International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 3 Issue 8, July 2016

ISSN: 2394-4404

Effects Of Faecal Disposal Methods On Contamination Of Hand Dug Well And Spring Waters Of Bomachoge Borabu Sub County, Kisii County- Kenya

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Abstract: ***This study was conducted to investigate effects of human faecal output on contamination of wells and spring water of Bomachoge Borabu Sub County. The study also investigated methods of human faecal disposal and physical characteristics that influence contamination of selected water sources by faecal matter with the aim of improving the well and spring water quality. A cross- sectional study design was used and the areas of study were; Magenche, Bokimonge, Bombaba and Boochi areas, targeting residential areas of high, middle and low classes. Methods of data collection were questionnaires, measurements and laboratory water samples testing for faecal coliforms as indicators of faecal water pollution. Data analysis was done using multiple regression and Anova. Results revealed significant ($P<0.05$) faecal coliforms pollution of well and spring water ($P>0.05$), with bout 25.3±0.16 colonies/100mls. It was concluded that water sources in Bomachoge Borabu faecally contaminated due to poor sanitary practices near water sources. The distance between pit latrines and investigated water sources also had significant influence on faecal coliforms levels of wells and springs ($P<0.05$).The results revealed that there was need for public health education on environmental management of faecal matter, disposal and protection of wells and springs so as to reduce prevalence of waterborne diseases which disturbs ecological balance in nature.***

Keywords: ***Ecological, Pollution, Faecal coliforms, Disposal, Environment.***

I. INTRODUCTION

The environmental degradation caused by inadequate disposal of human waste can be expressed by contamination of surface and underground water through seepage and soil contamination through direct contact. To prevent detrimental effects of human waste (faeces and mucus), these must be properly disposed. In rural residential areas of Kenya, it is mostly the poor who suffer from life threatening conditions as a result of deficient human waste management (Tebbut, 1992). As authorities tend to allocate their limited resources to richer areas of higher tax yields where citizens with more political power reside, and get better services like piped water and sewerage systems, they neglect the poorer citizens in the informal residential areas (Franceys *et al*., 1992).

With the emerging concern on large quantities of human waste being produced, both in the form of solid and liquid waste, their management becomes one of the key focus of sustainable development principles which is based on policies and practices that are resource conserving and respect values of equity in human access to resources (Olivieri, *et al*., 1977). Inadequate or biased distribution of services leads to improper management of human waste and hence environmental degradation. This may contaminate domestic water sources and the contamination can be detected by the presence of indicator organisms (APHA, 1998), such as faecal coliforms

ISSN: 2394-4404

isolated from water. The presence of faecal coliforms in water is definitive proof of faecal contamination (Cheesbrough 2006)

Testing for the presence of faecal organisms in water is a way of determining whether a water supply is faecally polluted (Cheesbrough, 2006). Exposure to faecally contaminated water does not always translate into infection (Ellis, 1998). However, the higher the faecal bacteria level in water, the higher the chances of pathogens to be present in significant numbers too. Poor hygienic conditions also accelerate the fecal-oral route of pathogen transmission (Tebbut, 1992). Pathogen levels in water and predispositions of persons play an important role in infections (Olivieri, *et. al*., 1977).

Disposal of human faeces occur in several modes worldwide and will most often display a wide disparity between urban and rural areas (WHO/ UNICEF 2008). Werner, *et al*. (2004) reported that safe disposal of faecal matter was very poor in rural and urban slum settlements and thus contamination of water sources, leading to major diarrhoea diseases which killed 100,000 children each year. Such cases of diarrhoea demonstrated a strong ecological interaction between the problems of poor human faecal matter disposal and contamination domestic water sources (Franceys *et al*., 1992).

In developing countries, pit latrine device were commonly used both in urban and rural settlements (Franceys *et al*., 1992). The disadvantage with pit latrine device was contamination of domestic water sources with pathogen in densely populated rural or urban slums, through underground seapage, direct contact and through ground water run offs (Werner, *et al*., 2004).

According to reports by (WHO/ UNICEF 2008), 40% of the population in sub-Saharan Africa had no pit latrines and therefore, use informal faecal disposal means, leading to serious faecal contamination of water sources. Utilization of flush toilets was limited by availability of piped water and inadequate water supply led to frequent use of pit latrine as an alternative disposal point. Flush toilets are suitable for controlling contamination of domestic water, which occurs when alternative disposal structures are not used properly (Lenton *et al*., 2005).

