DETECTION OF PATHOGENS IN WASTEWATER AND SOIL BY TAQMAN ARRAY CARD (TAC) SYSTEM

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Abstract: The study was conducted in an urban slum area of Dhaka city. The environmental samples (soil and water) were collected from Mirpur Bihari camp area including Madrasha camp, Muslim camp and ADC camp. The main areas of sample collection were near the sewerage lines, chicken coop, goat house etc. In the present investigation, out of 28 wastewater samples, Entamoeba, Shigella, Aeromonas, Campylobacter, Vibrio cholerae, Blastocystis, Salmonella, Trichuris, Ancylostoma, Plesiomonas, Bacteroides fragilis and Rota virus pathogens were recorded. In wastewater samples, 14.29% had single infection, 85.71% double infection, whereas, observation on 20 soil samples by TAC system, total 12 types of pathogens were recorded such as Shigella, Aeromonas, Campylobacter, Vibrio cholerae, Blastocystis, Salmonella, Plesiomonas, Bacteroides fragilis and Rota virus including Entamoeba sp., Ancylostoma sp. and Trichuris sp.

Key words: Soil, Water, Wastewater, Parasites, Bacteria and virus

INTRODUCTION

The prevalence of intestinal parasites in Bangladesh is very high. Parasitic infestation is a common health problem around the globe especially in the developing countries which imposes a continual and unacceptable threat to the well-being of millions of people in the tropics and subtropics; the cost of parasites in terms of human misery and economic loss is incalculable (Cox 2002, Mondal et al. 2012). In Bangladesh, infestation with protozoa and helminthes such as Giardia intestinalis, Ascaris lumbricoides, Entamoeba histolytica and Trichuris trichiura are major public health problem both in rural and urban areas with wide spread endemically. It was stated that health problems related to diarrhea and helminthes are mostly water borne (Kramer et al. 1998, Sultana et al. 2007, Krkoset et al. 2016).

Intestinal parasitic infections are among the most common infections worldwide. Most intestinal parasites are heterogeneously distributed in host populations; according to a frequently quoted estimate, 20% of hosts harbor 80% of the intestinal helminthes. Adolescents and children are at high risk of
parasitic infection because of their behavioral aspects, general hygiene knowledge, socio-economic status (SES), environmental contamination, etc. The intestinal parasite may present asymptotically or may cause mild or severe diseases, generally producing symptoms like abdominal pain and vomiting. Besides this there are other symptoms like anorexia, nausea, diarrhea, indignation etc. Some of them may produce severe clinical manifestation like anemia, obstruction, perforation of gastrointestinal tract through peptic ulcer which causes secondary infection of bacteria (Greenberg and Estes 2009, Hudson 2002, Khanum et al. 2008). In Bangladesh, one in 30 children die of diarrhea or dysentery by his or her fifth birthday. In Bangladesh, one third of the total child death burden is due to diarrhea (Haque et al. 2003, WHO 2013). In Bangladesh, incidence of intestinal parasites is high due to moist, hot climate, poor hygienic habit, ignorance, poverty and mostly importance in the lack of health education. Various studies have been carried out to find the prevalence of intestinal parasites in different rural and urban areas in Bangladesh. But the prevalence rate varied from place to place. The findings of the present investigation will also help in developing awareness among the people infected with parasites (Khanum et al. 2004). In Bangladesh intestinal parasitic infestation endemically widespread all over due to low standard of living condition, poor personal hygiene practices (Khanum et al. 2008).

MATERIAL AND METHODS

The study area was Mirpur (sector-11, avenue-5), an urban slum of Dhaka city. This area was selected as the living condition is unhygienic and impoverished children are mostly affected by diarrheal disease than the others. The majority of the inhabitants of the Mirpur site are of Bihari ethnic origin. This site is densely populated with more than one lakh people. The environmental samples (soil and water) were collected from Mirpur Bihari camp area including Madrasha camp, Muslim camp and ADC camp. Samples of soil and water were collected from the areas where children had diarrhea often through diarrheal surveillance system at this site conducted by ICDDR, B. Moreover, the main areas of sample collection were near the sewerage lines, chicken coop, goat house etc.

