Parasitological Profile of Raw Wastewater and the Efficacy of Biosand Filter in Reduction of Parasite Ova and Cysts

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ABSTRACT: The disposal of wastewater in water bodies has a negative impact in the environment and the health of people who use such water bodies for either irrigation or drinking purposes. In this study, we evaluated the parasitological profile of wastewater from the Ahmadu Bello University Teaching Hospital sewage treatment plant, Zaria, Nigeria using the magnesium sulphate floatation method. The parasite removal efficiency of biosand filter was also tested in comparison with the sewage treatment plant. A total of 960 L of wastewater was examined and a significant level of parasite eggs, cysts and oocysts were detected. In all, 1,648 parasites eggs, cysts and oocysts per litre were counted. Ova of *Ascaris* spp showed the highest count/litre of 307 (18.63%) followed by ova of *Taenia* spp (n=287; 17.42%). The least count per litre was exhibited by cysts of *Giardia* spp (n=58; 3.52%). The analysis revealed that 52.61% of the parasite eggs, cysts and oocysts was removed by the sewage treatment plant while egg removal efficiency of the biosand filter was 97.45%. Further comparison of mean parasite eggs/litre in the effluents of biosand filter and the sewage treatment plant using Wilcoxon's Signed Ranks Test indicated a significant difference ($p < 0.05$) with biosand filter having lower counts per litre. The results obtained therefore demonstrate that the raw wastewater was laden with parasite eggs, cysts and oocysts and hence pose public health threat to the users of the effluent downstream. The biosand filter was more efficient than the sewage treatment plant; its effluent contains insufficient level of the ova, cysts and oocysts of parasites well below the less than one (<1) helminth ova/protozoa cysts as recommended by WHO. © JASEM

The practice of discharging wastewater into water bodies causes considerable damage to the ecosystem, waterfront inhabitants, swimmers, and fishermen (Hamdani and Assobhei, 2001; Paraskevas *et al.,* 2002). Depending on its origin, wastewater can transport many pathogens depending upon the incidence of disease in the indigenous human and animal population that discharge to the sewer (Leclerc *et al.,* 2002). Therefore, hospital wastewater is heavily laden with pathogens and toxic chemicals and hence requires adequate treatment to remove or appreciably reduce the available pathogens to a level that agrees with permissive ranges stipulated by regulatory authorities. The problem of contamination caused by the discharge of wastewater into water bodies is directly evident in intoxications, skin problems and intestinal parasitiasis (Rodriguez *et al.,* 2004; Srikanth and Naik, 2004). This problem is compounded when these discharges are deposited in the vicinity of low-income neighbourhoods where basic hygiene practices are totally absent (Nyarango *et al.,* 2008).

Globally, millions of people suffer from parasitic infections such as Ascariasis (1.2 billion), Trichuriasis (795 million), hookworm infections (740 million) (de Silva *et al*., 2003), Amoebic dysentery (50 million) (Samuel *et al*., 2001) and Giardiasis (2.8 million) (Ali and Hill, 2003). In humans, these parasites are significantly associated with diarrhoea (Utzinger *et al.,* 1999). Faecal oral route is important in the transmission of parasitic infections to humans via poor personal hygiene (Okyay *et al.,* 2004), environmental conditions like contamination of soil and water sources with human faeces (Muttalib *et al.,*1983) and poor wastewater disposal such as use of night soil for fertiliser (Mustafa *et al.,* 2001).

This study was designed to examine the parasitological profile of the raw wastewater and effluent of the sewage treatment plant in comparison with biosand filter effluent.

MATERIALS AND METHODS

Sample collection: Samples of wastewater were collected from upstream (raw wastewater of influent) and downstream (effluent) of the Ahmadu Bello

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University Teaching Hospital sewage treatment plant, Zaria, Nigeria. A total of 960 L of wastewater was collected and analysed. Each sample was in volume of 20 L. Out of the 960 L collected, 320 L was filtered through the biosand filter; the filter effluent (filtrate) was collected and analysed. Another 320 litres of raw wastewater was analysed for parasite ova, cysts and oocysts without filtering it through the biosand filter. The third phase of sample collection involved the collection of 320 L of effluent from the sewage treatment plant.