Pit latrine usage in Africa was reported to be 0-5% in children of six months and increased with age reaching 25% by the age of 50 months (Curtis *et al*., 2001) further noted extremely low usage of pit latrine by children because of the fear of contamination from adult faeces in shared and poorly constructed pit latrines. As a result the faeces were disposed on the soil which is easily swept by water run offs into underground water sources (Lenton *et al*., 2005).

Children less than five years make up a significant proportion of up to 20% of population in many developing countries this shows that the indiscriminate disposal of excreta from children is health risk (Aulia, 1994). A potty is the most commonly used method for collection of children faeces in households within urban areas where the faeces are subsequently transported to flush toilets or pit latrines conversely in rural areas children are cleaned after long call using plant leaves or even grass and afterward the leaves are disposed on the ground to decompose (Sugden, 2004). This disposal method of faecal matter cause contamination of water sources if it is not properly used (Curtis *et al*., 2001).

Informal faecal disposal in open fields by adults and children has also been reported by; Aulia (1994) he further noted that indiscriminate disposal of faeces near or in bushes close to homesteads was associated with contamination of drinking water sources leading to increased cases of diarrheal outbreaks. Further reports also indicate that defaecation in either the bush, open field and soil caused water contamination by faecal coliforms (Ana, *et al*., 2004).

II. MATERIALS AND METHODS

STUDY AREA

The study was conducted in Bomachoge Borabu sub county, Kisii County it has a population of 107,199 people. In terms of topography, the sub county is mainly hilly with several ridges to the eastern part. The most notable topographical features are the hills of Nyataro (Senta), Nyabitunwa, Igorera and Emesa (KCDDP, 2008).

The sub county has a highland equatorial climate with reliable annual average rainfall of over 1,500mm. The long rains occur from the month of February to June while short rains occur from September to November. December and January are relatively dry months. Most parts of the district have red soils, which are deep and rich in organic matter .Other parts are characterized by clay, red-roam and sandy soils, which are poorly drained. The sub county is divided into three ecological zones, comprising of the Upper midland 75%, the lower highland 20%, and low midland 5% (KCDDP, 2008).

The area is part of Mau catchment and has several permanent rivers and streams that drain into Lake Victoria. The main sources of water are springs, wells and roof catchments of rain water of rain water. Piped water makes only a small proportion of the drinking water resource. The number of shallow wells in the sub county is approximately 1170 and most of them are in urban, peri-urban settlements. The number of springs is about 2200, there are 11 permanent rivers and the number households with roof catchments being estimated to be 70%. The average distance to the nearest domestic water resource is 1.5km (KCDDP, 2008).

STUDY DESIGN AND COLLECTION OF SAMPLES

A cross sectional study design was used to sample households' faecal disposal facilities and complete randomized design was used to sample the well and spring water contamination by human faecal matter. Water samples from wells and natural springs were collected from Magenche, Bokimonge, Bombaba and Boochi areas between March 2015 and January 2016. The total numbers of water samples that were collected were 50 from each area of study which were namely; Magenche, Bokimonge, Bombaba and Boochi.

This was done by modified protocols described by Tebbut (1992). Water samples from natural springs and hand dug wells were collected by suspending sterile sample bottles (200ml-capacity) using a nylon string and weighted with a

metal mass approximately 50g to facilitate sinking through the water column. Care was taken not to disturb the bottom sediments so as to avoid making the water samples turbid. An air space was created in the sample bottle by pouring out some little water before the lid was secured. Samples were labeled and placed in a cool box containing ice blocks and transported within six hours of collection to University of Eldoret Biotechnology laboratory for analysis and tabulation of results.

TESTING FOR INDICATOR ORGANISM (FAECAL COLIFORMS)

Testing for fecal coliforms in water samples was done using modified membrane filtration method as described in APHA, 1998. Laboratory testing of faecal coliforms was done using 100ml of the water sample which was measured into a measuring cylinder. A small amount of dilution water was added to the funnel before filtration was done to aid in uniform dispersion of the bacteria suspension over entire effective filtration surface. Sterile membrane filter papers were placed over a porous plate using flame sterilized forceps. The grid side of the filter membrane was placed to face up. The funnel unit was carefully matched over the receptacle and locked in place. The sample of the test water was passed through filter membrane under partial vacuum, 30-50 ml sterile buffered water was used to rinse the filter between the samples. The funnel was unlocked immediately after all the water was filtered and the forceps was used to remove the filter membrane which was placed on sterile agar with a rotating motion to avoid entrapment of air. The liquid medium was used and the culture dish was saturated with 1.8-2.0 ml of prepared M-ENDO medium. The culture agar was placed directly in the petri -dish then incubated for 22 to 24 hours at 37^{o}C ±0.5 in incubator, after incubation, the number of bacteria colonies if any were manually counted and expressed as colonies in 100ml of water samples.