Soil samples were collected from the site by a spatula in a falcon tube (5 mg) and the water samples were collected from the site by handled pot (5 ml) and kept in zip lock water pack. The study period was July, 2016 - June, 2017. Total 48 samples were collected (28 water and 20 soil samples) from Mirpur. Samples were examined by TaqMan Array Card (TAC) system. Soil samples that were collected from near the sewerage line were muddy as they were mixed with
sewerage water and other samples that were collected from near the chicken coop and goat house were silty and dry. Wastewater samples were collected from sewerage line was muddy (Table 1).

Table 1. The places and types of collected soil samples

| Sample     | Collection area     | Nature  |
|------------|---------------------|---------|
| Soil       | Near sewerage line | Muddy   |
|            | Near goat house    | Silt    |
|            | Near chicken coop  | Silt    |
| Wastewater | Sewerage line      | Muddy   |

RESULTS AND DISCUSSION

In the present observation on wastewater samples by TAC system, total ten types of pathogens were recorded such as *Shigella*, *Aeromonas*, *Campylobacter*, *Vibrio cholerae*, *Blastocystis*, *Salmonella*, *Plesiomonas*, *Bacteroides fragilis* and Rota virus including *Entamoeba* sp. Out of 28 water samples, 4 (14.29%) had single infection and 24 (85.71%) double infection, 16 (57.71%) triple infection, 20 (71.42%) quadruple infection with four different species. The presence of five or more parasite species at a time in a single host was considered as multiple infections and thus 12 (42.86%) had such multiple infection. Among 3 study areas, the single infection was highly prevalent (33.33%) near Muslim camp, lowest (0%) in both Madrasha camp and ADC camp. Double, triple and quadruple infections were highest (100%) in both Madrasha camp and ADC camp, whereas, lowest (66.66, 33.33 and 33.33%) in Muslim camp. Multiple infections were found highest (100%) in ADC camp and lowest (33.33 and 33.33%) in both Madrasha camp and Muslim camp (Table 2).

Observation on soil samples by TAC system: In the present observation on soil samples by TAC system, total 12 types of pathogens were recorded such as *Shigella*, *Aeromonas*, *Campylobacter*, *Vibrio cholerae*, *Blastocystis*, *salmonella*, *Plesiomonas*, *Bacteroides fragilis* and Rota virus including *Entamoeba* sp., *Ancylostoma* sp. and *Trichuris* sp. (Table 3).

Out of 20 soil samples, there was no single infection (0%) while, 20 (100%) double infection, 20 (100%) triple infection, 16 (80%) quadruple infection with four different species. The presence of five or more parasite species at a time in a single host was considered as multiple infections, 12 (60%) had such multiple infection. Among 3 study areas (Muslim camp, Madrasha camp and ADC camp) no single infection was found. Double and triple infection were highest (100%) among 3 study areas (Madrasha camp, ADC camp and Muslim camp).
Quadruple and multiple infections were found highest (100%) in both ADC camp and Muslim camp and lowest (66.66 and 33.33%) in Madrasha camp (Table 4).

**Table 2. Prevalence of pathogens in 28 wastewater samples**

| Pathogen          | Number of tested water samples | Number of positive samples | Prevalence (%) |
|-------------------|--------------------------------|---------------------------|----------------|
| *Entamoeba*       | 28                             | 20                        | 71.42          |
| *Shigella*        | 28                             | 8                         | 28.57          |
| *Aeromonas*       | 28                             | 16                        | 57.14          |
| *Campylobacter*   | 28                             | 24                        | 85.7           |
| *Vibrio cholerae* | 28                             | 12                        | 42.85          |
| *Blastocystis*    | 28                             | 8                         | 28.57          |
| *Bacteroides fragilis* | 28                         | 8                         | 28.57          |
| *Adenovirus*      | 28                             | 4                         | 14.29          |
| *Sapovirus*       | 28                             | 4                         | 14.29          |
| *Plesiomonas*     | 28                             | 4                         | 14.29          |

