KWAME NKRUMAH UNIVERSITY OF CSIENCE AND TECHNOLOGY, KUMASI

DEPARTMENT OF ENVIRONMENTAL SCIENCE

MICROBIOLOGICAL QUALITY OF WATER IN HANDWASHING BOWLS IN BASIC SCHOOLS IN THE ABLEKUMA SOUTH SUB- METROPOLIS OF ACCRA, GHANA

BY

WINIFRED EMMA ARTHUR

B. Sc. (Hons) APPLIED BIOLOGY

A THESIS SUBMITTED TO THE DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE

OF

MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

FACULTY OF BIOSCIENCES,

COLLEGE OF SCIENCE

JUNE, 2014

DECLARATION

I hereby declare that this submission is my own work towards the M Sc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of another degree of the University, except due acknowledgement has been made in the text.

WINIIFRED EMMA ARTHUR …..…………………….. ……..……………

PG6503611

(Student)

PROF. KWESI OBIRI DANSO ………………………….. …………………..

(Supervisor)

CERTIFIED BY:

REV. STEPHEN ACHEAMPONG ……………………….. …………………..

(Head of Department) SIGNATURE DATE

ABSTRACT

Inadequate hand-washing facilities have been reported as a barrier to hand washing. This study aimed to assess the microbiological quality of the water in the stand alone bowls for hand washing in the Tunga Islamic Community Basic School and Zamarama Line Basic School in the Ablekuma South Sub-metropolis of Accra. It also determined the Frequency in changing the water for hand washing in the selected schools.
Water samples from stand alone hand washing bowls in front of classrooms in the 'Tunga' Islamic Community Basic School where students washed without soap and the 'Zamarama' Line Basic School where an amount of liquid soap is poured into the hand washing water immediately it is placed there (although its efficacy could not be ascertained) for pupils to use on communal basis in the Ablekuma South Sub-metropolis of Accra were sampled before use at 8.00am and after use at 8.00am 11.00am and 2.00pm.

The study revealed that the microbiological quality of water in hand washing bowls used in the selected basic schools in the Ablekuma South Sub-metropolis of Accra were unacceptable for use by the pupils. The microbial quality was often relatively good before use in the morning but deteriorates as the day wears on mainly because there is no running tap water in the schools and the pupils have to carry water in plastic gallons to school.
Average total heterotrophic plate counts were initially 4.81×10^{1} cfu /ml when it was placed there for use in hand washing, but increased to 1.04×10^{8} cfu/ml after use by the children at 8.00am. This increased to 1.33×10^{8} cfu/ml after use at 11.00am and to 2.18×10^{9} cfu/ml after use at 2.00pm.

That of Zamarama Line Basic School also showed a similar trend. Average heterotrophic plate count before use by the pupils at 8am was 2.08×10^{1} and increased to 1.34×10^{4} cfu/ml after use at 8am. It later increased to $3.09\text{x}10^{4}$ cfu/ml at 11am after use and then to 2.46×10^{5} cfu/ml at 2.00pm after use. *Staphylococcus aureus* and faecal coliform were however absent in the hand washing water before use in both schools but were detected after use at 8:00 am and the levels increased with the passage of time in both schools.

E. coli which must not be present in water for hand washing, bathing and dish washing according to WFP/UNESCO/WHO (1999), and the Drinking Water Quality Standards by US EPA (2002), which has the Maximum Contaminant Level Goal (MCLG) of this microorganism in drinking water to be zero was detected.
The water used for hand washing in the schools studied was not changed throughout the day.
It was concluded that the aim of hand washing which is to decontaminate the hands and prevent cross transmission was not achieved because the hand washing water was being used on communal basis by the pupils in the schools, and this would contributes to, rather than prevent, cross-contamination as pathogens present on hands of infected persons and could be transferred to those who subsequently dip their hands in the same bowl of water as a result of inadequate hand-washing facilities.

DEDICATION

I dedicate this work to my maker for His love, protection, encouragement, and support throughout these years, and Who inspired me to keep looking for the best in life.

ACKNOWLEDGEMENTS

I acknowledge with sincere gratitude to God for his divine protection and guidance throughout my period of study.

My committed supervisor Prof. Kwesi Obiri Danso, words cannot express how grateful I am to you, for without your patience, advice, guidance and encouragement, this work would not have materialized. I am much thankful to the head and staff of the Department of Environmental Science for their support throughout my period of study.

I also wish to thank Mrs. Harriet Ofori Antwi, the head of the microbiology laboratory of the Food and Drugs Authority, Accra-Ghana and the staff for their directions and support throughout the course of study.

Mr. Justice Djokoto of Central University College, I am grateful for your support.

God richly bless you all.

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ARI	-	Acute Respiratory Infections
AIDS	-	Acquired Immune Deficiency Syndrome
CDC	-	Centers for Disease Control and Prevention
GHWD	-	Global Hand Washing Day
HIV	-	Human Immunodeficiency Virus
HWWS	-	Hand Washing With Soap
IMVIC	-	Indole production, Methyl Red test, Voges-Proskauer test and Citrate utilization test
LRTI	-	Lower Respiratory Tract Infections
MRSA	-	Methicillin-resistant *Staphylococcus aureus*
PIDAC	-	Provincial Infectious Diseases Advisory Committee
GPPPHW	-	Global Public-Private Partnership for Hand Washing
SARS	-	Severe Acute Respiratory Syndrome
SHEP	-	School Health Education Programme
TB	-	Tuberculosis
UNICEF	-	United Nations
USFDA	-	United State Food and Drugs Authority
USEPA	-	United State Environmental Protection Agency
USFDA	-	United State Food and Drugs Authority
WHO	-	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Millions of school-age children are affected by serious — yet easily treatable and preventable — illnesses, which inhibit their ability to learn across the developing world. Particularly, school children are at risk due to neglect of basic personal hygiene (Postma *et al*, 2004; Oduntan, 1974). The results in terms of morbidity and mortality are also more severe in them compared to adults. The increased problem of communicable diseases among school children due to poor hand washing practices and inadequate sanitary conditions remains a concern on the public health agenda in developing countries. The hands are probably the single most important route for transmission of infection in the home and community, as they are often in direct contact with the mouth, nose and conjunctiva of the eyes according to (NIMPE, 2000). Of all the communicable diseases promoted by poor personal hygiene, helminthic infestation contributes the greatest proportion. Although these helminths can infect all members of a population, the most vulnerable group are school children (WHO, 1997b; WHO, 2002). Hand washing hygienic practices encouraged through health education has been reported to be associated with low prevalence of communicable diseases in school children (Long-Shan *et al.*, 2000).

According to (WHO 2002), 62% of all deaths in Africa and 31% of all deaths in SE Asia are caused by infectious diseases. At the same time only five percent of all deaths in Europe are due to infections. Reducing these differences in rates of infection and mortality is a must for the global community. However persons that supervise efforts in reducing public health threats such as HIV/AIDS, malaria and TB relatively neglect the two biggest killers of children, Acute Respiratory Infections (ARI) and the diarrhoeal diseases. According to WHO (2008), 88% of diarrhoeal cases worldwide are related to unsafe water, inadequate sanitation or poor hygiene. In each year, 1.5 million deaths are recorded as a result, mostly in young children with dehydration being the cause of death (WHO, 2008).

Almost half of all child deaths each year are due to diarrhoeal and ARIs, both of which are transmitted from person to person during everyday interaction, through the air, skin contact and contamination of the environment (WHO, 2002). School children aged 5 – 15 years suffer the highest infection rate and worm burden that is attributed to poor sanitation and hygiene (Luong, 2003).This high incidence of diarrhoeal diseases and other communicable diseases among school children may be due to poor knowledge and practice of personal and environmental hygiene (Koopman, 1978; Oduntan, 1974; Hoque, 2003). Unfortunately, poor knowledge on basic hygienic practices and attitudes to personal hygiene, such as hand washing has negative impact for a child's long term overall development (GHWD 1, 2008). According to CDC (1996), as a result of common cold and other infectious diseases nearly 22 million school days are lost. It's not surprising when you think about it, because school is all about sharing: desks, books, pens, food, bathrooms, door handles, water fountains, computer mouse and keyboards. Touching these things results in picking of germs and prevention is the best intervention. Diarrhoea is not the only health effect of poor hygiene and sanitation– cholera, dysentery, worms, trachoma, pneumonia and malnutrition could also be reduced through improved sanitation and hygiene (Sanitation for all the drive to 2015). According to (School Health and Nutrition in Developing Countries) (www.savethechildren.org**)**, healthier children stay in school longer, attend school more regularly, learn more and become healthier and more productive adults. Oduntan, (1974) showed that hand hygiene is the most important and effective infection prevention and control measure to prevent the spread of infections.

Current epidemiological evidence has hand washing with soap (HWWS) as one of the best of all infection prevention methods. This simple act is thought to be capable of preventing about 47% of child diarrhoeas (Curtis and Cairncross, 2003) and 23% of respiratory infections (Rabie and Curtis, 2006; Luby *et al.,* 2005) which account for over 4-6m deaths of children under five around the world (WHO, 2002). The Centre for Disease Control and Prevention (CDC; 1996) has stated: "It is well documented that one of the most important measures for preventing the spread of pathogens is effective hand washing." This is because hand washing can remove the agents of infection both at the time that they are emitted from the primary host and prevent those reaching secondary hosts. Proper hygienic habits such as hand washing have been shown to reduce diarrhoea morbidity and life-threatening diarrhoea by 42 to 48% (Curtis *et al.,* 2003), the prevalence of upper respiratory infections by 24%, (Rabie *et al.,* 2006) and the prevalence of dermatological infections by 23 to 43% (Luby *et al.,* 2005). HWWS is also likely to be an effective means of preventing other diseases which are transmitted via the faecal-oral route, including worm infections and epidemics of cholera and typhoid (Danquah *et al.,* 2007).