ASSESSMENT OF FAECAL DISPOSAL FACILITIES

Assessment of utilization of available human faecal matter disposal facilities was done by use of a questionnaire. The survey targeted the presence and use of various modes of faecal disposal such as; pit latrines, flush toilets and informal disposals. Usage of the available disposal facilities among and within estates was assessed. Observations were made to identify the types of informal faecal deposition methods such as use of polythene bags, faecal deposition in nearby bushes and deposition of children faeces along foot paths and around households.

DATA ANALYSIS

Since some of the data were made in counts and scores, transformations were necessary. Logarithmic transformation was made to allow the use of completely randomized design. This design was used to compare the overall, among and within the estates level of faecal coliform contamination of water sources. Data from questionnaires was coded, scored and analyzed using one way ANOVA after appropriate transformations. Data correlations and relationships from measurements was analyzed using simple regression and the differences were significant at $p \leq 0.05$.

III. RESULTS AND DISCUSSION

Results: The assessment of the relationship between faecal disposal methods and pollution of hand dug wells and natural springs of Bomachoge Borabu Sub County. The study areas investigated were Bokimonge, Magenche, Bombaba and Boochi.

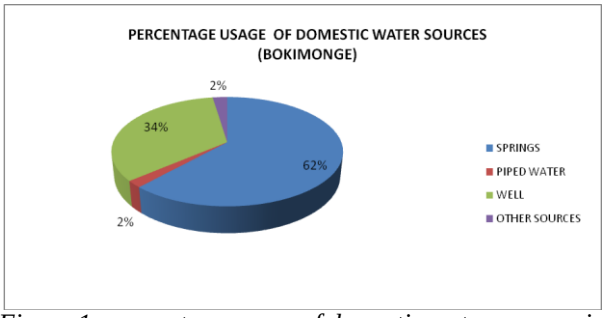

Figure 1: percentage usage of domestic water sources in Bokimonge area

Results indicate that 2%, 34%, 2%, and 62% were the usage levels of piped, well, unspecified and spring respectively, were percentage water usage in Bokimonge area. This show that the spring and well water sources were the most preferred.

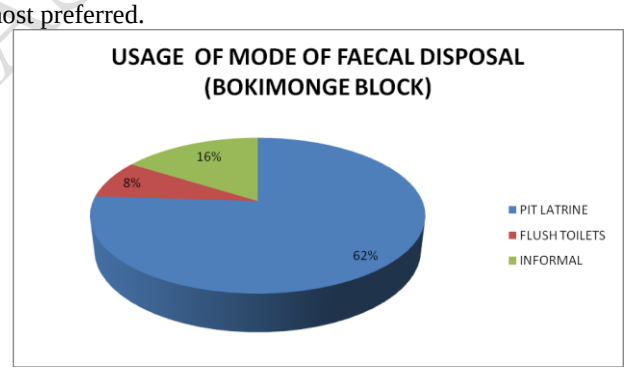

Figure 2: Percentage usage of mode of faecal disposal in Bokimonge area

Results indicate that 8%, 16%, and 62% were the usage levels of flush toilets, informal and pit latrine modes of faecal disposal usage in Bokimonge population. This show that pit latrines systems were the most preferred with the highest usage of 62%.

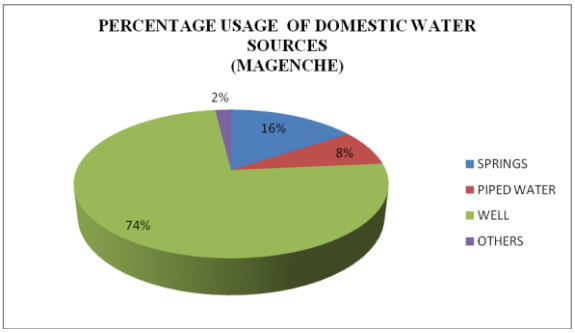

Figure 3: Percentage usage of domestic water sources in Magenche area (74%-wells, 16%-springs, 8%-piped water and 2%-unspecified)

ISSN: 2394-4404

Results indicate that 8%, 74%, 2%, and 16% were the usage levels of piped, well, unspecified and spring respectively, were percentage usage of water sources in magenche population. This show that well water sources were the most preferred with 74% usage.

