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HUMAN FAECAL MATTER AS A CONTAMINANT OF WELL WATER SOURCES IN KISII MUNICIPALITY

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ABSTRACT

As a result of a rapid growth of urbanization in developing countries, the majority of urban residents in sub-Saharan Africa live often in areas characterized by lack of basic amenities such as water and sewerage disposal facilities. Consequently, the urban population often use pit latrines which are not expensive to construct while at the same time use cheap domestic water source from the nearby hand dug wells. This study sought to assess sanitary practices of urban residents and feacal matter contamination of domestic water sources. A cross- sectional study design was used. The areas studied were; Nyanchwa, Mwembe and Nyamataro estates, targeting people or residential areas of high, middle and low classes. Methods of data collection used in the study were questionnaires, observations, measurements and laboratory water samples testing for faecal coliforms as indicators of faecal contamination. Data analysis was done using multiple regression and Anova. Results revealed significant ($P<0.05$) faecal coliforms contamination of water in wells with contamination level of 54.9 ± 0.6 faecal coliforms colonies/100ml). It was concluded that hand dug well water sources in Kisii municipality was contaminated with human faecal matter due to unsanitary practices near the water source as it was observed in residential areas. The proximity between pit latrines and well water source also had significant influence on faecal coliforms contamination of domestic water sources ($P<0.05$). Results justified recommendation for public health education on sustainable management of human faecal matter disposal points to keep water borne disease at bay.

Key words: Sanitary practices, Contamination, Faecal coliforms, Sewerage, Pit latrines, Hand dug wells, Disposal.

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INTRODUCTION

Human concentration in urban areas has led to increased generation of large quantities of human waste consequently posing challenges on its safe disposal. This has become a threat to human health. Safe disposal requires high level of investment and due to inadequate funds this is a problem in developing countries United Nation's International Children's Education Fund (1997) and Gesellschaft far Technique Zusammenarbeit (2003).

This problem is even more pronounced in urban areas where safe human waste disposal systems do not reach all the residential areas. This causes health problems especially contamination of hand dug well water sources. Most municipal human waste in Kenya is disposed in improper manner (Obabori, 2009). This has created serious environmental health problems that may affect human health and cause serious economical and other welfare losses (Kirimi, 2008).

Environmental degradation of residential areas 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), they must be properly disposed to avoid spread of pathogens. In urban residential areas of Kenya, it is mostly the urban poor who suffer from life threatening conditions as a result of deficient human waste management (Obabori, 2009). As municipal 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 (Van, 2000).