1.2 STATEMENT OF THE PROBLEM

Acute respiratory infections (ARI), particularly lower respiratory tract infections (LRTI), are the leading cause of death among children under five years of age and are estimated to be responsible for between 1.9 and 2.2 million childhood deaths globally of which 42% of these ARI-associated deaths occur in Africa (Williams, 2002). However, persons in charge of public health relatively neglect the two biggest killers of children; the diarrhoeal diseases and the Acute Respiratory Infections (ARI). According to WHO (2008), 88% of diarrhoeal cases worldwide are related to unsafe water, inadequate sanitation or poor hygiene. In each year, 1.5 million deaths are recorded as a result, mostly in young children with dehydration being the cause of death (WHO, 2008). An effective means of preventing other diseases which are transmitted via the faecal-oral route, including worm infections and epidemics of cholera and typhoid is HWWS. Key hygiene habits such as good hand washing practice that are likely to be taken further into adulthood can be adopted by encouraging millions of school children to engage in these good repetitive, non-reflective behaviours. To the achievement of two of the Millennium Development Goals (2 and 4), which support Education and Health, these habits can also contribute. Bennell (2002) argues that since school children in developing countries account for up to half of the population, promotion of good hygiene and hand washing practices is not only necessary but also very relevant (Bennell, 2002). According to a UNICEF report, a sense of ownership that makes new behaviours more likely to be adhered to is when the children themselves are involved as active participants in promoting hand washing with soap in schools creates in the children, (UNICEF, 2008).

In Ghana, the National Community on Water and Sanitation Programme has among its mandate to increase the number of school children, aged 6-15 years, who wash their hands with soap, especially after using the toilet (GPPPHW Ghana, 2009). In addition, the School Health and Education Programme (SHEP) in Ghana is to provide a comprehensive health education and services, as well as ensure availability and use of water and sanitation facilities in schools to facilitate the practice of hand washing (SHEP, 2008). Tunga Community Islamic Basic School and Zamarama Line Basic School are among the numerous schools located in the Ablekuma South Sub-metropolis of the Accra metropolis in the Greater Accra Region of Ghana. Tunga Community Islamic Basic School has a population of about 350 pupils housed in six class rooms i.e. from basic 1 to 6. The school has no access to water and toilet facilities. Pupils brought water in gallons from their homes and poured into bowls that are mounted on wooden stands in front of the classrooms from which all wash their hands without using soap. Zamarama Line Basic School also has a population of about 412 pupils housed in six class rooms i.e. from basic 1 to 6. The school also has no access to water and toilet facilities. Pupils walk about 150 meters to fetch water into bowls that are mounted on metal stands in front of the classes with an amount of liquid soap poured into it from which all wash their hands. Centres for Disease Control (2007) and Scott *et al.*, (2007) avers that a hand washing facility, even with soap, on a communal basis, where the same water is used by more than one person, does not constitute an adequate hand washing facility. The question that arises is what is the quality of water in the hand washing bowls available to the school children? Although interventions such as the SHEP exist in schools (Tay, 2005; SHEP, 2008), studies have not been conducted to assess the impact of these interventions on school children's health in the Ablekuma South Sub-metropolis of Accra, Ghana.

1.3 OBJECTIVES

- **General Objectives:**

The study is to assess the microbiological quality of the water in the stand alone bowls for hand washing in the Tunga Islamic Community Basic School and Zamarama Line Basic School in the Ablekuma South Sub- metropolis of Accra, Ghana.

- **Specifically this study will :**

Determine the microbial numbers (total heterotrophic plate count, *Staphylococcus aureus* total coliforms, and faecal coliforms,) and *Escherichia coli* isolation in the water in the stand alone hand washing bowls before use at 8.00am, and after use at 8.00am, 11.00am and 2.00pm.

CHAPTER TWO

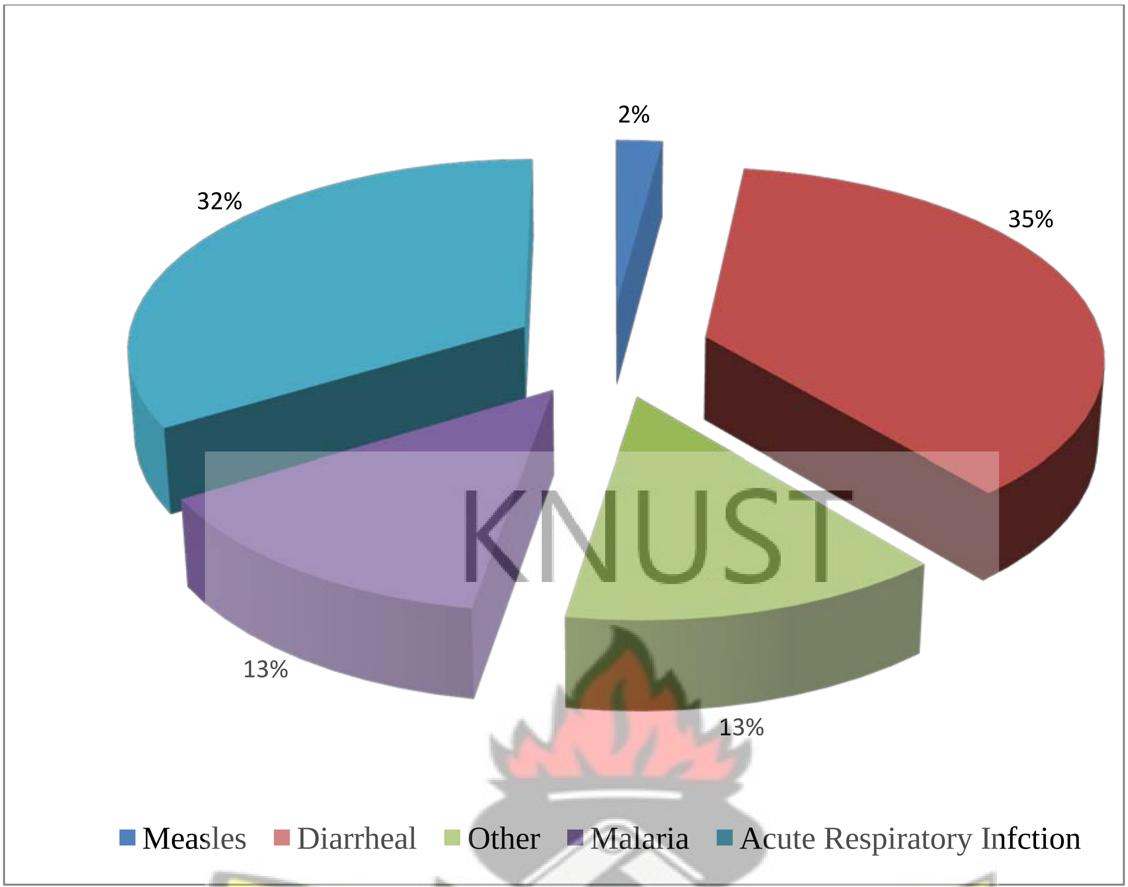
2.0 LITERATURE REVIEW

2.1 Hand washing

Removing microorganisms physically from the hands using soap (plain or antimicrobial) and running water according to Oduntan, (1974) is hand washing. Boyce and Pittet, (2002) defined 'Hand hygiene' as actions involving proper hand washing, the use of antiseptic hand wash or antiseptic hand rub. Among school children, one of the most important hygiene behaviours to promote is hand washing with water and soap — at least before eating and after using the toilet according to Bennell (2002). The school children can be encouraged to wash their hands with water and a small amount of wood ash if soap is not available (although this should be avoided if it is likely to block the drainage system) and water point should be close to the classrooms as much as possible (Zomerplaag & Mooijman, 2005). Global Hand washing Day focuses on children because not only do they suffer disproportionately from diarrheal and respiratory diseases and deaths, but research shows that children – the segment of society which is often the most energetic, enthusiastic, and open to new ideas – can also be powerful agents for changing behaviours like hand washing with soap in their communities (Hand washing and it importance: http://globalhandwashing.org) as the theme for the 2013 global hand washing day was 'Power is in your hands'. During the 2006 outbreak of severe acute respiratory syndrome (SARS), studies carried out by WFP/UNESCO/WHO (1999) suggests that washing hands as often as possible a day can reduce the spread of the respiratory virus by 55% and washing hands in particular — should not be compromised by lack of water or lack of access to hand washing basins or suitable alternatives (WFP/UNESCO/WHO, 1999). Hoffman in 2003 indicated that water is and has always been mankind's most important resource and is recognized as the key environmental issue of the 21st century and a key to poverty alleviation (Hoffman, 2003). According to

WFP/UNESCO/WHO (1999), water for hand washing, bathing and dishwashing should be of drinking-water quality, particularly if there are no specific drinking-water points. The Centres for Disease Control and Prevention (CDC, 1996) has stated: “It is well documented that one of the most important measures for preventing the spread of pathogens is effective hand washing”. Among the environmental health challenges in several regions worldwide are water and sanitation inadequacy; and a billion people lack access to safe drinking water, while 2.4 billion people still have inadequate sanitation according to Macy and Quick, (2003) and this has an adverse effect on individuals, households, communities and countries. Millions of people suffer devastating diseases and millions of children die where there is no clean water and proper sanitation as identified by Hoffman, (2003) and Plate *et al*, (2004). Snyder and Merson (1982) also stated that lack of clean drinking water and sanitation services is a cause of water-related diseases globally and between five-ten million deaths occur annually, basically of small children.