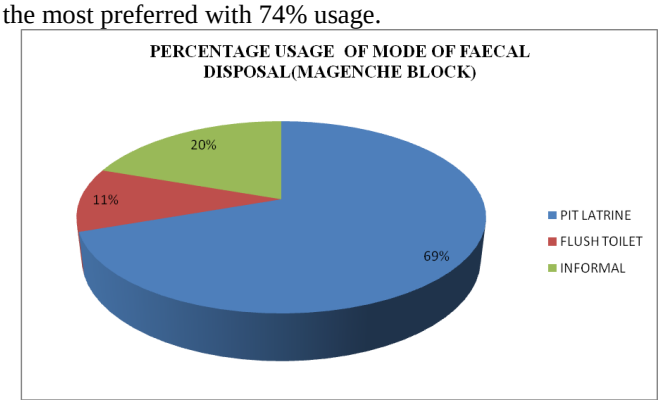

Figure 4: Percentage usage of modes of faecal disposal in Magenche area

Results indicate that 11%, 20%, and 69% were the usage levels of flush toilets, informal and pit latrine respectively were percentage usage of modes of faecal disposal in magenche population. This show that pit latrines systems were the most preferred with the highest usage of 69%.

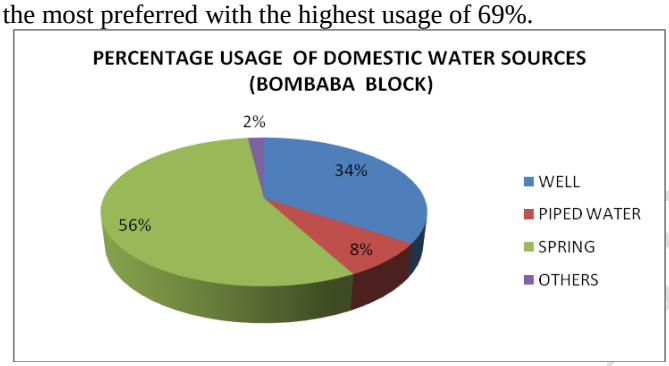

Figure 5: percentage usage of domestic water sources in Bombaba area

Results indicate that 8%, 34%, 2%, and 56% were the usage levels of piped, well, unspecified and spring respectively, were percentage water usage in Bombaba population. This show that the spring and well water sources were the most preferred.

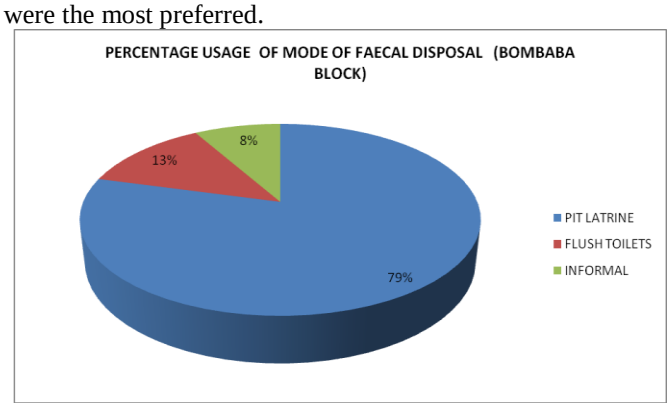

Figure 6: Percentage usage of modes of faecal disposal in Bombaba area

Results indicate that 13%, 8%, and 79% were the usage levels of flush toilets, informal and pit latrine respectively were percentage usage of modes of faecal disposal in Bombaba population. This show that pit latrines systems were the most preferred with the highest usage of 79%.

