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# Ground water fecal contamination in Kalpitiya Peninsula of Sri Lanka

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**Abstract**
Ground water table of Coastal dry zone areas in Sri Lanka is exposed to fecal contamination due to the typically used human excreta disposal method of pit – latrines. Though there available standards and commonly accepted factors regulating the construction of shallow wells in the proximity of pit latrines, fecal contamination continuously been a burden to the dry zone coastal areas. This research consider 'depth of the water table', 'gap of infiltration layer', 'depth of the latrine pit' and 'the distance between dug well and latrine pit' on preventing ground water fecal contamination, taking Kalpitiya Peninsula of Sri Lanka as the case study. On the derived results the paper concludes that the considered commonly accepted factors are not the determining factors of fecal contamination in coastal land strips alike the case study area. The results suggest more attention on site specific reasons on developing standards to prevent ground water fecal contamination.

**Keywords:** aquifer, coliform, E Coli, salinity, coast

## Introduction

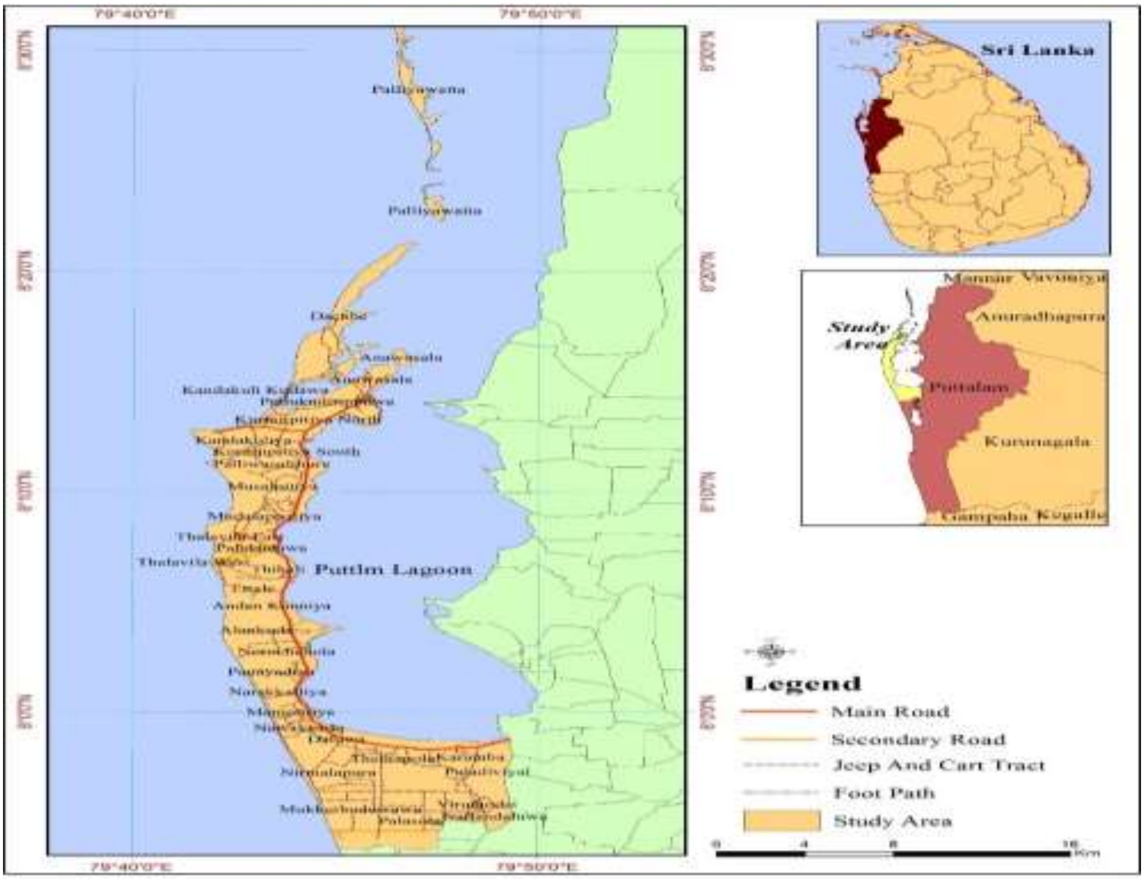
Ground water is the extensively used water source in the developing countries of the world. Especially Asian countries depend on this precious resource where Sri Lanka is not an exception. The estimation of Sri Lankan ground water resources recorded as 7800 million m3 per year (Nandalal, 2010) [5] Shallow dug wells and deeper tube wells serve as the drinking water source for more than 80% of the Dry Zone coastal rural population of Sri Lanka (Panabokke, 2007) [6] Due to the vast utilization and less concern regarding the hydrological cycle, ground water has become one of the fast diminishing resource. Available ground water aquifers constantly threatened due to contamination caused futility. Among the reasons of contamination, fecal matter contamination is one of the most hazardous reason (Panabokke, 2007) [6] Pit latrines are the utmost popular method used in the rural coastal areas of the island for the disposal of human excreta. Standards regarding the distance from human excreta disposal point and the drinking water source which extract ground water has been established in the country since Urban Development Authority Act No 41 of 1978. Ever since it has been included in other laws such as Local Authority laws and especially in the Public Health Inspector Manuals. Unlike in urban areas of the country, land availability in rural areas lead these standards unintentionally followed in most cases. Still, fecal matter contamination to the ground water highly considered as a matter which causes waterborne diseases in rural coastal areas. The most high risk diseases namely 'bacterial diarrhoea' and 'hepatitis A' are the vastly recorded water borne diseases in Sri Lanka. These diseases are considered as resultant due to usage of contaminated drinking water and accord for 12% of the 'certain infectious and parasitic diseases' caused deaths in year 2006 according to the records. This rate has been doubled by the year 2012 where the number of deaths were 403 in 2006 (Department of Census & statistics, 2006) and 705 in 2012 (WHO, 2014) [12] Even though there is no evidence these diseases spread due to fecal contamination of ground water, the figures indicate it is extremely important to eliminate even a slight chance of ground water exposure to fecal contamination. This study focus on opening a discussion to fill the gap on 'does following the available regulations and standards matter in lesser exposure to fecal contamination of ground water?' The foremost objective of this paper is to identify whether the commonly accepted factors of 'depth of the water table', 'gap of infiltration layer', 'depth of the latrine pit' and 'the distance between dug well and latrine pit' always effectively applicable on preventing the pit latrines correlated ground water contamination.