A generous amount of clean water for washing Hands is effective at reducing the presence of some viruses but to remove contamination from bacteria, parasites, and fungi, the use of soap or alternative rubbing agents is necessary. (Curtis *et al*, 2005, Aiello *et al*, 2007). An alternative to soap that may be considered is alcohol-based hand sanitizers (White *et al*, 2003) but the risk of poisoning and intoxication and the high cost must be considered carefully according to Roberts *et al.*, (2000). Too often one forgets hand washing which is a simple and effective way to reduce cross-contamination (Luby, 2005). According to Pittet *et al.*, (2001) lack of knowledge among personnel about the importance of hand hygiene in reducing the spread of infection and how hands become contaminated, lack of understanding of correct hand hygiene technique, understaffing and overcrowding, poor access to hand washing facilities, irritant contact dermatitis associated with often exposure to soap and water, and lack of institutional commitment to good hand hygiene are among the many factors that have contributed to poor hand washing compliance among health care workers. The US FDA stated that food employees should clean their hands and expose portions of their arms for at least 20 seconds while paying attention to removing soil from underneath the fingernails. Food employees may use disposable paper towels or similar clean barriers when touching surfaces such as manually operated faucet handles to prevent recontamination of the hands after washing. (USFDA Food Code 2005). An essential component of effective hand washing is hand drying. Damp hands as a result of ineffective hand drying can lead to skin excoriation which in turn leads to higher numbers of bacteria colonizing the skin and facilitating the spread of microorganisms (Jumaa, 2005). Stebbins *et al* (2011) found that education and hand hygiene was highly effective in reducing school absenteeism and confirmed cases of influenza A (but not influenza B). infrastructural, cultural, and behavioural changes as well as substantial resources which take time to develop (e.g. trained personnel, community organization, provision of water supply and soap) may be required in hand washing (Cave, 1999; Yeager, *et al.*, 1999; Luby, 2005). Therefore a prerequisite to a child's survival is good hand washing practice (UNICEF, 2008; Curtis and Caimcross, 2003). Bennell (2002) also argues that since school children in developing countries account for up to half of the population, promotion of this good hygiene and hand washing practice is not only necessary but also very relevant.



Source: WHO 2001

Figure 1.0 Distribution of Global Child Deaths by Cause

2.2 Hand washing facility

A "hand washing facility" can be defined as "a facility, providing a basin, container, or outlet with an adequate supply of potable water, soap and single-use towels (Kesavan *et al,* 1998). In ensuring proper hand washing practices, a well functioning school sanitation and hand washing facilities can play a major role according to Tay, (2005). Sources of pathogenic bacteria can be from Hand washing sinks because they usually contain stagnant water that supports the growth of microorganisms, which can be transferred to hands during hand washing practices (Griffith *et al,* 2003). An effective way of removing pathogens from the surface of the hands is to wash hands with soap and running water (Larson *et al.*, 2003). Provision of soap according to Luby *et al.*, (2005) and Peterson *et al,* (1998) has been shown to be important in promoting hygiene practices, preventing and controlling the spread of communicable diseases. Danquah *et al.*, (2007) also avers that washing hands with soap is important and cost-effective means of preventing the infections that kill millions of children in the developing world each year. Even using soap to wash hands on a communal basis, where the same water is used by more than one person, does not constitute an adequate hand washing facility according to the Centres for Disease Control (2007) and Scott *et al.*, (2007). According to the PPPHW the presence of a hand washing facility is critical in getting people to wash their hands.

2.3 The Purpose of Hand washing

The main source of diarrhoeal pathogens is human faeces. They are also the source of shigellosis, typhoid, cholera, all other common endemic gastro-enteric infections and some respiratory infections: just one gram of human faeces can contain 10 million viruses and one million bacteria. UNICEF (2008) estimates that at least in every 30 seconds diarrhoea kills one child. Ejemot *et al*., in (2008) suggested that hand washing may substantially reduce the risk of diarrhoeal diseases. Many of the studies conducted have proven that it is imperative to care about personal hygiene, and especially hand cleanliness (Bao *et al*, 2006)

Curtis and Cairncross, (2003) has cited hand washing with soap as one of the most cost effective interventions to prevent diarrhoeal related diseases and deaths . Oduntan (1974) also argues that, the transmission of disease agents are interrupted by hand washing and so diarrhoea and respiratory infections as well as skin infections and trachoma can significantly be reduced. Hand washing according to Curtis and Cairncross (2003) can be a critical measure in controlling pandemic outbreaks of respiratory infections. Numerous studies have suggested that hand hygiene compliance can be improved, at least modestly, by a variety of interventions such as introduction of alcohol-based hand rub and educational and behavioural initiatives. Most authorities believe that multidimensional interventions are more effective. For example, Pittet *et al* implemented a multidisciplinary, multimodal hand hygiene improvement program featuring promotion of alcohol-based hand rub and achieved substantial improvement in hand hygiene compliance. Much of the improvement in compliance was attributed to increased use of the alcohol-based hand rub. As hand hygiene compliance improved, both the incidence of nosocomial infections and new methicillin-resistant *Staphylococcus aureus* (MRSA) cases decreased, although the authors did not assert that they had rigorously demonstrated a causal link (Pittet *et al.*, 2000). Snyder and Merson (1982) estimated that lack of clean drinking water and sanitation services leads to water-related diseases globally and between 5-10 million deaths occur annually, primarily of small children. Several studies carried out during the 2006 outbreak of severe acute respiratory syndrome (SARS) suggest that, washing hands more often in a day can cut the spread of the respiratory virus by 55% (WFP/UNESCO/WHO 1999). Nokes *et al.*, (1993) explained that the most important and effective infection prevention and control measure to prevent the spread of infections to consider is hand hygiene. A study by Nokes *et al.*, (1993) revealed that in institutions such as primary schools and day-care centres hand washing reduced the incidence of diarrhoea by an average of 30% (Nokes *et al.*, 1993). Studies have also been made in various institutions including kindergartens, schools, university campuses and military facilities, but the results of compliance and effectiveness of these interventions in open communities is less well known (Roberts *et al.*, 2000; Ryan *et al.*, 2001; Falsey *et al.*, 1999; Larson *et al.*, 2003; White *et al.*, 2003). Faecal oral or simply hands are routes through which some respiratory tract infections, including the SARS- causing corona virus, are transmitted, so these infections can as well be prevented through hand washing (UNICEF, 2008.). Godoy *et al*, in 2011, stated that in Spain as in other countries, among the measures to reduce the transmission of pandemic influenza and other respiratory viruses are the promotion of hand hygiene and the provision of information on respiratory and hand hygiene while Fung and Cairncross (2006) as cited by Godoy *et al.,* (2011), indicated that some of these measures were also used to mitigate the 2003 outbreak of severe acute respiratory syndrome (SARS). Skin infections, eye infections, intestinal worms, SARS, and avian flu can also be prevented through hand washing (Godoy *et al.,* 2011). By bringing the lessons learned in social and commercial marketing to hygiene programming, the PPPHW aims to catalyze effective, sustainable changes in hand washing behaviour on a large scale. Epidemiological evidence shows that the most important risk factors are attitudes that encourage human contact with faecal matter, including improper disposal of faeces and lack of hand washing after defecation, after handling faeces (including children's faeces), and before handling food (LeBaron ,1990; Traore, 1994; Curtis, 1995; Lanata, 1998). Although hand washing with soap is among the most effective and inexpensive ways of preventing diarrhoeal diseases and pneumonia, which together are responsible for the majority of child deaths globally each year, it is seldom practised and not always easy to promote, despite its life saving abilities (GHWD 1, 2008, GHWD 2, 2008). Thus the global awareness to the outbreak of the Pandemic Influenza H1N1 in 2009 included hand washing with clean water and soap, after critical moments, as a way of prevention (World News, 2009). A great change in hand washing behaviour is critical to achieving the Millennium Development Goal of reducing deaths among children under the age of five by two-thirds by 2015.

2.4 When to wash hands

Washing hands with soap under running water or large quantities of water with vigorous rubbing has been found to be more effective than when members of a household dip their hands in the same bowl of water (often without soap) (Kaltenthaler, 1991) which is commonly practiced in many resource-poor countries, especially before eating (Maxine *et al*., 2011). Rather than preventing, this may contributes to food contamination as pathogens present on hands of infected household members can be transferred to those who subsequently dip their hands in the same bowl of water (Schmitt, 1997). A recent review by Curtis and Cairncross (2003) argues that hand washing with soap, particularly after contact with faeces (post-defecation and after handling a child's stool), can reduce diarrhoeal incidence by 42-47%. Crucial times for hand washing include after using the toilet, after cleaning a child, and before handling food (GHWD 1, 2008). For children in particular, critical moments include after playing outside, or with toys and pets (Quinn, 2008; Ali, 2008). According to CDC, hands should be washed with soap and clean, running water (if available):

- Before, during, and after preparing food
- Before eating food
- Before and after caring for someone who is sick
- Between handling raw and cooked or ready-to-eat food
- After using the toilet
- After changing diapers or cleaning up a child who has used the toilet
- After blowing your nose, coughing, or sneezing
- After touching an animal or animal waste
- After handling pet food or pet treats
- After touching garbage or working in the garden
- After using a tissue or handkerchief
- After attending to sick children or other family members.

2.5 How to wash your hands properly

Langeri (1983) identified the standard for good hand washing practices which is to first wet hands thoroughly all over, then use neutral soap, after which the hands are rubbed vigorously together for about fifteen to twenty seconds, paying particular attention to fingertips, thumbs, wrists, finger webs and back of hands. The soap should be well-lathered all over hands, rinsed under running water, and hands finally dried with a clean towel. One of the most important hygiene behaviours to promote among school children is hand washing with water and soap (or ash) — at least before eating and after using the toilet. (Bennell, 2002)

To wash hands properly: Wet your hands with warm water.

- Apply one dose of liquid soap and lather (wash) well for 15–20 seconds (or longer if the dirt is ingrained).
- Rub hands together rapidly across all surfaces of your hands and wrists to help remove dirt and germs.
- Don't forget the backs of your hands, your wrists, between your fingers and under your fingernails.
- If possible, remove rings and watches before you wash your hands, or ensure you move the rings to wash under them, as microorganisms can exist under them.
- Rinse well under running water and make sure all traces of soap are removed, as residues may cause irritation.
- Pat your hands dry using paper towels (or single-use cloth towels). Make sure your hands are thoroughly dry.
- Dry under any rings you wear, as they can be a source of future contamination if they remain moist.
- Hot air driers can be used but, again, you should ensure your hands are thoroughly dry (NIMPE, 2000).