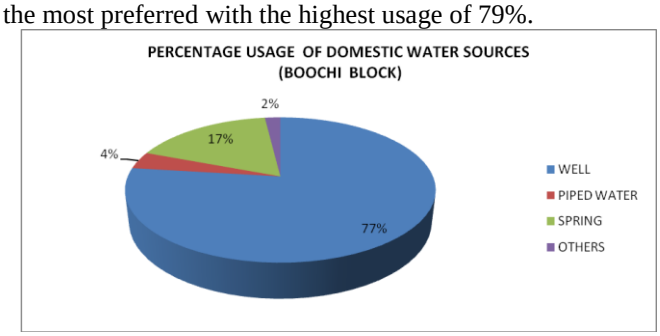

Figure 7: Percentage usage of domestic water sources in Boochi area

Results indicate that 4%, 77%, 2%, and 17% were the usage levels of piped, well, unspecified and spring respectively, were percentage water usage by Boochi residents. This show that the well water sources were the most preferred with 77% usage.

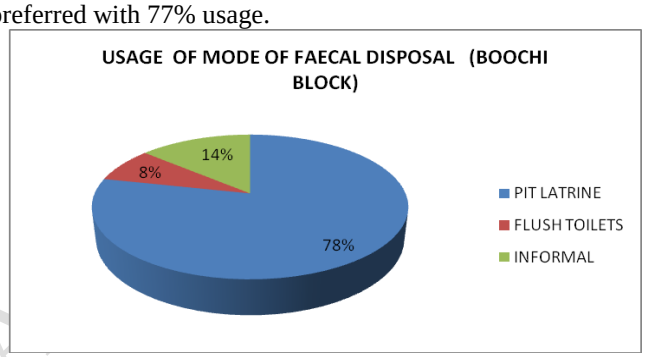

Figure 8: percentage usage of different modes of faecal disposal in Boochi area

Results indicate that 8%, 14%, and 78% were the usage levels of flush toilets, informal and pit latrine respectively were percentage usage of modes of faecal disposal in Boochi population. This show that pit latrines systems were the most preferred with the highest usage of 78%.

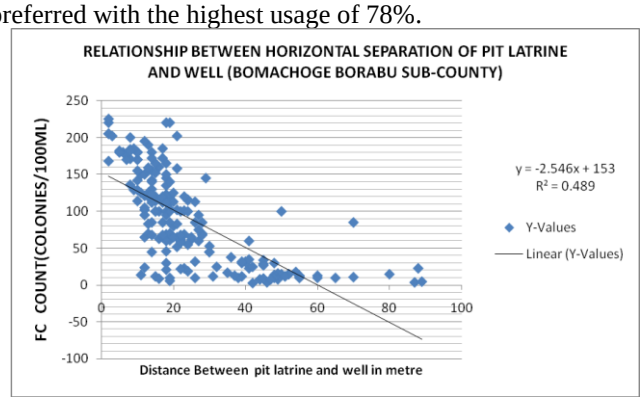

Figure 9: General relationship between horizontal distance of pit latrines and wells to that of faecal coliform count in Bomachoge- Borabu Sub-County

Results show that the faecal coliforms count (cfu/100mls) decrease as the horizontal distance between pit latrines and hand dug wells increase, therefore from the figure 9 above there is a significant ($P<0.05$) relationship between horizontal distance between wells and pit latrines and faecal coliform count, maximum horizontal distance is about 60 meters beyond which no faecal coliform is observed generally in Bomachoge area.

ISSN: 2394-4404

Discussion: Natural springs and hand dug wells are major domestic water sources in Bomachoge Borabu Sub County. Results indicated that water wells and springs were generally accessible among domestic water sources. Responses from residents indicated that the both water sources were used for multiple domestic purposes which included drinking, bathing, watering livestock and washing clothes. Reports from other studies indicated that the spring and well water were the most utilized resource (Kabogo and Kabiswa (2008). Therefore utilization of these water sources in other areas which experience rainfall throughout the year is similar to that observed in the present study.

The preference in utilization of well and spring water in Bomachoge Borabu was based on their distance from the homestead which makes it convenient to fetch and in addition, drawing water is free and does not attract any cost.

Findings of the current study also indicate that preference of wells and springs water was quite varied among estates. Well water was generally the most preferred due to its accessibility. Similar preferential report has been published in literature (Dzwairo, *et al.* 2006). The report identified several factors including topography of the area as the driving force towards accessibility of hand dug well water.