The method of concentration which seems the most successful in the parasitological analysis of the samples was selected based on previous studies. The method of USEPA (2005) as modified by Lim *et al.* (2007) was adopted with slight modification.

Sample processing: Forty litres (40 L) of raw wastewater was collected in two portions of 20 L volume while 20 of effluent of the effluent (treated wastewater) was collected in another container. Each 20 litre sample was concentrated by repeated centrifugation at $1500 \times g$ for 15 minutes in 250 ml conical bottomed centrifuge tubes and the supernatant was carefully discarded. The deposit (pellet) was slowly under-layered with 10 ml of magnesium sulphate floatation solution of specific gravity 1.3 and further centrifuged at $1000 \times g$ for 5 minutes. The magnesium sulphate floatation solution was filled to the brim and a cover slip was superimposed and allowed to stand for 15 – 20 minutes. The cover slip was lifted and examined under a light microscope (Olympus Microscope XSZ – 107BN No. 001677, Japan). The ova, cysts and oocysts of various parasite species present were identified (Nyarango *et al.,* 2008). The oocysts of *Cryptosporidium parvum* were identified by the modified Kinyoun carbol-fuchsin staining procedure (Visvesvara *et al*., 1997). Eggs, cysts or oocysts of the parasite present in the sample were counted and densities of each species were expressed as eggs, cysts of oocysts per litre.

Statistical Analysis: The computer statistical software, SPSS 17.0 for Windows®, was used for the statistic analysis of the data. The confidence interval in 95% was used to calculate and compare the mean of parasite eggs, cysts or oocysts concentration in the samples.

RESULTS AND DISCUSSION
Parasite eggs or (oo)cysts in the raw wastewater (Influent): A total of three hundred and twenty litres (320 L) of raw sewage was collected and analysed. In all, 1648 eggs, cysts and oocysts of parasites per litre were counted during the period of the study. *Ascaris* spp had the highest number of eggs per litre 307 (18.63%), this was closely followed by *Taenia* spp (n=287; 17.42%) and *Schistosoma* spp (n=253; 15.35%) while *Giardia* spp had the least count per

litre (n=58; 3.52%) (Table 1). *Trichuris* spp and *Hymenolepis* spp had equal number of eggs per litre (n=92; 5.58%) with mean eggs/litre of 5.69 ± 0.44 and 5.75 ± 1.09 respectively.

In Table 3, the sewage treatment plant showed a percentage reduction of 52.61% in contrast with 97.45% reduction in total parasite eggs per litre exhibited by the biosand filter. A perusal of the percentage reduction in the individual parasite eggs showed that *Hymenolepis* spp was the most removed by the sewage treatment plant with percentage removal of 61.67% while *Ancylostoma* spp (37.78%) was the least removed. On the other hand, the highest percentage removal of parasite eggs by the biosand filter was observed for ova of *Hymenolepis* spp (98.91%) followed by *Trichuris* spp (98.90%).

A comparison of the mean parasites eggs/litre obtained from the biosand filter and the effluent of the sewage treatment plant using Wilcoxon's Signed Ranks Test at significant level of 0.05 revealed that there was significant difference ($p < 0.05$) between the means concentration of the parasite eggs, cysts or oocysts/litre obtained from effluent of biosand filter. A graphical comparison of the mean parasite eggs, cysts and oocysts is presented in Figure 1.

The Total number of eggs or (oo)cysts/litre of wastewater (influent) was higher than that of the effluent from the sewage treatment plant. This may be due to the adherence of the eggs/cysts of helminthes and protozoa to the suspended particles and settle out in the sedimentation tank.

However, eight (8) helminths among which are *Ascaris lumbricoides, Taenia* spp, *Ancylostoma* spp*, Hymenolepis* spp and *Enterobius vermicularis.* The WHO limit for helminth ova in wastewater for use in crop irrigation is less than one (≤ 1) Helminth Ova (HO) per Litre (WHO, 2010). Mean egg counts of helminthes such as *Ascaris lumbricoides, Trichuris* spp, *Ancylostoma* spp and *Toxocara* spp in the untreated wastewater (influent) were higher than the effluent from the sewage treatment plant. There is a great public health risk of re-use of these waters for crop irrigation without prior treatment. However, the effluent from the biosand filter contained less than one mean egg per litre. Earlier studies by Feachem *et al*. (1983) and Shanthala *et al*. (2007) have shown that helminth ova can live in water, soil, and crops for several months or years.