2.6 Some Hand washing Related Diseases

2.6.1 Respiratory tract infections

Respiratory tract infections are largely caused by viruses. The common cold is reported to be the most frequent, acute infectious illness to humans (Dingle *et al.*, 1964). An estimation of 1.9 and 2.2 million childhood deaths among children under five years of age are caused by acute respiratory infections (ARI), particularly lower respiratory tract infections (LRTI) with 42% of these ARI-associated deaths occurring in Africa according to Williams, (2002). Although colds are generally mild and self-limiting, they represent a significant economic burden because of loss in productivity and medical costs. Furthermore, otitis media, sinusitis, or lower respiratory infections including pneumonia are secondary infections produced from complications with its risk of mortality, particularly in elderly adults. Several studies have demonstrated that colds are also a trigger for asthma (Gem, 1995).

2.6.2 Diarrhoeal disease

Diarrhoeal disease pathogens are usually transmitted through the faecal-oral route (Curtis 2000). Among the modes of transmission diarrhoeal disease pathogens include ingestion of food and water contaminated by faecal matter, person to- person contact, or direct contact with infected faeces (Black, 1989). Some studies estimate that over 70% of all cases of diarrhoea can be attributed to contaminated food and water (Esrey, 1989; Motarjemi, 1993; Curtis, 2003). The World Health Organization recognizes the spread of diarrhoeal diseases as a serious global problem (WHO Health Statistics 2008) and estimates that each year, there are more than 2.2 million lives lost due to these infections, more than from malaria, HIV/AIDS and measles combined (Boschi-Pinto et al, 2008). Diarrheal infections claim the lives of 1.87 million children under five each year, making diarrhoea the second-most common cause of death among children under five, despite intensive international efforts to reduce the number of deaths it causes (WHO, 2002). Oral rehydration therapy (ORT) has more than halved the global toll of acute watery diarrhoea in the last 20 years. The remaining deaths are increasingly due to persistent and bloody diarrhoeas, which do not respond to ORT. For these, the best cure is prevention – through better hygiene and sanitation. Diarrheal diseases are often described as water-related, but they are more accurately excreta-related since the pathogens come from faecal matter *(Sustainable Sanitation:* sanitationdrive2015.org) and these pathogens make people ill when they enter the mouth via hands that have been in contact with faeces.

2.6.3 Intestinal worm infections

Intestinal worm infections in humans is a silent epidemic that destroys the health, well being and learning potential of millions of children in many developing countries today and has an enormous impact on children's ability to learn (NIMPE, 2000). Worms are spread when children inadvertently ingest human faeces or food contaminated with faeces. These parasites consume nutrients from children they infect. Thus, they aggravate malnutrition and retard children's physical development (Luong, 2003). They also destroy the tissues and organs in which they live, and cause abdominal pain, diarrhoea, intestinal obstruction, anaemia, ulcers and various health problems. All of these consequences of infection can lead to an impairment of learning and slower cognitive development, leading to poor school performance (NIMPE, 2000). This happens mainly when proper toilet and hand washing facilities are lacking. The positive effects on school attendance and achievement of providing such facilities have been proven *(Sustainable Sanitation:* sanitationdrive2015.org).

Research shows that hand washing with soap reduces the incidence of infections like intestinal worms, especially ascariasis and trichuriasis. According to the *Sustainable Sanitation:* (sanitationdrive2015.org) worms affect an estimated 400 million school-aged children in the developing world. Infestation with parasitic worms (helminths) is a major health problem and children in countries which have low sanitation coverage commonly carry up to 1,000 hookworms, roundworms and whipworms at a time, which can cause anaemia and other debilitating conditions (NIMPE, 2000). Worldwide, soil-transmitted helminths infect more than one billion people due to a lack of adequate sanitation. Chronic hookworm infestations are associated with reduced physical growth and impaired intellectual development, and children suffering from intense infestations with whipworm miss twice as many school days as kids who are not infested. One hundred percent of roundworm, whipworm or hookworm cases are related to poor water, sanitation and hygiene (NIMPE, 2000).

2.6.4 Conjunctivitis (Pink-Eye)

Conjunctivitis (or pink-eye) is an inflammation of the mucous membranes that line the eyelids, most often caused by a virus but occasionally caused by bacteria or allergies. With this inflammation, the white part of the eye becomes pink and the eye produces lots of tears and discharge. Organisms that cause conjunctivitis are transmitted by direct contact with discharge from the conjunctivae or upper respiratory tracts of infected people. The organisms are also transmitted from contaminated fingers or other articles. Children under five are most often affected. *(Sustainable Sanitation:* sanitationdrive2015.org).

2.6.5 Giardiasis

Giardiasis is a parasitic infection principally of the upper small intestine caused by *Giardia lamblia*. It is a fairly common cause of diarrheal illness. Infections with *giardia* may vary from no symptoms to mild, severe, or chronic diarrhoea accompanied by cramping and bloating of the abdomen, pale and foul smelling stools, weight loss, and fatigue. The parasite that causes giardiasis is transmitted from person to person by hand-to mouth transfer of the organism from the faeces of an infected individual (usually due to poor hand washing practices), especially in institutions and day-care centres; this is the principal mode of spread. *(Sustainable Sanitation:* sanitationdrive2015.org)

2.6.6 Hepatitis A

Hepatitis A (formerly infectious hepatitis) is a viral infection of the liver caused by the hepatitis A virus (HAV). The hepatitis A virus is transmitted from person to person by the faecal-oral route. The hepatitis A virus enters through the mouth, multiplies in the body, and is passed in the faeces (stool). The virus can then be carried by an infected person's hands and can be spread by direct contact or by consuming food or drink that has been handled by the individual. *(Sustainable Sanitation:* sanitationdrive2015.org).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study site

Tunga Islamic Community Basic School is among the cluster of schools located at Sahara down in Dansoman a suburb of Accra in the Ablekuma South Sub-metropolis. The school has no pipe and no toilet facility but pupils patronize a public toilet in the locality when they feel like attending to natures call for a fee. There is a public playing grounds in the school set up by the then first lady, Nana Kunadu Agyeman Rawlings where all children go to play during break times. 'Zamrama' Line Basic School is also located north of Sahara in Dansoman, a suburb of Accra in the Ablekuma South Sub-metropolis. The school also has no toilet facility and a tap but pupils patronize a public toilet in the locality when they feel like attending to natures call for a fee. They have a rubbish dump in the school where fire is set into it each day after school. Both schools have been in existence for the past two decades.

3.2 Sample collection

3.2.1 Hand washing water

Water samples from stand alone hand washing bowls in front of classrooms in the 'Tunga' Islamic Community Basic School where students washed without soap and the 'Zamrama' Line Basic School where an amount of liquid soap is poured into hand washing water immediately it is placed there for pupils to use on communal basis in the Ablekuma South Sub-metropolis of Accra were sampled before use at 8.00am and after use at 8.00am 11.00am and 2.00pm. The water samples were collected in 500 ml sterilized plastic bottles. The first set of water samples were collected at 8.00am before use, just when the hand washing water has been placed in front of the classrooms. The second set of water samples were collected after the school pupils had returned from the first break at 9:30am (8.00am after use). The third sets were collected immediately the school pupils had returned from the second break at 11:45pm (11:00am after use). The fourth sets of samples were collected at 2:00pm (2:00pm after use), that is when the pupils were about to close from school at 2:30pm. The water samples were taken directly from the bowl offered for washing hands. Prior to sampling, the water in the stand alone hand washing bowl was mixed thoroughly by swirling clockwise and then anticlockwise. This was to ensure homogeneity and also to ensure the sample taken from the bowl was representative of the quality of the water being assessed. The samples were transported in an ice chest with ice packs to the Food and Drugs Board laboratory for analysis.

3.3 Isolation and Enumeration of Total heterotrophic plate count bacteria

Serial dilution series of 10^{-1} to 10^{-7} of the sample was prepared and 1ml aliquots of the each dilution was inoculated in duplicate into labelled Petri dishes with the appropriate dilution factor, the class, time of sampling, and name of media. Approximately 15 -20 ml of molten Plate Count Agar (PCA) maintained at 45-47°C was poured into the inoculated Petri dish, gently swirled to mix and allowed to set. The plates were incubated at 30°C for 72 hr. Colonies were counted after the incubation period.

3.4 Isolation and Enumeration of coliforms

Serial dilution of 10^{-1} to 10^{-7} of the sample was prepared and 1ml aliquots of the appropriate dilution inoculated in duplicate into labelled Petri dishes with the appropriate class, time for which sample was taken, name of media and dilution factor. Approximately 15ml of Violet Red Bile Lactose Agar **(**VRBLA) was poured into each of the inoculated Petri dish, gently swirled and allowed to set. This was then overlaid with further 10-15 mls of VRBLA and allowed to set. The plates were then incubated at 37°C for 48 hr. All typical colonies (purplish red with diameter of 0.5mm or greater and with or without halo) were counted.

3.4.1. Confirmation of faecal coliforms

Five (5) typical colonies of coliforms on VRBLA were picked with a loop and inoculated into separate tubes of Brilliant Green Bile Broth (BGBB) with inverted Durham tubes. This was incubated at 37°C for 48 hr. Tubes showing gas production was confirmed for faecal coliforms.