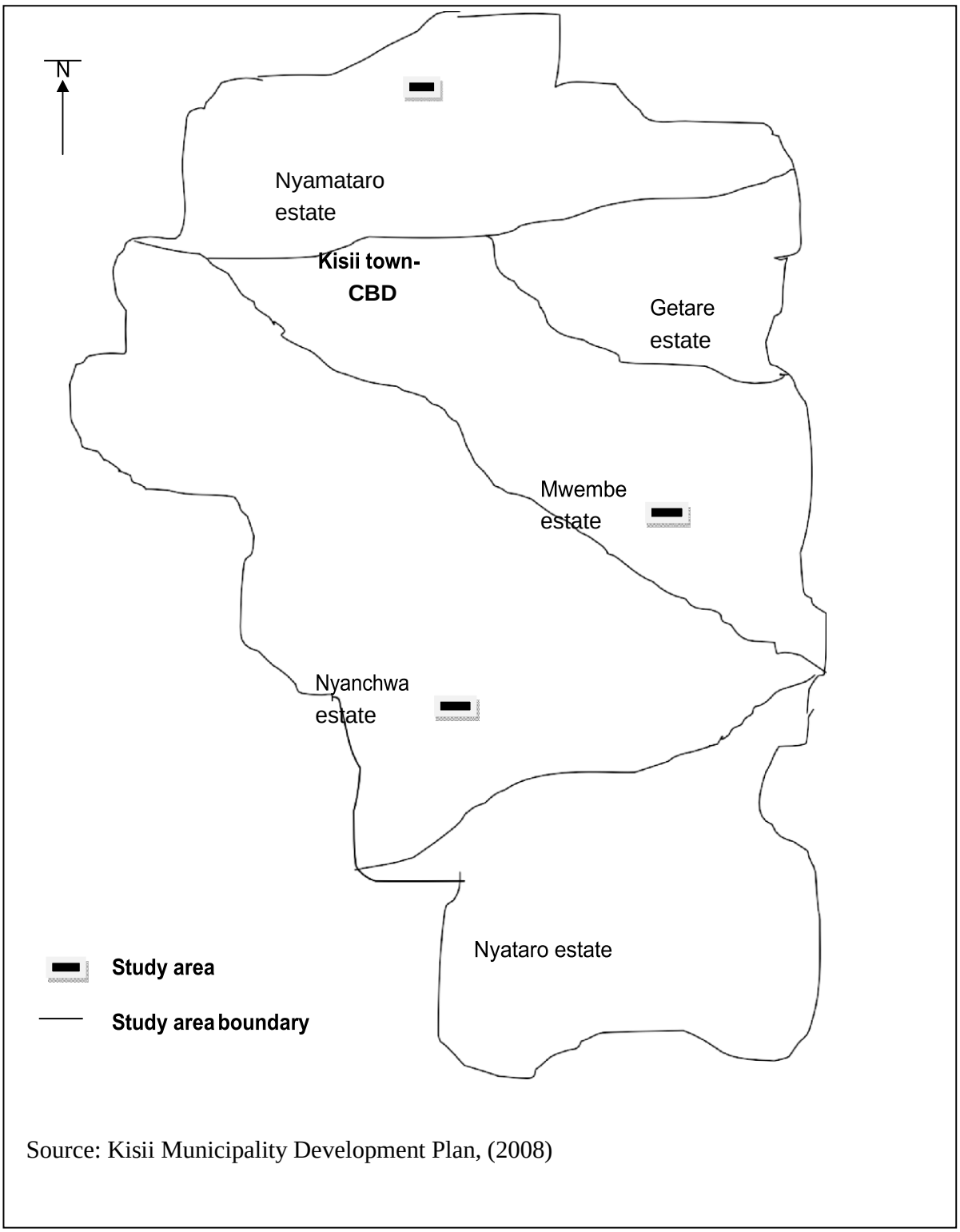
With the emerging concern on large quantities of human waste being produced, both in the form of solid and liquid waste, their management becomes one of the key focus of sustainable development principles which is based on policies and practices that are resource conserving and respect values of equity in human access to resources (Renkow and Otieno, 2008). Inadequate or biased distribution of services leads to improper management of human waste. This may contaminate domestic water sources and contamination can be detected by the presence of indicator organisms (American Public Health Association, 1998). Usually more than 95% of thermo-tolerant coliforms isolated from water are the faecal coliforms their presence of which is definitive proof of faecal contamination (Bartram and Balance, 1996).

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 and Jorge *et. al*., 2010).

The study sought to determine the presence of human faecal matter indicator organisms in hand dug wells, identify various disposal methods of human faecal matter and their degree of contamination of hand dug wells and to determine contamination levels by human faecal matter on well water influenced by the distance between pit latrines and the well of Kisii Municipality.

METHODOLOGY

The study was conducted in Kisii Municipality in Kisii County. On sanitation, the district has 70,225 pit latrines, negligible number of flush toilets while informal disposal methods are common among children. The areas of study within Kisii Municipality were Nyanchwa, Mwembe and Nyamataro settlement areas (Figure 1).



Source: Kisii Municipality Development Plan, (2008)

Figure 1: Sketch map of the study area

A cross sectional study design was used to sample households and the water sources. Water sample collection took place between September 2010 and January 2011. Sampling of hand dug wells was based on criteria that sampled households that were 100m apart. The total numbers of samples that were collected from hand dug wells were 210. The sample size was determined using the Fisher's formula.

$N= Z^2p\ (100-p)/d^2$, Where; Z=1.96, d = any value between 5 and 10.

The P =value was based on potable water accessibility of 27% in Kisii municipality (Kisii District Development Plan, 2002-2008). Calculations using this formula gave a sample size of 210. During sampling the protocols described by Tebbut (1992) were followed. Sample bottles were autoclaved at 115^0C. Samples from hand dug wells were collected by suspending the sample 200ml-capacity bottles 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 Eldoret Water and Sanitation (ELDOWAS) laboratory in Eldoret town for analysis. Faecal coliforms in water samples were tested for using membrane filtration method as described in American Public Health Association, (1998). A small amount of dilution water was added to the funnel before filtration was done to aid in uniform dispersion of bacteria suspension over entire effective filtration surface, sterile 0.45µm membrane filter papers were placed over a porous plate using a sterile 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 containing the culture which was placed on sterile agar with a rotating motion to avoid entrapment of air. 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^oC ±0.5 in incubator, after incubation, the number of bacteria colonies were counted.