## Literature Review

Basically, measuring the ground water quality related to fecal contamination carryout using several laboratory tests for microbiology. The main parameters usually testing are Total coliform, Fecal coliform, Enterococci, E. coli and Salmonella (Frank, 2012) [2] Among these the testing for Total coliform count and E.Coli test are considered as most important. Sri Lanka standards 614 Part 2, 1983 is valid up to present regarding the water quality measures related to Total Coliform and E.Coli availability in Ground water. If the water source is a Public water supply (Municipal supply, Water board supply) the total coliform count /100ml should be three (3) and in an individual or small community supply (Well / Tube well) it should be ten (10). In both cases the E.Coli count /100ml should be absent. The main source of ground water fecal contamination in developing countries has been identified as pit latrines being in the proximity of drinking water source in number of studies (Still & Nash, 2002) [9]. Due to many conditions and site specific reasons the pathogens cultured in pit latrines has been detected even distant water sources more than 30 meters away from the latrine pit hence most of the regulations and guidelines necessitate pit latrines to be 30 meters or more away from the water sources (Still & Nash, 2002) [9]. The pathogens can transmit to ground water aquifers in two main ways. One is direct transmission where the latrine pit directly contact with the ground water flow and the other is indirect transmission where the pathogens diffuse with the seepage of latrine pit in to the saturated zone via soil layers (Piyadasa *et al*; 2008) [7]. One of the vastly discussed reasons for both direct and indirect transmission of pathogens is the distance between the dug/tube well and the pit latrine. According to Lewis *et al* (1980) [4], extreme distance a human excreta based pathogen will transfer via a ground with favourable soil is as distant as the groundwater flows in ten days in the particular area. It is accepted that if the distance between wells and pit latrine is not satisfactory, bacteria and microorganism pathogens can transfer from the latrine pit to the ground water source (Kimani & Ngindu, 2003) [3]. When the parallel distance increases which the pathogens has to transmit into the saturated zone from the pit latrine point, it is held over and the possibility of pathogens' destruction also increases (Sugden, 2006) [10]. This over and over proven factor has resultant guidelines to keep pit latrines and the water sources apart. PHI manual, Sri Lanka recommend 15 m / 50 feet distance while Sri Lanka Standards (SLS) 745 instruct on 18 m / 59 feet. Yet the international standards indicate increased measurements where WHO (wet areas with rapidly moving GW) & USA (Federal regulations) recommend 30 m / 98 feet distance (Werellagama and Hettiarachchi, 2004) [11]. Also the vertical separation between the latrine pit and the ground water table is considered as an important factor which is considered as the 'infiltration layer.' When the infiltration layer is higher additional time is added to the pathogens' transmission procedure lowering the risk of ground water contamination (Sugden, 2006) [10] It is recommended that when the drinking water source is based on ground water and a pit latrine is to be built in proximity, the well have to be dug higher than at least 15 meters from the pit latrine (Kimani & Ngindu, 2003) [3] The ground water level of a particular area is considered as another specific reason for higher contamination exposure. If the ground water lens is in higher elevation level which creates shallow aquifers or a higher ground water table, the risk factor to contamination arise due to pit latrine is considerable (Parry, 1999). According to Kimani & Ngindu (2003) [3], commonly used guidelines in most of the countries states that the pit latrine must be built at least 20 meters above the water table. To maintain these guidelines the pit latrine depth need to be decide wisely.