Piped water in municipalities suffers frequent shortages in supply and as Howard *et al., (*2003) suggested, the use of flush toilets and other water based systems would not be appropriate where water supply services are unreliable under such circumstances people prefer using well water. Under these conditions the population may suffer serious exposure to faecal coliforms contamination in wells especially if the distance is short between disposal point and water source. This may explain the higher occurrence of faecal coliform counts in the study areas. The usage of wells and springs in Bomachoge Sub County was notably high. As indicated in the local development plan (Kisii Development Plan, 2008) most residents would travel long distances of up to 1.5km on average to reach natural spring while hand dug wells are within homesteads, this positioned the two on top in terms of usage. However, utilization of hand dug wells was highest at all times. The higher the usage the higher the risks of pollution through run offs and poor sanitary practices due to short distances between disposal points and water sources. Dzwairo, *et. al.* (2006) noted that degree of faecal contamination is complex and must be approached from several dimensions if contamination of domestic water sources is to be tackled effectively. The present study demonstrated that hand dug well and natural springs were contaminated by faecal coliforms. Faecal coliforms have widely been used as indicators of quality of drinking water (Cheesbrough, 2006 and Bartram and Balance, 1996). Although presumed to be harmless, (Olivieri, *et. al*., 1997) presence of faecal coliforms is an indicator of likely presence of other pathogenic organisms (Olivieri *et al* ,1977).Also the intensity of faecal coliforms in water is usually taken as a measure of degree of contamination of water sources (Cheesbrough ,2006). Different modes of human faecal disposal contribute variously to the contamination of water sources (Howard *et. al*., 2003).

Pollution of wells and springs are more serious in developing than in developed countries as was noted by Olivieri *et al*. (1977), where spring water was found to be heavily contaminated with faecal coliforms. Whereas, in developed countries, on-site sanitation facilities were properly sited, designed, constructed and maintained in settlement areas, these conditions presumably limited the risk of groundwater contamination by human faecal materials.

Pit latrines are the most preferred structures due to their affordability in terms of construction and utilization. They also work under the principle of "drop and store" () as compared to flush toilets that are more expensive to install (Lenton, *et al*.,2005).The later also require a lot of water to run. Despite the numerous merits, pit latrines contribute to the highest risk of contaminating wells springs. Improper construction, design and unhygienic management of pit latrines in urban areas may lead to environmental degradation expressed by contamination of surface and ground water through seepage and direct faecal contact with the soils as noted by Lenton, *et al*. (2005).

Pit latrines easily contaminate underground water sources through seepage and infiltration of it is contents. In addition, contamination worsens when the pit latrines are poorly designed, constructed and managed. Probably this is the main source of high level of faecal coliforms count found in the drinking water sources of Bomachoge Sub County. If the design and infrastructure are poor the clean disposable facilities may not function to the expected levels in terms of hygiene. The economic power of an area may not play a major role in hygiene if the culture of residents is unhygienic and human faecal disposal structures are not properly designed and maintained (Shannon, 2003).

Informal methods of human faecal disposal are important sources of domestic water contamination in Kisii municipality, especially the main domestic water source like hand dug wells this has also been observed by Dzwairo *et al*., (2006).The situation is complicated by the fact that there is no order or regularity in the way disposals are made, thus making the existing safe disposal policies implementation difficult.

In the current study it was also found that children faeces were commonly disposed on open ground in most homesteads among the four areas of Bomachoge Borabu Sub County and this was presumed to be the cause of domestic water source contamination, through surface runoffs which carry the faeces and polluted soils into the water sources.

Apart from disposal methods, physical factors have also been implicated in contamination of domestic water sources by faecal coliforms (Sugden, 2004) The distance between pit latrine and hand dug wells at which there are no faecal coliforms count found has been defined by several authors including Ben and Kolsky (1999) and Morgan (1990.

As evidenced in the current study the distance between well and pit latrine affects faecal contamination in the well. Topography of the area may also influence faecal coliform contamination on spring water. It is expected that hilly area contributes more in faecal coliforms contamination on spring water than flat areas, hilly areas increases the flow of runoffs than flat areas.

IV. CONCLUSIONS AND RECOMMENDATION

Hand dug wells were highly contaminated with human feacal matter and this indicated poor waste disposal systems.

This was attributed by topography and distance of water source to that of human faecal disposal points such as the distance between the pit latrine and the hand dug well. Informal disposal of human faecal matter like flying toilets, open field defaecation and improper disposal of children's faeces combined with other unsanitary practices impacted on bacteriological water quality**.** Further studies can be done on other water sources like, tap water and reservoir water so that the contamination levels can be determined to provide suitable human feacal disposal methods which can 1.

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