**Table 3. Prevalence (%) of other pathogens in soil samples**

| Pathogen          | Number of tested soil samples | Number of positive samples | Prevalence (%) |
|-------------------|-------------------------------|---------------------------|----------------|
| *Entamoeba*       | 20                            | 16                        | 80             |
| *Shigella*        | 20                            | 4                         | 20             |
| *Aeromonas*       | 20                            | 12                        | 60             |
| *Campylobacter*   | 20                            | 20                        | 100            |
| *Vibrio cholerae* | 20                            | 16                        | 80             |
| *Blastocystis*    | 20                            | 8                         | 40             |
| *Salmonella*      | 20                            | 4                         | 20             |
| *Ancylostoma*     | 20                            | 8                         | 40             |
| *Trichuris sp.*   | 20                            | 4                         | 20             |
| *Plesiomonas*     | 20                            | 12                        | 60             |
| *Bacteroides fragilis* | 20                         | 4                         | 20             |
| *Rota virus*      | 20                            | 4                         | 20             |

Diarrhea was acquired from food or water that has been contaminated by stool, or directly from another person who is infected. Environmental conditions also make human beings vulnerable to parasites, and 1000 of people in developing countries live in below standard condition like, lacking safe water supplies and proper sanitation. Under these conditions parasitic diseases are common due to environmental pollution by human and animal excreta (Vicetora et al. 1993). So, overcrowding, lack of personal hygienic and sanitary conditions of the area, contaminated drinking water, may be responsible for higher
Table 4. Prevalence of different double infections in total wastewater samples

| Pathogen                                   | Total no. of soil samples examined | No. of positive samples with two parasites | Prevalence (%) |
|--------------------------------------------|-----------------------------------|-------------------------------------------|----------------|
| Cryptosporidium + Entamoeba                | 28                                | 12                                        | 42.86          |
| Cryptosporidium + Campylobacter            | 28                                | 12                                        | 42.86          |
| Cryptosporidium + Aeromonas                | 28                                | 8                                         | 28.57          |
| Cryptosporidium + Blastocystis             | 28                                | 8                                         | 28.57          |
| Cryptosporidium + Shigella                 | 28                                | 4                                         | 14.29          |
| Entamoeba + Campylobacter                  | 28                                | 20                                        | 71.42          |
| Entamoeba + Blastocystis                   | 28                                | 12                                        | 42.86          |
| Entamoeba + Aeromonas                      | 28                                | 16                                        | 57.14          |
| Entamoeba + Plesiomonas                    | 28                                | 4                                         | 14.29          |
| Entamoeba + Sapovirus                      | 28                                | 12                                        | 42.86          |
| Entamoeba + Adenovirus                     | 28                                | 4                                         | 14.29          |
| Entamoeba + Vibrio cholera                 | 28                                | 8                                         | 28.57          |
| Entamoeba + Bacteroides fragilis           | 28                                | 4                                         | 14.29          |
| Campylobacter + Aeromonas                  | 28                                | 16                                        | 57.14          |
| Campylobacter + Plesiomonas                | 28                                | 4                                         | 14.29          |
| Campylobacter + Vibrio cholerae            | 28                                | 8                                         | 28.57          |
| Campylobacter + Sapovirus                  | 28                                | 8                                         | 28.57          |
| Campylobacter + Shigella                   | 28                                | 8                                         | 28.57          |
| Campylobacter + Blastocystis               | 28                                | 8                                         | 28.57          |
| Campylobacter + Bacteroides fragilis       | 28                                | 8                                         | 28.57          |
| Vibrio cholerae + Aeromonas                | 28                                | 12                                        | 42.86          |
| Vibrio cholerae + Plesiomonas              | 28                                | 4                                         | 14.29          |
| Vibrio cholerae + Shigella                 | 28                                | 8                                         | 28.57          |
| Vibrio cholerae + Sapovirus                | 28                                | 4                                         | 14.29          |
| Vibrio cholerae + Blastocystis             | 28                                | 8                                         | 28.57          |
| Vibrio cholerae + Bacteroides fragilis     | 28                                | 8                                         | 28.57          |
| Shigella + Sapovirus                       | 28                                | 4                                         | 14.29          |
| Shigella + Adenovirus                      | 28                                | 4                                         | 14.29          |
| Shigella + Plesiomonas                     | 28                                | 4                                         | 14.29          |
| Shigella + Bacteroides fragilis            | 28                                | 8                                         | 28.57          |
| Blastocystis + Aeromonas                   | 28                                | 8                                         | 28.57          |
| Blastocystis + Plesiomonas                 | 28                                | 4                                         | 14.29          |
| Blastocystis + Bacteroides Fragilis        | 28                                | 8                                         | 28.57          |
| Blastocystis + Adenovirus                  | 28                                | 4                                         | 14.29          |
prevalence of infections. However, the prevalence of the parasites the present study was contradictory with previous studies (Ngan et al. 1992, Verle et al. 2003). This difference may be due to diagnostic techniques.