**Study Area**

Kalpitiya peninsula is located in North Western coastal belt of Sri Lanka. It includes in the Dry zone climatic region between79° 40 and 7° 50'– 8° 30' latitudes. Kalpitiya belongs to Puttalam district administrative boundaries of North Western province in Sri Lanka. Total population was recorded as 98,470 in the year 2011 including 49,397 male population and 49,136 female population (DC & S, 2011). The area has a multi-ethnic population consisting of Sinhalese, Tamils, Burgher and Muslims. The average annual rain fall of the study area recorded between 500 – 600 mm from the North East monsoon between December and February. Highest rainfall values area recorded usually on October, November and December. Average annual temperature of Kalpitiya area recorded as maximum of 31oC to minimum of 27oC. Humidity and evaporation is very high in this area according to the records of the Meteorological Department of Sri Lanka. As a costal split, elevation of most parts of the area do not surpass 10 meter. Kalpitiya peninsula includes in the Coastal Sand Aquifer and the groundwater "lens" mainly recharged during the North - East Monsoon period. The seasonal crop cultivations and coconut cultivations are the main land uses of the area. Lagoon and Marine fishing and prawn cultivations are highly active fisheries sectors and agriculture is the second most important income source.




***Source:*** Prepared by Author using Geographical Information System, Data from Department of Survey, 2014

**Fig 1:** Case Study Area

## Methodology

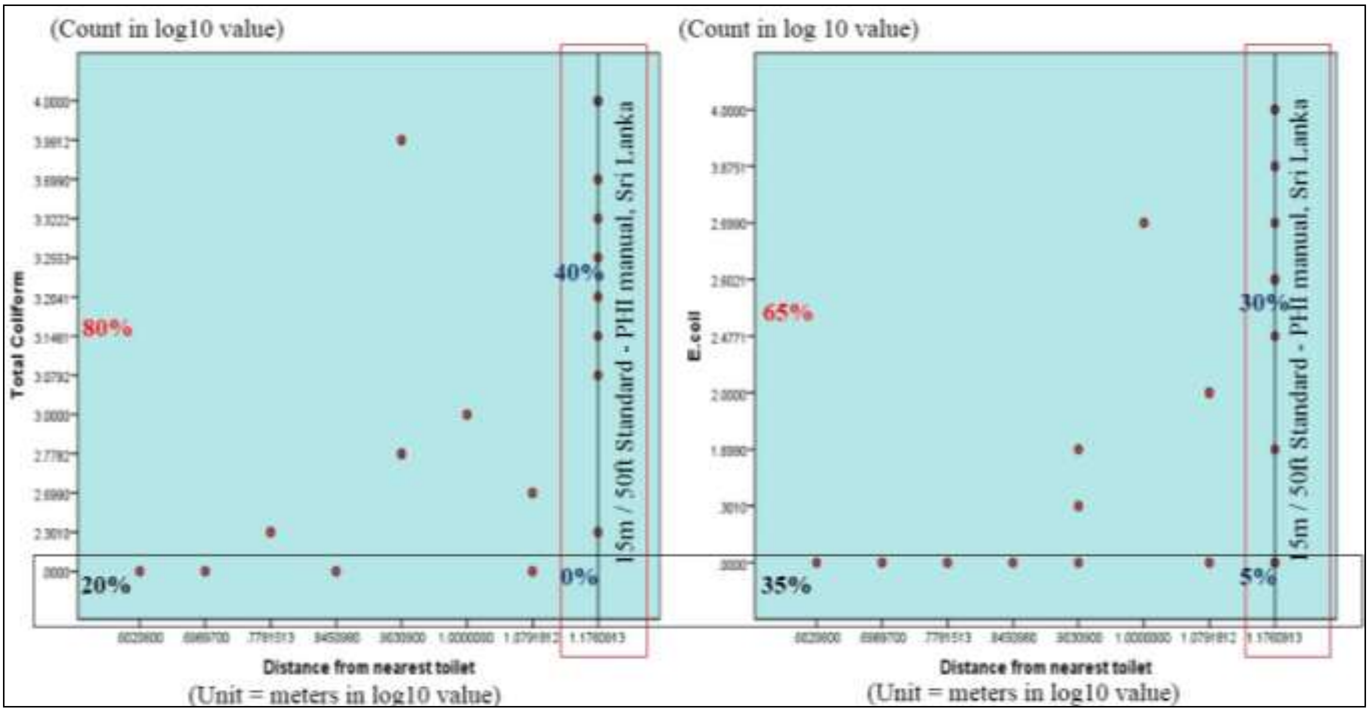
Twenty (20) randomly picked sampling Dug Well locations representing each portion of Kalpitiya peninsula were selected for the testing. Water samples were collected using sterile glass bottles each tied with 3 to 5 meter lengthy threads. Two samples from each sampling location were collected for Total coliform test and E.Coli test. The samples were placed in a container with ice as soon as collected and were transported to the laboratory within 8 hours. Two days were spent for the sampling procedure due to the higher distance between the sampling locations. GPS points were recorded in each point for identifying the position of the well and point elevation of the place. In-situ measurements using tape measure were recorded regarding the distance between nearest latrine pit to the sampling location, the depth of the sampling dug wells and water level of the wells. The latrine users were consulted in order to get details regarding the latrine pit depth and the conditions of latrine pit construction. In-situ observation regarding the condition of the dug wells, land uses and the on-site situation were recorded regarding each location. All the unit measurement values were taken in meters. Number present in 100ml of sample where Total coliform bacteria at 37 °C and E.Coli at 44 °C was the test