3.4.2 Confirmation of *E. coli*

Gas positive tubes of faecal coliforms in the BGBB were transferred into EC Broth in test tubes containing inverted Durham tubes. The EC Broth was incubated at 44°C for 48 hr. at the end of the incubation period all test tubes were examined for gas production in the Durham tubes. Gas positive EC tubes were then transferred onto Eosin Methylene Blue Agar (EMBA) plates and incubated at 37°C for 24 hr. Colonies with greenish metallic sheen on EMBA plates were counted as being positive for *E. coli*. Confirmation of *E. coli* was carried out using the IMVIC test i.e. (Indole production, Methyl red test, Voges-Proskauer test, and Citrate utilization test)

3.5 Isolation and Enumeration of *Staphylococcus aureus*

Suitable dilutions were prepared and 0.1 ml aliquots inoculated in duplicate onto the surface of pre-poured Baird Parker Agar (BPA) plates labelled with appropriate class, time of sampling, name of media and dilution factor and spread evenly with a sterile glass hockey stick. The plates were incubated at 37°C for 48 hr.

3.5.1 Confirmation of *Staphylococcus aureus*

A minimum of five characteristic colonies from BPA plates were picked onto DNase agar plates and incubated at 37^{o}C for 24 hr. Three millilitres of 1% solution of HCl was flooded over the colonies on the DNase agar plates and allowed to stand for one second. Clear zones around colonies on DNase agar confirmed positive test for *Staphylococcus aureus.*

3.6 Colony Counting

The plates were checked for growth after the end of the incubation periods. The colonies on the PCA, BPA and VRLBA were counted using the colony counter (J. P. SELECTA, Abrera, and (Barcelona). Counts were made from plates supporting 30–300 colonies and their means noted. The mean was then multiplied by the reciprocal dilution factor to give the number of colony forming units per ml (cfu/ml) of test sample.

3.6.1Analysis of results

Statistical Product for Service Solutions (SPSS) and Microsoft Excel would be employed for the organization of the data presentation, description and analysis. The statistical tools to be employed for the analysis would be descriptive statistics and Analysis of Variance (ANOVA) for examining significant differences in the water samples between subjects. Also, the results and the analysis of the research would be presented in the form of texts and figures.

CHAPTER FOUR

4.0 RESULTS

4.1 Total Heterotrophic Plate Counts

Mean total heterotrophic plate counts in the water samples used for hand washing in the Tunga Islamic Community School varied from the initial numbers of 4.81×10^{1} cfu/ml before use in hand washing to 1.04×10^{8} cfu/ml after use by the children at 8.00am. This increased to 1.33×10^{8} cfu/ml after use at 11.00am and to 2.18×10^{9} cfu/ml after use at 2.00pm.

Figure 4.1a: Total heterotrophic plate counts for Tunga Islamic Community Basic

That of Zamarama Line Basic School also showed a similar trend. Average heterotrophic plate count before use by the pupils at 8am was 2.08×10^1. This increased to 1.34×10^4 cfu/ml after use at 8am. It later increased to 3.09×10^4 cfu/ml at 11am after use and then to 2.46×10^5 cfu/ml at 2.00pm after use.

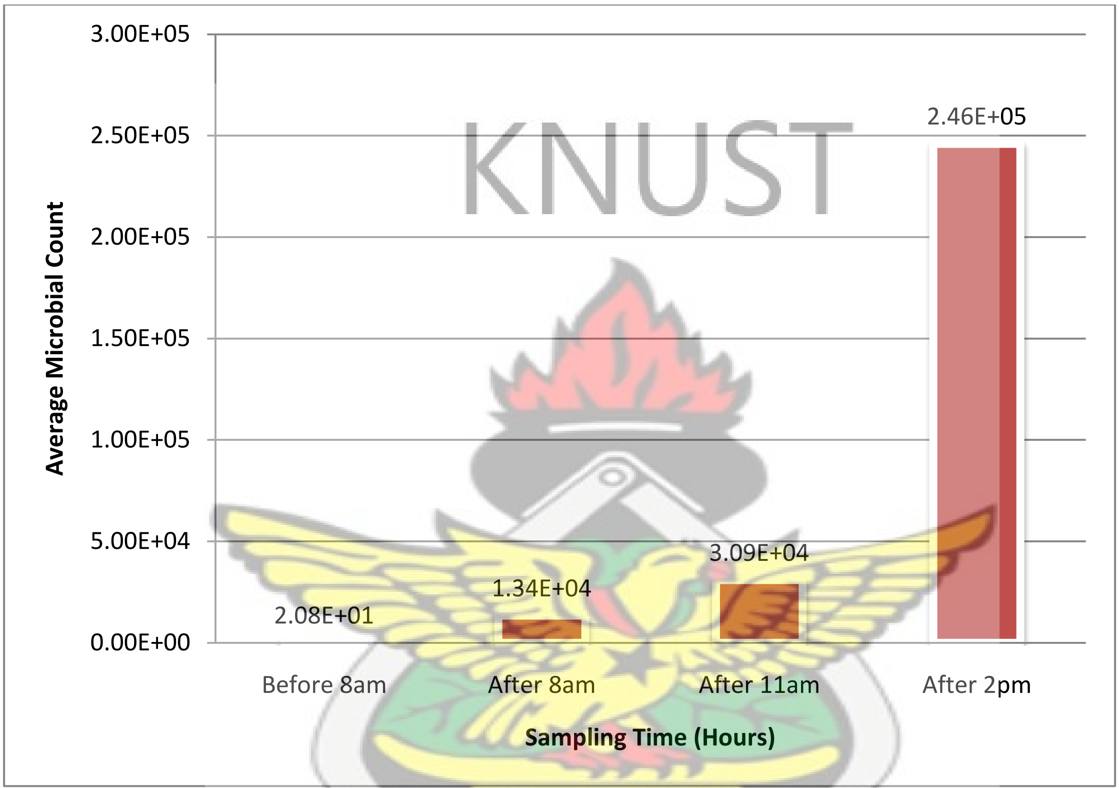


Figure 4.1b: Total heterotrophic plate counts for Zamarama Line Basic

4.2 *Staphylococcus aureus* counts

Staphylococcus aureus was absent in the water sample used for hand washing in the Tunga Islamic Community School before use at 8.00am. *Staphylococcus aureus* counts recorded 1.33×10^7 cfu/ml after use by the children at 8.00am. These numbers increased to 2.30×10^7 cfu/ml at 11.00am after use and to 1.77×10^9 cfu/ml at 2.00pm after use.

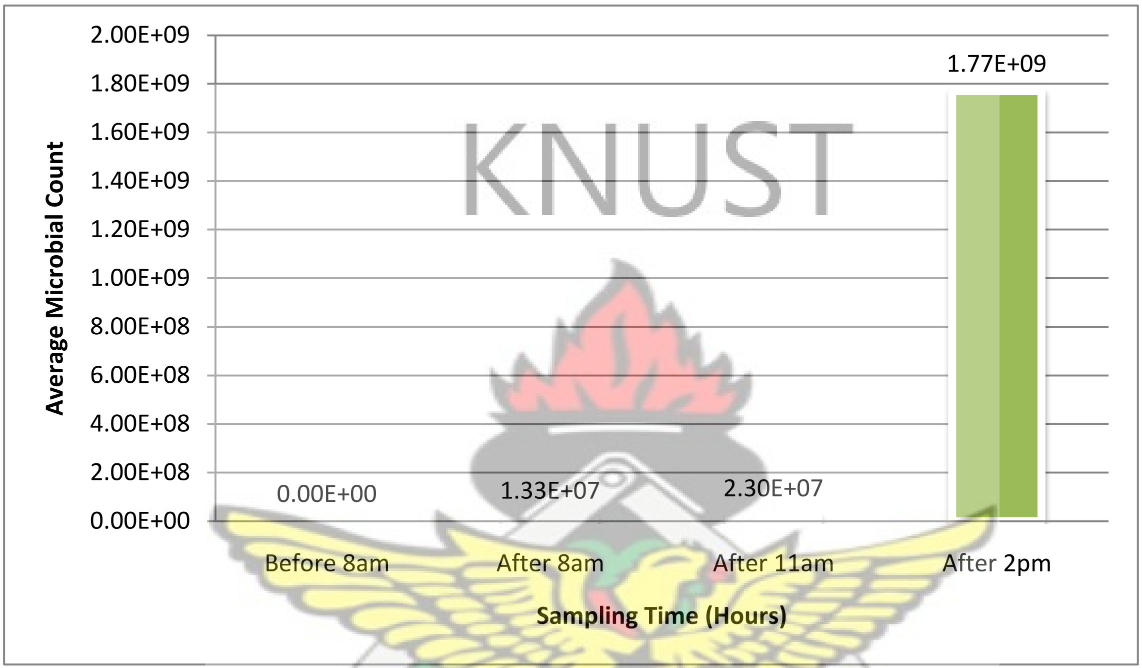


Figure 4.2a: *S. aureus* counts for Tunga Islamic Community Basic School

At the Zamarama Line Basic School, a similar observation was made with respect to the average *S. aureus* counts at the different times. *Staphylococcus aureus* were absent in the hand washing water before use at 8.00am but after use at 8.00am, $4.48x10^{3}$ cfu/ml of *Staphylococcus aureus* counts were recorded. After use at 11.00am the numbers increased to an average of $7.83x10^{3}$ cfu/ml and further increased to $8.04x10^{5}$ cfu/ml at 2.00pm after use.