About 1.7 to 5 billion cases of diarrhea occur per year (Abdelmalak and Doyle 2013). Diarrhea is a major public health problem which is most common in developing countries, including Bangladesh where young children get diarrhea on average three times a year (WHO 2013). Walker et al. (2013) estimated high rate of diarrhea mortality among young children in low and middle income countries. Diarrheal disease may have a negative impact on both physical fitness and mental development. “Early childhood malnutrition resulting from any cause reduces physical fitness and work productivity in adults, and diarrhea is a primary cause of childhood malnutrition” (Guerrant et al. 1992, WHO 1987).

The most common cause is an infection of the intestines due to either a virus, bacteria, or parasite; a condition known as gastroenteritis. According to Wright et al. (1991) environmental factors influence the prevalence of diarrheal causing agent. They stated that house structure (28%), water usage (24%), toilet and bathing area (12%), animal management (11%), food preparation area (10%), hygiene (8%) and wastewater management (6%) also influence their presence which is similar to the findings of the present study.

In the present study, soil samples were also collected from chicken coop, goat house and out of total 20 soil samples 8 were positive for Cryptosporidium spp. (14.29%). There was no single infection 0%, 100% double infection, 100% triple infection, 80% quadruple infection and 60% had multiple infections. Water samples were wastewater. Out of total 28 water samples 24 samples were positive for Cryptosporidium (85.71%). In the present study, in soil and wastewater samples rotavirus, adenovirus, Campylobacter spp., Salmonella spp. and Shigella spp. were also found. There was 14.29% single infection, 85.71% double infection, 47.71% triple infection, 71.42% quadruple infection and 42.86% multiple infections (Tables 5, 6, 7).

There are many causes of infectious diarrhea, which include viruses, bacteria and parasites (Navneethan and Gianella 2008, Abrahams 2002). Along with Cryptosporidium spp. and Giardia lamblia, rota virus is the most common cause in children under five years old (Greenberg and Estes 2009) and Adenovirus (Uhnno et al. 1990) cause a significant number of infections (Rose 1990, Rose et al. 1991). Campylobacter spp. is a common cause of bacterial diarrhea but infections by Salmonella spp., Shigella spp. are also a frequent cause (Viswanathan et al. 2009). Soil ingestion is also associated with child diarrhea. Environmental characteristics and behavioral practices have been
### Table 5. Prevalence of different triple infections in total wastewater samples