Data Collection and Analysis

Data from membrane filtration technique were recorded as faecal coliform colonies per 100mls of sampled water. Assessment of available human faecal matter disposal facilities was done by use of a questionnaire. The survey targeted the presence and use of pit latrines, flush toilets and informal disposals. Usage of the available disposal facilities among and within estates was assessed visually. 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 that were thought to influence degree of hand dug well water source contamination were measured horizontal separation between pit latrines and hand dug water points, and the distance between water points and nearby bushes with observed deposits of faecal matter. In addition, the ground surface of Nyanchwa, Mwembe and Nyamataro estates was categorized as either rocky or deep soils based on the dominant characteristic observed in the residential areas.

Data from questionnaires was coded, scored and analyzed using one way ANOVAs after appropriate transformations. Data correlations and relationships from measurements was analyzed using simple and multiple regression and the differences were significant at $p \leq 0.05$.

RESULTS

The level of contamination of hand dug water sources among estates ranged from 49-53 faecal colonies/100ml and did not differ significantly (P>0.05) among estates (Table 1). This clearly indicated that all the hand dug wells in the three estates of Kisii Municipality were contaminated with faecal coliforms and the level of contamination did not vary significantly.

Table 1: Faecal coliforms count for hand dug well water among Estates

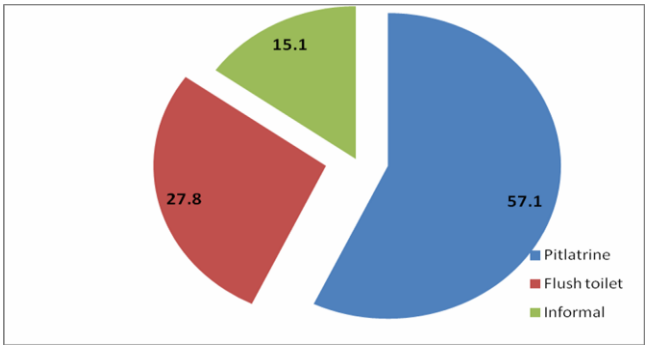
Estates	n	Mean ±	SE	Sig (P=0.8972)
Nyanchwa	21	52.7 ±	0.38	
Mwembe	22	59.8 ±	0.35	
Nyamataro	23	49.0 +	0.34	

Insignificant difference p=0.8972

The overall usage of disposal facilities for human faecal matter in Kisii Municipality is depicted in Figure 2. Pit latrine was the most commonly used mode of faecal disposal.

The percentage of people who use pit latrines was slightly more than double (57 %) those used flush toilets (27%). Less than a quarter (15%) of those interviewed used informal means of disposal.

Figure 2: Percentage of overall usage of three disposal methods for faecal matter.



The proportion of estate respondents using three methods of faecal matter disposal in the three estates (Nyanchwa, Mwembe and Nyamataro) of Kisii municipality are shown in Figures 3, 4 and 5. Majority of the respondents in all the three estates used pit latrines as the main disposal method of faecal matter. The percentage of the respondents using pit latrines is similar (54%) for Nyanchwa and Mwembe but higher than that for Nyamataro (49%). The highest percentage of flush toilet users was recorded in Mwembe and the least was in Nyanchwa while Nyamataro had an intermediate percentage of users. For informal depositions (Flying toilets, bushes and open fields) the percentage of respondents in Nyanchwa and Nyamataro was similar but about double that of Mwembe.

Figure 3: Percentage usage of three disposal methods for faecal matter in Nyanchwa.

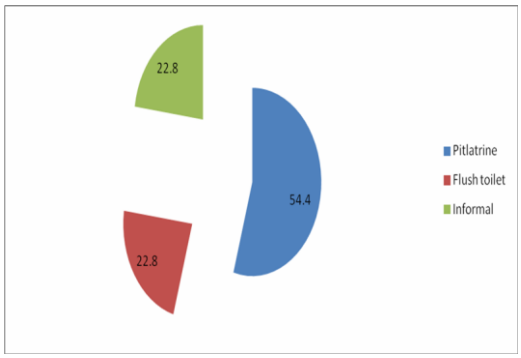
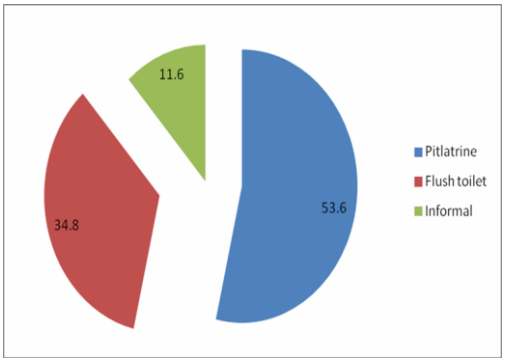
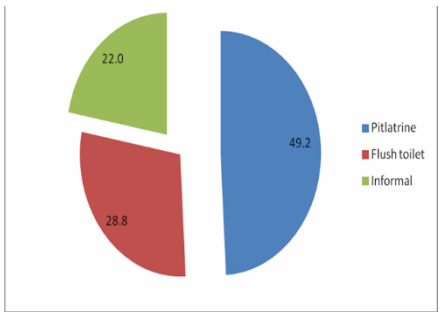