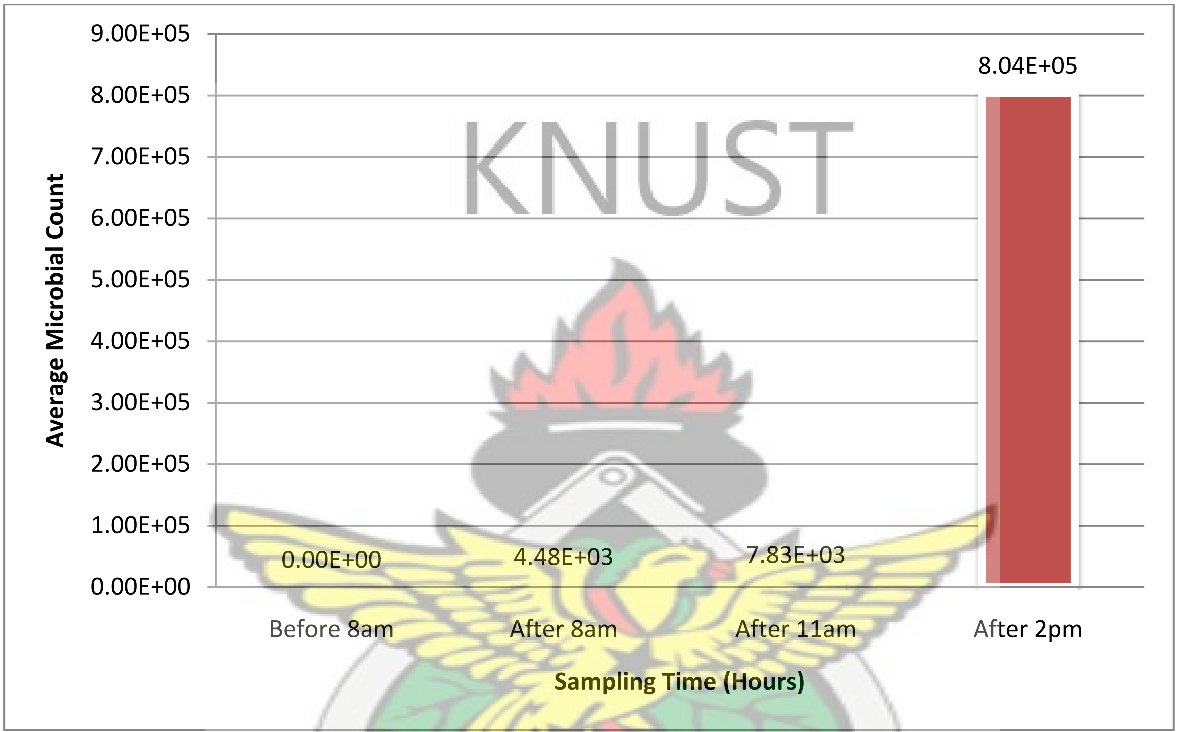


Figure 4.2b: ***S. aureus*** **counts for and Zamarama Line Basic School**

4.3 Total Coliform counts

Total coliforms was absent in the water sample used for hand washing in the Tunga Islamic Community School before use. After pupils have used it at 8.00am total coliforms recorded was 1.26×10^6 cfu/ml. These numbers increased to 1.33×10^6 cfu/ml after use at 11.00am and to 1.49×10^8 cfu/ml after 2.00pm after use.

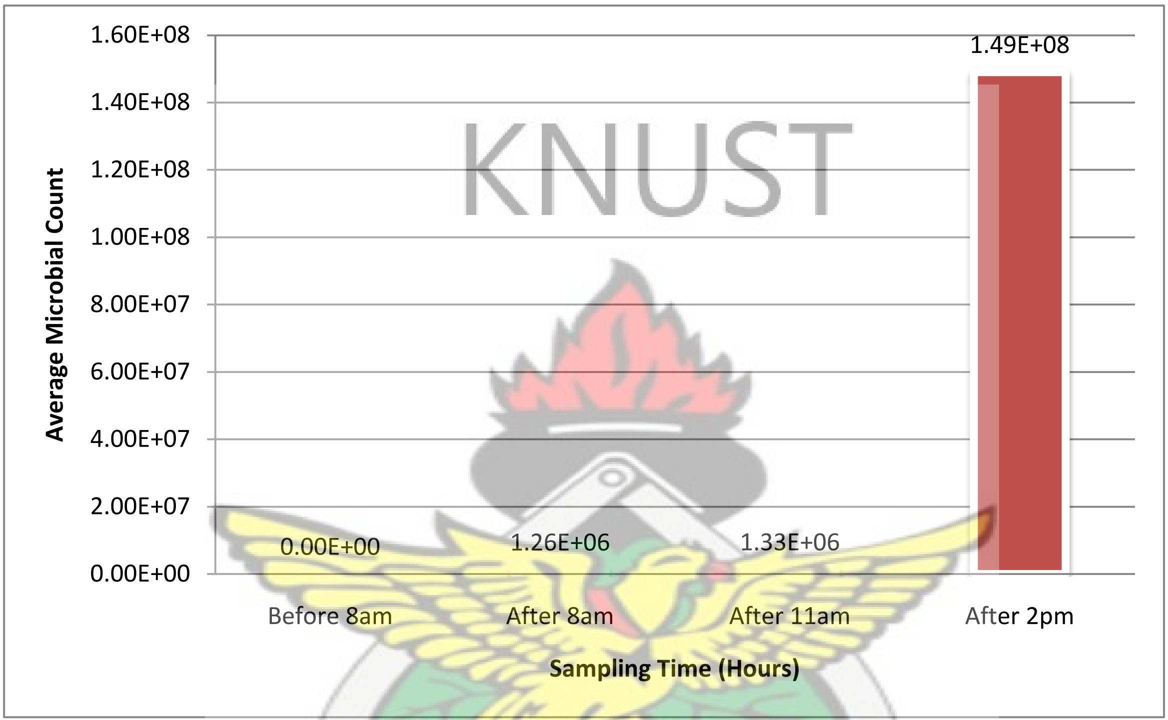


Figure 4.3a: Total Coliform counts for Tunga Islamic Community Basic School

A similar observation was made at the Zamarama Line Basic School, with respect to the average counts of total coliforms. Total coliforms was absent in the water before use but a count of $2.33x10^3$ cfu/ml was made after use at 8.00am. This increased further to $5.53x10^3$ cfu/ml at 11am after use and to $2.79x10^4$ cfu/ml at 2.00pm after use.

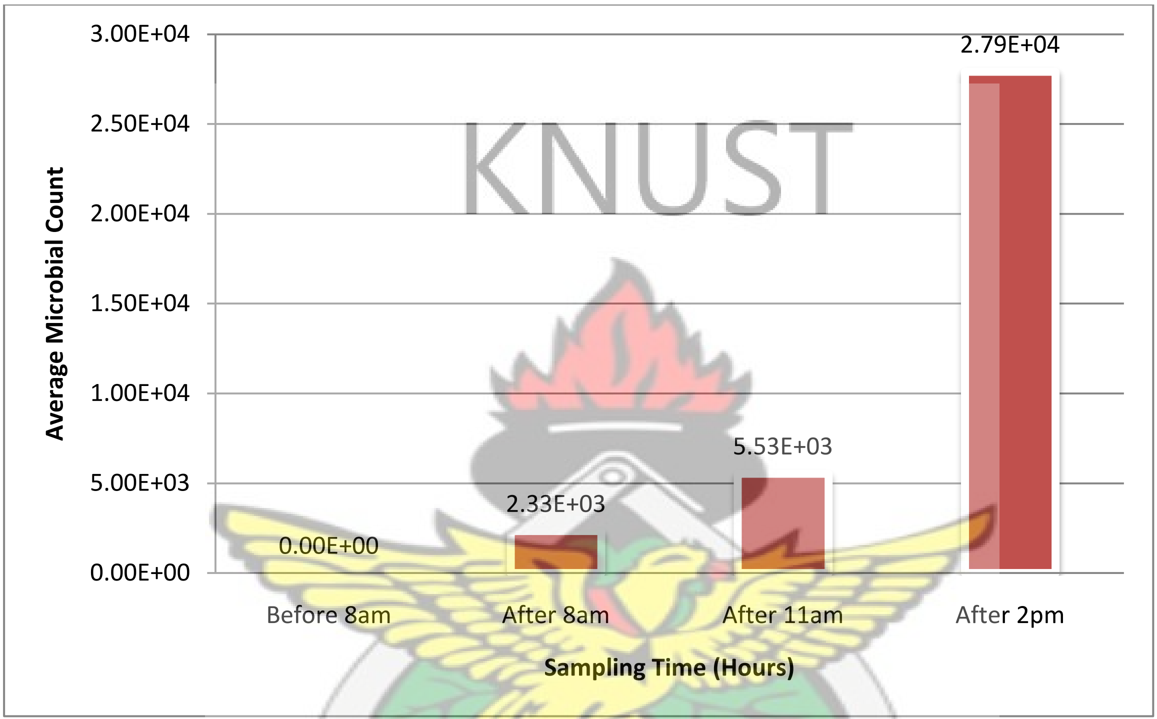


Figure 4.3b: Total Coliform counts for Zamarama Line Basic Line Basic School

4.4: Faecal Coliform counts

Similarly, faecal Coliforms were absent in the water sample used for hand washing in the Tunga Islamic Community Basic School before use for hand washing but later recorded 3.81×10^5 cfu/ml after use at 8.00am by the children. This increased to 4.08×10^5 cfu/ml at 11.00am after use and to 4.34×10^7 cfu/ml 2.00pm after use.