In Nigeria, eggs of *Ascaris lumbricoides* and cysts of Protozoa particularly *Entamoeba histolytica* remain viable in stabilization pond effluents used to irrigate vegetables that were eaten raw (Shanthala *et al*., 2007).

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Table 1: Occurrence and mean of ova or (oo)cysts/litre of raw sewage (influent)

Parasites	Total number of eggs or (oo)cysts/litre of Influent	Percentage
Cryptosporidium parvum	130	7.89
Schistosoma spp	253	15.35
Taenia spp	287	17.42
Ancylostoma spp	135	8.19
Ascaris lumbricoides	307	18.63
Toxocara spp	176	10.68
Trichuris spp	92	5.58
Hymenolepis spp	92	5.58
Enterobius spp	118	7.16
Giardia lamblia	58	3.52
Total	**1648**	**100.00**

Table 2: Occurrence and mean of ova or (oo)cysts/litre of raw sewage (influent) and effluents

Parasites	Total number of eggs or (oo)cysts/litre of Influent	Mean ± SEM		
		Raw Sewage (Influent)	STP Effluent	Biosand Filter Effluent
C. parvum	130	8.13 ± 0.90	4.19 ± 0.34	0.13 ± 0.09
Schistosoma spp	253	15.81 ± 1.33	6.31 ± 0.98	0.50 ± 0.22
Taenia spp	287	17.75 ± 1.38	9.56 ± 0.98	0.38 ± 0.15
Ancylostoma spp	135	8.56 ± 0.89	5.25 ± 0.69	0.19 ± 0.10
Ascaris lumbricoides	307	19.25 ± 0.95	7.81 ± 0.73	0.63 ± 0.18
Toxocara spp	176	10.94 ± 1.08	6.00 ± 0.53	0.50 ± 0.16
Trichuris spp	92	5.69 ± 0.44	3.44 ± 0.42	0.06 ± 0.06
Hymenolepis spp	92	5.75 ± 1.09	2.38 ± 0.50	0.06 ± 0.06
Enterobius spp	118	7.38 ± 0.36	3.13 ± 0.45	0.13 ± 0.09
Giardia lamblia	58	3.75 ± 0.48	1.44 ± 0.29	0.06 ± 0.06
Total	**1648**			

SEM = Standard error of mean; STP = Sewage treatment plant

Table 3: Average percentage reduction of eggs or (oo)cysts/litre of influent and effluents.

| Parasites	Average Number of eggs or (oo)cysts/litre of raw sewage (Influent)	STP Effluent		Biosand Filter Effluent	
		Number of eggs or (oo)cysts/litre	Percentage reduction (%)	Number of eggs or (oo)cysts/litre	Percentage reduction (%)
C. parvum	130	67	48.46	2	98.46
Schistosoma spp	253	101	60.08	8	96.84
Taenia spp	284	143	49.65	6	97.89
Ancylostoma spp	135	84	37.78	3	97.78
Ascaris lumbricoides	308	125	59.42	10	96.75
Toxocara spp	175	96	45.14	8	95.43
Trichuris spp	91	55	39.56	1	98.90
Hymenolepis spp	92	37	61.67	1	98.91
Enterobius spp	118	50	51.63	2	98.31
Giardia lamblia	60	23	60.34	1	98.33
Total	**1648**	**781**	**52.61**	**42**	**97.45**

STP = Sewage treatment plant

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Table 4: Wilcoxon's Signed Ranks Test of mean differences between effluents of biosand filter and sewage treatment plants.

			z	p	Decision
Cryptosporidium spp BSF –	*Cryptosporidium* spp STP		– 3.434	0.001	BSF < STP
Schistosoma spp BSF	– *Schistosoma* spp STP		– 3.533	0.000	BSF < STP
Taenia spp BSF	– *Taenia* spp STP		– 3.524	0.000	BSF < STP
Ancylostoma spp BSF	– *Ancylostoma* spp STP		– 3.304	0.001	BSF < STP
Ascaris spp BSF	– *Ascaris* spp STP		– 3.531	0.000	BSF < STP
Toxocara spp BSF	– *Toxocara* spp STP		– 3.523	0.000	BSF < STP
Trichuris spp BSF	– *Trichuris* spp STP		– 3.534	0.000	BSF < STP
Hymenolepis spp BSF	– *Hymenolepis* spp STP		– 3.081	0.002	BSF < STP
Enterobius spp BSF	– *Enterobius* spp STP		– 3.534	0.000	BSF < STP
Giardia spp BSF	– *Giardia* spp STP		– 2.952	0.003	BSF < STP