| Pathogen                                                                 | Total no. of soil samples examined | No. of positive samples with three parasites | Prevalence (%) |
|--------------------------------------------------------------------------|------------------------------------|---------------------------------------------|-----------------|
| Cryptosporidium + Entamoeba + Blastocystis                               | 28                                 | 8                                           | 28.57           |
| Cryptosporidium + Entamoeba + Campylobacter                             | 28                                 | 16                                          | 57.14           |
| Cryptosporidium + Entamoeba + Shigella                                   | 28                                 | 4                                           | 14.29           |
| Cryptosporidium + Entamoeba + Aeromonas                                 | 28                                 | 4                                           | 14.29           |
| Entamoeba + Campylobacter + Blastocystis                                 | 28                                 | 12                                          | 42.86           |
| Entamoeba + Campylobacter + Aeromonas                                    | 28                                 | 16                                          | 57.14           |
| Entamoeba + Campylobacter + Vibrio cholera                               | 28                                 | 12                                          | 42.86           |
| Entamoeba + Shigella + Bacteroides fragilis                             | 28                                 | 4                                           | 14.29           |
| Entamoeba + Adenovirus + Aeromonas                                      | 28                                 | 4                                           | 14.29           |
| Entamoeba + Aeromonas + P + Campylobacter                               | 28                                 | 4                                           | 14.29           |
| Entamoeba + Aeromonas + P + Vibrio cholera                               | 28                                 | 4                                           | 14.29           |
| Entamoeba + Aeromonas + P + Sapovirus                                   | 28                                 | 4                                           | 14.29           |
| Entamoeba + Aeromonas + Vibrio cholera                                   | 28                                 | 12                                          | 42.86           |
| Shigella + Campylobacter + Sapovirus                                    | 28                                 | 4                                           | 14.29           |
| Shigella + Campylobacter + Adenovirus                                   | 28                                 | 4                                           | 14.29           |
| Shigella + Campylobacter + Blastocystis                                 | 28                                 | 8                                           | 28.57           |
| Shigella + Blastocystis + Bacteroides fragilis                          | 28                                 | 8                                           | 28.57           |
| Shigella + Aeromonas + Plesiomonas                                      | 28                                 | 4                                           | 14.29           |
| Blastocystis + Campylobacter + Vibrio cholera                            | 28                                 | 8                                           | 28.57           |
| Blastocystis + Aeromonas + Bacteroides fragilis                         | 28                                 | 8                                           | 28.57           |
| Blastocystis + Aeromonas + Plesiomonas                                  | 28                                 | 4                                           | 14.29           |
| Blastocystis + Adenovirus + Plesiomonas                                 | 28                                 | 4                                           | 14.29           |
| Blastocystis + Sapovirus + Vibrio cholera                               | 28                                 | 4                                           | 14.29           |
| Campylobacter + Vibrio cholera + Aeromonas                              | 28                                 | 12                                          | 42.86           |
| Adenovirus + Plesiomonas + Aeromonas                                    | 28                                 | 4                                           | 14.29           |
Table 6. Prevalence of different quadruple infections in total wastewater samples

| Pathogen                                      | Total no. of soil samples examined | No. of positive samples with four parasites | Prevalence (%) |
|-----------------------------------------------|-----------------------------------|---------------------------------------------|----------------|
| Cryptosporidium + Entamoeba + Campylobacter + Blasocystis | 28                                | 8                                           | 28.57          |
| Cryptosporidium + Entamoeba + Campylobacter + Aeromonas    | 28                                | 8                                           | 28.57          |
| Cryptosporidium + Entamoeba + Campylobacter + Vibrio cholera | 28                                | 4                                           | 14.29          |
| Cryptosporidium + Entamoeba + Bacteroides fragilis + Shigella | 28                                | 4                                           | 14.29          |
| Cryptosporidium + Entamoeba + Aeromonas + Sapovirus        | 28                                | 4                                           | 14.29          |
| Cryptosporidium + Blastocystis + Shigella + Vibrio cholerae | 28                                |                                             | 14.29          |
| Entamoeba + Blastocystis + Campylobacter + Sapovirus       | 28                                | 4                                           | 14.29          |
| Entamoeba + Blastocystis + Campylobacter + Adenovirus      | 28                                | 4                                           | 14.29          |
| Entamoeba + Blastocystis + Shigella + Bacteroides fragilis | 28                                | 8                                           | 28.57          |
| Entamoeba + Blastocystis + Aeromonas + Plesiomonas         | 28                                | 4                                           | 14.29          |
| Entamoeba + Campylobacter + Aeromonas + Vibrio cholerae    | 28                                | 8                                           | 28.57          |
| Shigella + Campylobacter + Sapovirus + Bacteroides fragilis | 28                                | 4                                           | 14.29          |
| Shigella + Campylobacter + Bacteroides fragilis + Blastocystis | 28                                | 8                                           | 28.57          |
| Shigella + Plesiomonas + Aeromonas + Vibrio cholerae       | 28                                | 4                                           | 14.29          |
| Campylobacter + Plesiomonas + Aeromonas + Vibrio cholerae  | 28                                | 4                                           | 14.29          |