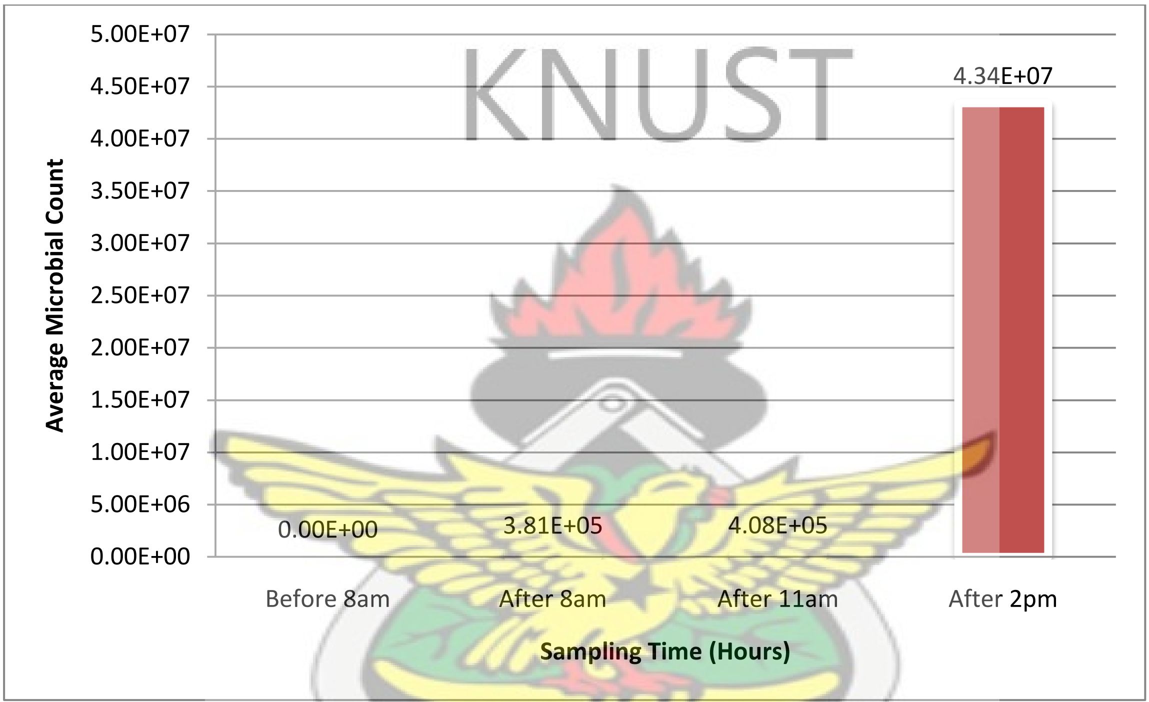


Figure 4.4a: Faecal Coliform counts for Tunga Islamic Community Basic School

Similarly, at the Zamarama Line Basic School faecal coliforms were absent in the water before use but after use at 8.00am, the microbial numbers recorded was 4.36×10^2 cfu/ml. After use at 11.00am, these numbers increased to 5.05×10^2 cfu/ml and again to 6.38×10^3 cfu/ml at 2.00pm after use.

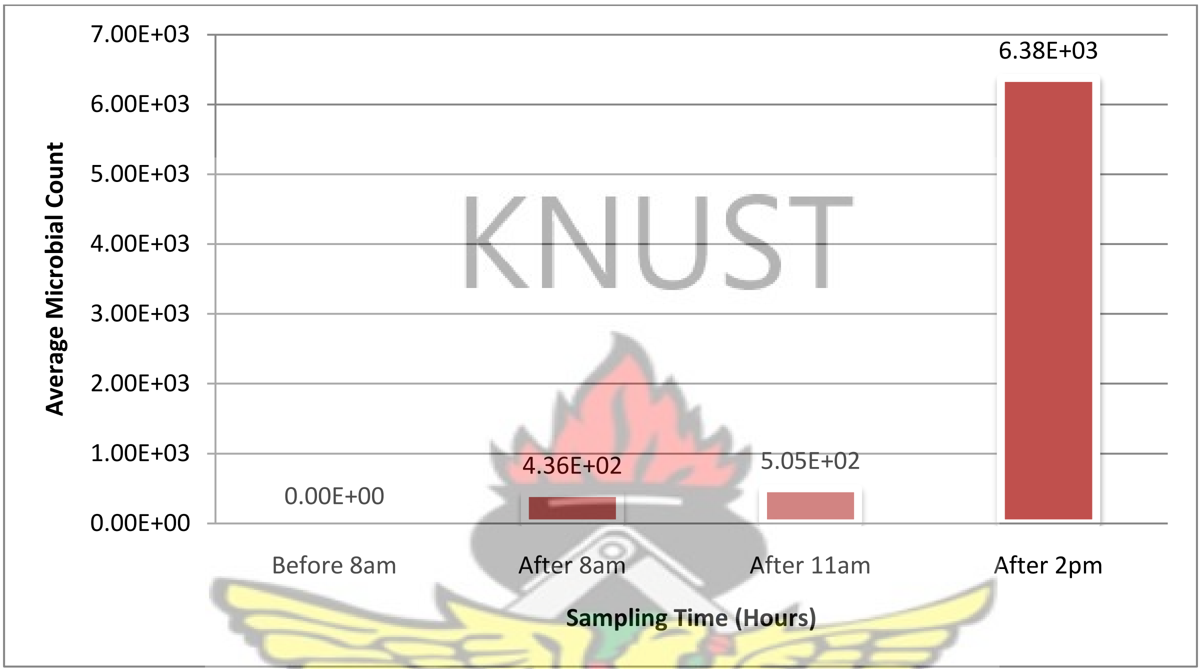


Figure 4.4b: Faecal Coliform counts for Zamarama Line Basic School

4.5: Biochemical characterization of coliforms

IMVIC test conducted on the coliform isolates confirmed them to be *E. coli*

Test	Reaction
Indole	Positive
Methyl Red	Positive
Voges Proskauer	Negative
Citrate Utilization	Negative

Table 1: Biochemical characteristics of faecal coliforms from the hand washing water samples.

CHAPTER FIVE

5.0 DISCUSSION

The study has shown that the microbiological quality of water in hand washing bowls used in the Tunga Islamic Community and Zamarama Line Basic Schools in the Ablekuma South Sub-metropolis of Accra were unacceptable for use by the pupils. The microbial quality was often relatively good before use in the morning but deteriorates as the day wears on mainly because they continually use the same water placed there from the morning till closing and this is supported by Lopez-Quintero (2007) who reported that several primary schools in developing countries do not have access to running water within their schools premises. Steiner-Asiedu *et al.* (2011) also showed that, of the many primary schools surveyed in a study in Tema, Ghana, only one had a water tank with a tap at the base and soap for the pupils to wash their hands. All the others had no other source of clean running water available to the children for rinsing their hands. The Tunga Islamic Community Basic School in this study had neither soap nor appropriate running tap water for hand washing and is supported by Bolt *et al*., (2006), GHWD 1, (2008) in consistent with the present study have shown that in developing countries, lack of soap is one of the barriers to hand washing in schools. Zamarama Line Basic School had an amount of liquid soap poured into the water to be used throughout the day which is contrary to this. What is common in developing countries is that majority of schools in advanced countries have access to hand washing facilities, and pupils were also supplied with soap (Afroza, 2007).

before use at 8am, average total heterotrophic plate counts for Tunga Islamic Community School was 4.81×10^{1} cfu/ml whiles that of Zamarama Line Basic School was $2.08\text{x}10^{1}$ cfu/ml. counts of Tunga Islamic Community increased to1.04×10^{8} after use at 8.00am whiles that of Zamarama Line Basic School increased to1.34×10^{4} cfu/ml. After use at 11.00am, the counts of Tunga Islamic Community School increased to 1.33×10^8 cfu/ml and further increased to 2.18×10^9 cfu/ml after use 2.00pm whiles counts of Zamarama Line Basic School after use at 11.00am was $3.09\text{x}10^4$ cfu/ml and then increased to 2.46×10^5 cfu/ml after use 2.00pm. The same trend was observed for the various microorganisms isolated in this study. These increases support the fact that the practices within the classroom and on the dirty compounds of these schools make the children pick up a lot of contaminants from their environment as the day progresses hence the incremental numbers of microorganisms. The microbial numbers at the Tunga Islamic Community School was always higher compared to that of the Zamarama Line Basic School. This might be due to the fact that before use at 8:00am, the latter had an amount of liquid soap which might have had some antimicrobial component in the water. Rotter (1999) avers that hand washing with plain soap and water for 15 seconds reduces bacterial counts on the skin by 0.6–1.1 $\log_{10}$, whereas washing for 30 seconds reduces counts by 1.8–2.8 $\log_{10}$. It was therefore expected that Zamarama Line Basic School which had some amount of soap in the starting water would have lower microbial numbers compared to the Tunga Basic Schools which did not have any soap.

The standard for good hand washing practices according to Langeri (1983), are to first wet hands thoroughly all over, and then use neutral soap, after which the hands are rubbed vigorously together for about fifteen to twenty seconds, paying particular attention to fingertips, thumbs, wrists, finger webs and back of hands. The soap should be well-lathered all over hands and rinsed under running water. The practice in the Zamarama Line Basic School where pupils used soap did not support Langeri's (1983) standard as pupils only dipped their hands in the dirty soapy water for some few seconds because the water might have been unsightly. The microbial numbers also increased with time in this school though it was less than that of the school without soap. The reason might be because the soap might have lost it efficacy within a short time because of the number of pupils that used the hand washing water (Maxine *et al.,* 2011). Current epidemiological evidence has hand washing with soap (HWWS) as one of the best of all infection prevention methods as stated by Curtis and Cairncross (2003) but pupils of Tunga Islamic Community Basic School were not using soap at all whilst those in Zamarama Line Basic had liquid soap in the hand washing water at the beginning of the school day although its efficacy could not be ascertained.

The water used for hand washing in the schools studied was not changed throughout the day i.e. from morning till closing and this could account for the microbial numbers build-up. This supports the assertion by Yalcin *et al.,* (2004) and Bolt *et al.,* (2006) that compliance with hand-washing initiatives is still low among school children and health care professionals (Boyce *et al.,* 2002) although 150 years have passed since Semmelweis demonstrated the effectiveness of hand washing in preventing nosocomial infections (Best *et al.,* 2004; Jarvis, 1994). Most basic schools in Ghana use stand alone hand washing receptacles and do not have clean running water in the schools and also encourage communal hand washing (Boyce *et al.,* 2002).

Hand washing is supposed to decontaminate hands and prevent cross transmission (Kaltenthaler, 1991; Larson, 1995; Rotter, 1999). This simple act of hand washing is thought to be capable of preventing about 47% of child diarrhoea (Curtis and Cairncross, 2003) and 23% of respiratory infections (Rabie and Curtis, 2006; Luby, *et al.,* 2005) which, between them, account for over 4-6m deaths of children under five around the world (WHO, 2002).