BSF = Biosand filter; STP = sewage treatment plant

BSF < STP = the number of eggs or (oo)cysts in effluent of BSF is less than that in STP i.e. BSF is more efficient than STP at $p < 0.05$.
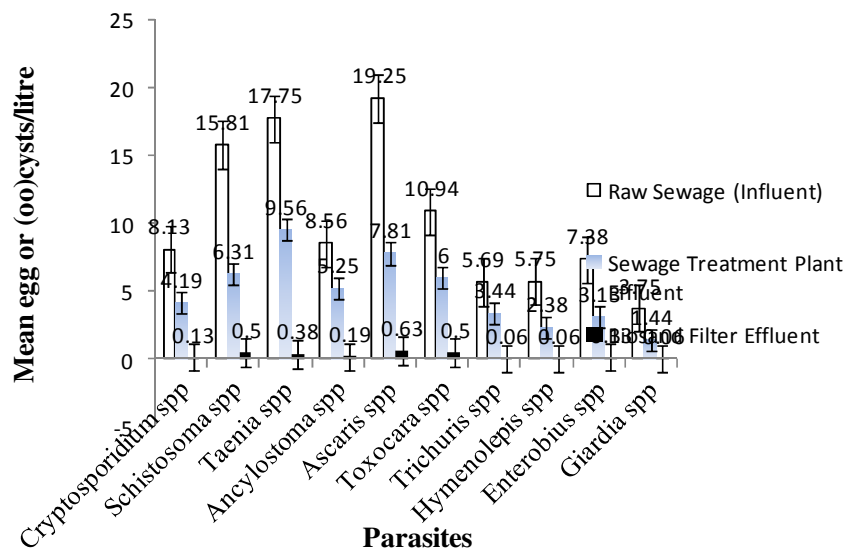
Fig: 1: Mean eggs or (oo)cysts/litre of parasites in raw sewage (influent) and effluents of Sewage Treatment Plant and Biosand Filter over the study period

Such inadequately treated sewage used for irrigation has been identified as increasing the risk towards the incidence of helminthic infections in both the farmers and consumers (Damen *et al*., 2007; Uneke, 2007). We also observed that farmers were using the discharged wastewater to irrigate their vegetable gardens downstream.

The presence of these ova of *Taenia* in the wastewater indicates the risk of human cysticercosis in members of the community eating unwashed, raw vegetables irrigated with untreated wastewater. There is also risk of bovine cystercicosis if reared cattle drink from any body of water contaminated with wastewater.

Cryptosporidiasis caused by *Cryptosporidium parvum* and Giardiasis cause chronic diarrhoea especially in the immunocompromised subjects can be life threatening. The (oo)cysts of both protozoan parasites were efficiently removed by the biosand filter. It is of utmost importance that pollution of water and vegetables is prevented by substituting the rapid sand filter used in the sewage plant with the biosand filter.

The rate of ova removal in biosand filter was 96.75%, 97.89%, 97.78.9% and 98.91% for the respective species as compared to the lower rates of ova removal by the sewage treatment plant (STP). This shows that the biosand filter is more efficient in removal of helminth ova and oocysts of *Cryptosporidium* spp and *Giardia lamblia* as indicated by the statistically significant difference when compared with the Sewage Treatment Plant. The analysis revealed that

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52.61% of the parasite eggs, cysts and oocysts were removed by the sewage treatment plant while egg removal efficiency of the biosand filter was 97.45%
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We conclude that biosand filtration of wastewater (slow sand filtration) is a better alternative to rapid sand filter which is used in the conventional sewage treatment plant as it ensures removal or reduction of helminth ova and protozoan (oo)cysts.
The use of biosand filter effluent for irrigation farming in Zaria, Nigeria metropolis will prevent the parasitological pollution of vegetables.

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