the law regulating this practice. Government bodies are not routinely involved in the monitoring and control of the health and agricultural effects of waste re-use. Treatment of the irrigation water is therefore; absolutely necessary in order to reduce the health risks to the dry-season farmers and consumers of the vegetables and salad crops.

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