Figure 4: Usage of three disposal methods for faecal matter in Mwembe.



In Mwembe estate 53.6% residents used pit latrines to dispose human faeces, 34.8% used flush toilets and 11.6% used informal faecal disposal method. Generally pit latrine was the most preferred method in Mwembe as shown in figure 5.

Figure 5: Percentage usages of three disposal methods for faecal matter in Nyamataro.



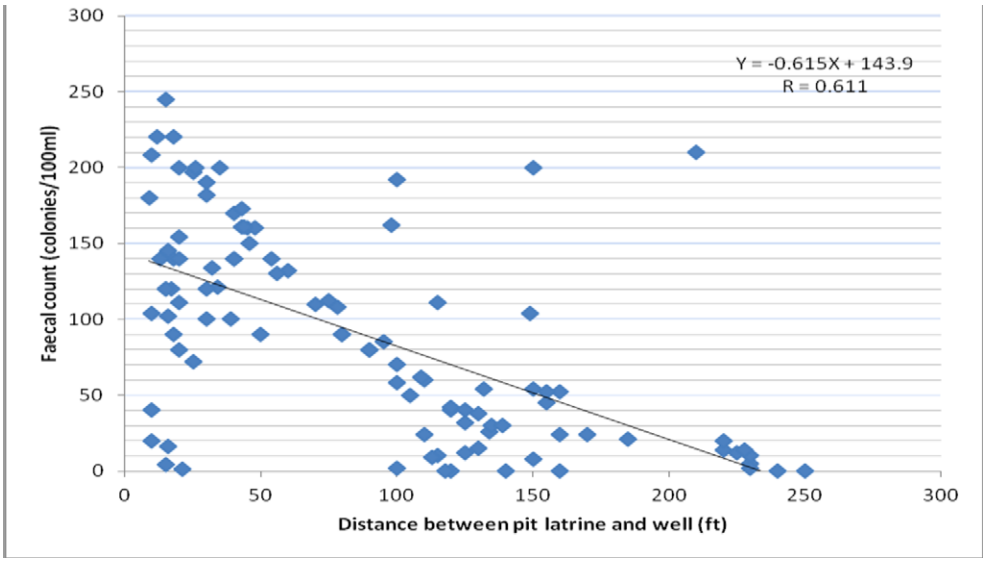
Results from the multiple regression analysis of the relationship between distance of pit latrine and the wells as a physical parameter and the degree of contamination of water by coli forms are indicated in Table 2 and Figure 6. Only the distance between pit latrine and water source significantly ($P<0.05$) affected water quality amongst the several physical parameters that were investigated. Contamination by faecal coliforms increased as distance between pit latrine and water source decreased. The distance between pit latrine and hand dug well water corresponding to the World Health Organization (WHO) and Kenya standard of zero faecal coliforms (faecal colonies/100ml) was 69 metres (230 feet).

Table 2: Physical characteristics which influenced well water contamination by human faecal matter.

Parameter	Estimate	SE	T-statistic	P-Value
Distance (P-W)	-0.6127	0.084476	-7.25303	0.00000
Depth of W	0.073658	0.435571	0.169106	0.86610
Depth of P	-0.02669	0.379185	-0.0704	0.94400
Distance (W-B)	0.010771	0.104102	0.103463	0.91780

P=pit latrine, W= well, B=bush

Figure 6: Relationship between faecal coliform count and inter-Distance between pit latrines and the wells.