identified as risk factors for diarrhea in developing countries as people living in slums or in the lower socio-economic stratum have little or no access to services such as water sanitation, proper drainage and waste disposal and as a result also become polluted by diarrhea causing agents. Worldwide in 2004, approximately 2.5 billion cases of diarrhea occurred, which resulted in 1.5 million deaths among children under the age of five. Greater than half of these were in Africa and South Asia (WHO 2009). This is lower from a death rate of 4.5 million in 1980 for gastroenteritis (Mandell et al. 2004). Diarrhea remains the second leading cause of infant mortality (16%) after pneumonia (17%) in this age group (WHO 2009).
**Table 7. Prevalence of different multiple infections in total wastewater samples**

| Pathogen                                                                 | Total no. of soil samples examined | No. of positive samples with five parasites | Prevalence (%) |
|--------------------------------------------------------------------------|-----------------------------------|-------------------------------------------|---------------|
| Cryptosporidium + Entamoeba + Campylobacter + Blastocystis + Shigella    | 28                                | 4                                         | 14.29         |
| Cryptosporidium + Entamoeba + Campylobacter + Blastocystis + Bacteroides fragilis | 28                                | 4                                         | 14.29         |
| Cryptosporidium + Entamoeba + Campylobacter + Shigella + Sapovirus       | 28                                | 4                                         | 14.29         |
| Entamoeba + Campylobacter + Shigella + Vibrio cholera + Sapovirus        | 28                                | 4                                         | 14.29         |
| Entamoeba + Campylobacter + Aeromonas + Plesiomonas + Bacteroides fragilis | 28                                | 4                                         | 14.29         |
| Entamoeba + Vibrio cholera + Aeromonas + Plesiomonas + Shigella          | 28                                | 4                                         | 14.29         |
| Entamoeba + Vibrio cholera + Aeromonas + Plesiomonas + Adenovirus        | 28                                | 4                                         | 14.29         |
| Campylobacter + Aeromonas + Plesiomonas + Bacteroides fragilis + Adenovirus | 28                                | 4                                         | 14.29         |
| Campylobacter + Bacteroides fragilis + Shigella + Sapovirus + Blastocystis | 28                                | 4                                         | 14.29         |

**CONCLUSION**

In ICDDR.B, Dhaka, 1000s of diarrheal patients admit every month. It is a matter of great sorrow that death from diarrheal infection decreased but levels of morbidity have not been declined in comparison to historical levels. For this reason diarrhea is still a major cause of morbidity and mortality among children in developing countries. Absolute requirement for rapid and cost effective diagnostic methods are essential of detection for the intestinal protozoan parasites which causes diarrhea. Regarding the socio-economic condition of Bangladesh, it can be said that that PCR (Polymerase Chain Reaction) is one of the best method for detection of intestinal parasites. PCR test and TAC system were demonstrated to be accurate and useful tool in the detection of parasites and other diarrhea causing agent in human stool and environmental samples (soil and wastewater) that can be transmitted by fecal-oral route.

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