Also proper hand-washing and other simple procedures can also decrease the rate of catheter-related bloodstream infections by 66% but in the case of the two schools in this study, pupils were rather cross-contaminating their hands as the same water was being used from morning till closing. Using the hand washing water on communal basis is also not hygienically proper as pupils might pick some microorganisms from the hand washing water as washing hands with soap under running water or large quantities of water with vigorous rubbing was found to be more effective than several members of a household dipping their hands in the same bowl of water (often without soap) (Kaltenthaler, 1991), which is common practice in many resource-poor countries, especially before eating. This may contribute to, rather than prevent, food contamination as pathogens present on hands of infected members can be transferred to those who subsequently dip their hands in the same bowl of water (Schmitt, 1997).

The two schools studied did not also have adequate hand washing facilities because the water was being used on communal basis by the pupils in the schools since the Centers for Disease Control (2007) and Scott *et al*., (2007) avers that a hand washing facility, even with soap, on a communal basis, where the same water is used by more than one person, does not constitute an adequate hand washing facility. These findings were challenges that were not peculiar to only these schools in this study (Steiner-Asiedu *et al.*, 2011). Many infections could be prevented by correct hand washing to remove the germs that are picked up through daily tasks. This is the best defence we have in preventing infections from spreading and can help save lives. Proper hygienic habits such as hand washing have been shown to reduce diarrhoea morbidity and life-threatening diarrhoea by 42-48% (Curtis *et al.,* 2003), the prevalence of upper respiratory infections by 24%, (Rabie *et al.*, 2006) and the prevalence of dermatological infections by 23-43% (Luby *et al.,* 2002). HWWS is also likely to be an effective means of preventing other diseases which are transmitted via the faecal-oral route, including worm infections and epidemics of cholera and typhoid (Danquah *et al.,* 2007) but in the case of these two schools, such diseases are more likely to be prevalent though they were not specifically researched into, because faecal coliform which must not be present in hand washing water were found to have been present and increased from 0.00 cfu/ml to as high as $3.81x10^5$ cfu/ml after use at 8:00am after use and this increased to $4.08x10^5$ cfu/ml at 11.00am after use and then to $4.34x10^7$ cfu/ml 2.00pm after use for Tunga Islamic Community Basic School. Meanwhile, at the same time for Zamarama Line Basic School, the counts were $4.36x10^2$ cfu/ml, $5.05x10^2$ cfu/ml and $6.38x10^3$ cfu/ml at 2.00pm respectively.

Specifically *E. coli* which must not be present according to WFP/UNESCO/WHO (1999) was detected as in the case of these schools. Also the WHO (WHO, 1996) bacteriological quality of drinking water for all water intended for drinking also indicated that, total coliform bacteria and *E. coli* or thermo tolerant coliform bacteria must not be detectable in any 100ml sample. Moreover, the US EPA (2002) Drinking Water Quality Standards also has it that the Maximum Contaminant Level Goal (MCLG) of these microorganisms in drinking water should be zero. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems. This supports the studies that estimate that, over 70% of all cases of diarrhoea can be attributed to contaminated food and water (Esrey, 1989; Motarjemi, 1993; Curtis, 2000).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

Effective hand washing is one of the most important measures for preventing the spread of pathogens and although both schools were practicing hand washing, this was on communal basis in one bowl due to scarcity of water and unavailability of soap in the case of Tunga Islamic Basic School. This practice did sustain and increased microbial numbers in the water in the hand washing bowls with time. Mean total heterotrophic plate counts with time increased by an average of 644% at the Tunga Islamic Basic schools and by 78% at the Zamarama Line Basic Schools.

Staphylococcus aureus, total and faecal coliforms were however absent in the hand washing water before use in both schools but were detected after use and increased progressively by 400% in both schools. The water for hand washing in the stand alone hand washing bowls for the two schools understudied, were not changed when it was placed there from the morning till school closed.

The paramount contextual-level barrier facing these students however, is the scarcity of adequate facilities for hand washing in the schools. This not only prevents children from adopting proper hygienic behaviour but also thwarts school-based educational and health-promotion efforts. Provision of clean running water with soap will encourage the students to wash their hands more frequently and this will reduce the absenteeism of students to school as all episodes of germ contamination will be reduced hence reduction of poverty. Students will also be motivated to even teach members in their homes as children are agents of change thereby helping the country in the achievement of the Education for All objectives and the Millennium Developmental Goals.

6.2 RECOMMENDATION

- To ensure the adoption of proper hand-washing practices amongst school children, a more coordinated approach is needed from stakeholders.
- Hand washing at least 5 times a day and, if possible, > 10 times a day, should be recommended at the school level in order to prevent severe or complicated cases of influenza and other communicable diseases requiring hospitalisation.
- Hand-washing promotion can be incorporated into the school curriculum, and other stakeholders (e.g., soap manufacturers) can be invited to participate in these educational activities.
- At the broader societal level, governments and other agencies responsible for the well being of children need to be made aware that financial and technical support of simple and inexpensive interventions, such as hand washing with soap, may be effective in the achievement of the Education for All objectives and the Millennium Developmental Goals.
- Sanitizing alcohol-based hand rubs (liquid, gel or foam hand sanitizers) can provide an effective and convenient alternate solution to hand hygiene in school.
- Children often learn by watching adults. Especially young children cannot wash their hands properly. Therefore, it is important for school personnel to know and utilize good hand washing techniques. This will ensure that they can demonstrate to the students the proper techniques in addition to telling them.

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APPENDIX

Table 4.1.1: Total heterotrophic plate counts in hand washing bowls at different times at the Tunga Islamic Community School

Time	Period	Mean	Std. Deviation	% Change
8 am	Before	4.81E+01	3.50E+00	
	After	1.04E+08	1.19E+08	-
11am	After	1.33E+08	1.15E+08	231%
2 pm	After	2.18E+09	6.44E+08	796%

Table 4.1.2: Total heterotrophic plate counts in hand washing bowls at different times at Zamarama Line Basic School

Time	Period	Mean	Std. Deviation	% Change
8 am	Before	2.08E+01	5.10E+00	
	After	1.34E+04	5.14E+03	-
11 am	After	3.09E+04	4.38E+04	6.1%
2 pm	After	2.46E+05	5.15E+03	78.2%

Table 4.1.3: Results of Significance test for Total heterotrophic counts

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	6.871E18	1	6.871E18	183.224	.000
Error	4.950E18	132	3.750E16		

The F tests the effect of School. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The observed differences in total heterotrophic plate count numbers before washing hands in the bowls provided before and after were statistically significant (p=0.00) (Table 4.1.3) between the two schools; Tunga Islamic Community Basic and the Zamarama Line Basic with Tunga Islamic Community Basic showing higher compared to the Zamarama Line Basic.

Table 4.2.1: *S. aureus* counts at Tunga Islamic Community School

Time	Period	Mean	Std. Deviation	% Change
8 am	Before After	0.00E+00 1.33E+07	0.00E+00 1.01E+07	-
11am	After	2.30E+07	1.25E+07	173%
2 pm	After	1.77E+09	1.29E+09	770%

Table 4.2.2: *S. aureus* counts at Zamarama Line Basic School

Time	Period	Mean	Std. Deviation	% Change
8 am	Before After	0.00E+00 4.48E+03	0.00E+00 7.18E+03	-
11am	After	7.83E+03	7.20E+03	170%
2 pm	After	8.04E+05	1.16E+06	520%

Table 4.2.3 Results of Test of Significance for S. aureus counts

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	3.235E18	1	3.235E18	23.283	.000
Error	1.834E19	132	1.389E17		

The F tests the effect of School. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The observed differences in *Staphylococcus aureus* numbers between the two schools were statistically significant (p=0.00)

Similarly, *Staphylococcus aureus* numbers in the Tunga Islamic Community Basic were higher than in the Zamarama Line Basic (Table 4.2.3).

Table 4.3.1: Total Coliform counts at the Tunga Islamic Community Basic School

Time	Period	Mean	Std. Deviation	% Change
8 am	Before After	0.00E+00 1.26E+06	0.00E+00 1.51E+05	-
11am	After	1.33E+06	1.29E+05	111%
2 pm	After	1.49E+08	1.27E+08	1120%

Table 4.3.2: Total Coliform counts at Zamarama Line Basic School

Time	Period	Mean	Std. Deviation	% Change
8 am	Before After	0.00E+00 2.33E+03	0.00E+00 2.59E+03	-
11am	After	5.53E+03	6.93E+03	137%
2 pm	After	2.79E+04	9.96E+04	504%

Table 4.3.3: Results for Test of Significance for Total Coliform

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	2.327E16	1	2.327E16	17.363	.000
Error	1.769E17	132	1.340E15		

The F tests the effect of School. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The observed differences in total coliform numbers between the two schools were statistically significant (p=0.00) (Table 4.3.3).

Total coliform numbers in the Tunga Islamic Community Basic were higher than in the Zamarama Line Basic (Figures 4.3a and 4.3b).

Table 4.4.1: Feacal Coliform counts at Tunga Islamic Community School

Time	Period	Mean	Std. Deviation	% Change
8 am	Before After	0.00E+00 3.81E+05	0.00E+00 3.13E+05	-
11am	After	4.08E+05	3.46E+05	110%
2 pm	After	4.34E+07	4.35E+07	1063%

Table 4.4.2: Feacal Coliform counts at Zamarama Line Basic School

Time	Period	Mean	Std. Deviation	% Change
8 am	Before After	0.00E+00 4.36E+02	0.00E+00 4.43E+02	-
11am	After	5.05E+02	3.18E+02	115%
2pm	After	6.38E+03	3.66E+03	1263%

Table 4.4.3: Result for Test of Significance in Faecal Coliforms

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	1.987E15	1	1.987E15	12.600	.001
Error	2.082E16	132	1.577E14		

The F tests the effect of School. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Differences in faecal coliform numbers between the two schools; Tunga Islamic Community Basic and Zamarama Line Basic were statistically significant (p=0.00) (Table 4.2.3) with numbers in Tunga Islamic Community Basic being higher than in the Zamarama Line Basic (Figure 4.4a and 4.4b).