$X(3.0\ X10^{-1})m$

Distance between pit latrine and well in metres

DISCUSSION

The main domestic water sources in Kisii Municipality is hand dug well water. Results indicated that hand dug wells were generally the most accessed among domestic water sources. Responses from residents indicated that the hand dug well was used for multiple domestic purposes which included drinking, bathing, watering livestock and washing clothes. Reports from other studies indicated that the hand dug well was the most utilized resource (Kabogo and Kabiswa, 2008) and Kabede, 1978). Therefore utilization of well water in other towns is similar to that observed in the present study.

The preference in utilization of hand dug well water in Kisii municipality was based on their proximity within the homestead which makes it convenient to fetch and in addition, the water is free of charge. The report identified several factors including topography of the area as the driving force towards accessibility of hand dug well water. The higher preference of well water in Nyanchwa was probably due to the topography of its location. 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 water sources was 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 (Bartram and Balance, 1996 and 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 different water sources (Howard *et. al*., 2003).

Contamination of domestic water sources is more serious in developing than in developed countries as was noted in Tanzania (Kauzeni,1981 and Norconsult,1981) and (Lloyd,1990), where domestic water sources were 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 (Lerner, 1996). These conditions presumably limited the risk of groundwater contamination by human faecal materials.

Faecal disposal management in three estates (Nyanchwa, Mwembe, Nyamataro) that were studied involves use of pit latrines, flush toilets and informal methods. The main mode of human faecal matter disposal in the three estates was pit latrines with over 50% of the residents using the facility. This mode of human faecal disposal is reported to be also common elsewhere, (Esrey, *et. al.*, 2001 and Gakukia, *et. al*., 2010).

Pit latrines were the most preferred structures due to their affordability in terms of construction and utilization. They also work under the principle of "drop and store" (Esrey, *et al*., 2001) 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 domestic water sources. 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 Obabori (2009).

Utilization of flush toilets was highest in Mwembe compared to other estates. The

highest usage of flush toilets was probably due to dominance of storey buildings and availability of piped water although Nyanchwa and Nyamataro were inhabited by low income population who could afford simple residential structures which did have installation of flush toilets. The presence of improved disposal facilities like flush toilets may be translated in terms of strong economic empowerment of residents of an area (Eckhard, *et. al*., 2002). This would result in high hygienic conditions. However, despite high presence of flush toilets in Mwembe estate, the estate had unreliable supply of piped water which led to heavy usage of pit latrines as an alternative disposal facility.

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. Most buildings in Mwembe estate do not feed their waste into the main sewerage system, instead they are conveyed into septic tanks which are likely to leak leading to sewage floods and underground water contamination by faecal coliforms (Huttly, 1990; Howard *et al.*, 2003 and WHO, 2008). Probably this is the main source of high level of faecal coliforms count found in the drinking water sources in Mwembe estate. If the design and infrastructure are poor the clean disposable facilities may not function to the expected levels in terms of hygiene. The economic status of an area may not play a major role in hygiene if the culture of residents are unhygienic and human faecal disposal structures are not properly designed and maintained (Shannon, 2003).

Informal methods of human faecal disposal are important sources of hand dug water contamination in Kisii municipality,

unreliable at Mwembe, which made use of the facility inevitable. Comparatively

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.

Use of informal disposal methods is a worldwide issue, (House, *et al*., 2004), reported that in Bangladesh a large population used informal faecal matter disposal methods, a similar situation was reported in Kenya by Guardian Development Network (2010) which revealed that 10% of Kenyan population use informal methods for faecal matter disposal Yeager *et al*., (1999) also noted that majority of young children defaecate informally on soil thus poor disposal of wastes. In the current study it was found that children faeces were commonly disposed on open ground in most homesteads among the three estates of Kisii municipality 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 hand dug waters.

Apart from disposal methods, physical factors have also been implicated in contamination of domestic water sources by faecal coliforms (Sugden, 2004 and Kimani and Ngindu, 2007). The distance between pit latrine and hand dug wells where no faecal coliforms were found has been explained. Several authors show that inter-distance between the pit latrine and the well water above 30 metres show no faecal coliforms (Ben and Kolsky,1999); Morgan (1990); Kimani and Ngindu (2008) and World Health Organization, (2007). As evidenced in the current study the distance between

well and pit latrine affects faecal contamination in the well. Contamination at various distances may depend upon soil types and hydraulic gradient or slope of an area.

The main domestic water source in Kisii municipality was contaminated by faecal coliforms. Well water was contaminated in all the three estates. The levels of contamination were attributed to topography and distance of water source to that of faecal disposal point such as the distance between the pit latrine and the 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 in the hand dug well. More research should be done on other domestic water sources like water springs to establish their contamination levels.

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