method used in the laboratory in order to determine the presence of pathogens in the Sampling Dug Well locations. Comparing the results with the Bacteriological Requirements for Potable Water (SLS 614 Part 2, 1983), sampling dug well locations were put in to two categories as ‘Satisfactory’ and ‘Unsatisfactory’. Since the values of bacteria count are in larger figures and other values in small figures, all the figures were converted in to base 10 logarithm values for the convenience of analysis. The Total coliform bacteria and E.Coli presence is compared with the standards of distance maintenance since the available regulations indicate the distance between Ground water extraction point and the latrine pit as the most important factor to prevent ground water fecal contamination. It was not possible to carryout correlation or regression analysis due to the considered 20 sample size was not adequate. Therefore the results of laboratory tests were analysed applying inverse distance weighted (IDW) interpolation method in Arc.GIS10.3 in order to identify the spatial distribution of Total coliform bacteria at 37 °C and E.Coli at 44 °C in the Kalpitiya peninsula. The results of the analysis were logically compared with the in-situ observation records.

## Results and the Discussion

**Table 1:** The sampling locations which recorded "Satisfactory Water Quality" level

| No. | Sample | Test Method: Number present in 100ml of sample | | Remarks | *Distance to nearest toilets (unit = Meters)* | | | *Mean Water Level (Meters)* |
|---|---|---|---|---|---|---|---|---|
| | | **Total coil from bacteria at 37 °C** | **E.Coli at 44 °C** | | **Toilet 1** | **Toilet 2** | **Toilet 3** | |
| 1 | KWM 05 | Nil | Nil | Satisfactory | 12 | *15<* | *15<* | 2.66 |
| 2 | KWM 18A | Nil | Nil | Satisfactory | 4 | *4* | *7* | 1.15 |
| 3 | KWM 24 | Nil | Nil | Satisfactory | 7 | *8* | *15<* | 2.65 |
| 4 | KWM 27 | Nil | Nil | Satisfactory | 5 | *15<* | *15<* | 1.56 |

According to the field observations and tape measurement data 50% of the dug wells are situated full filling the available minimum requirement of distance which is 15meter/50feet between the well and latrine pit (Figure 02). Yet only 10 % of the locations meet the commonly acknowledged international standard of 30meter/98 feet distance while 5% of the locations only maintain less than 5meter distance. 30% of the wells and pit latrines owners are aware about the 15 meter/50feet requirement between the ground water extraction point and the on-site excreta disposal point while even though the required distance is maintained 70% of the constructers did not have the awareness regarding the standards. They commonly have the knowledge passed through generations that do not hold any scientific grounds regarding well must be away from the latrine.




***Source:*** Compiled by author using the field survey data analysis results, 2017

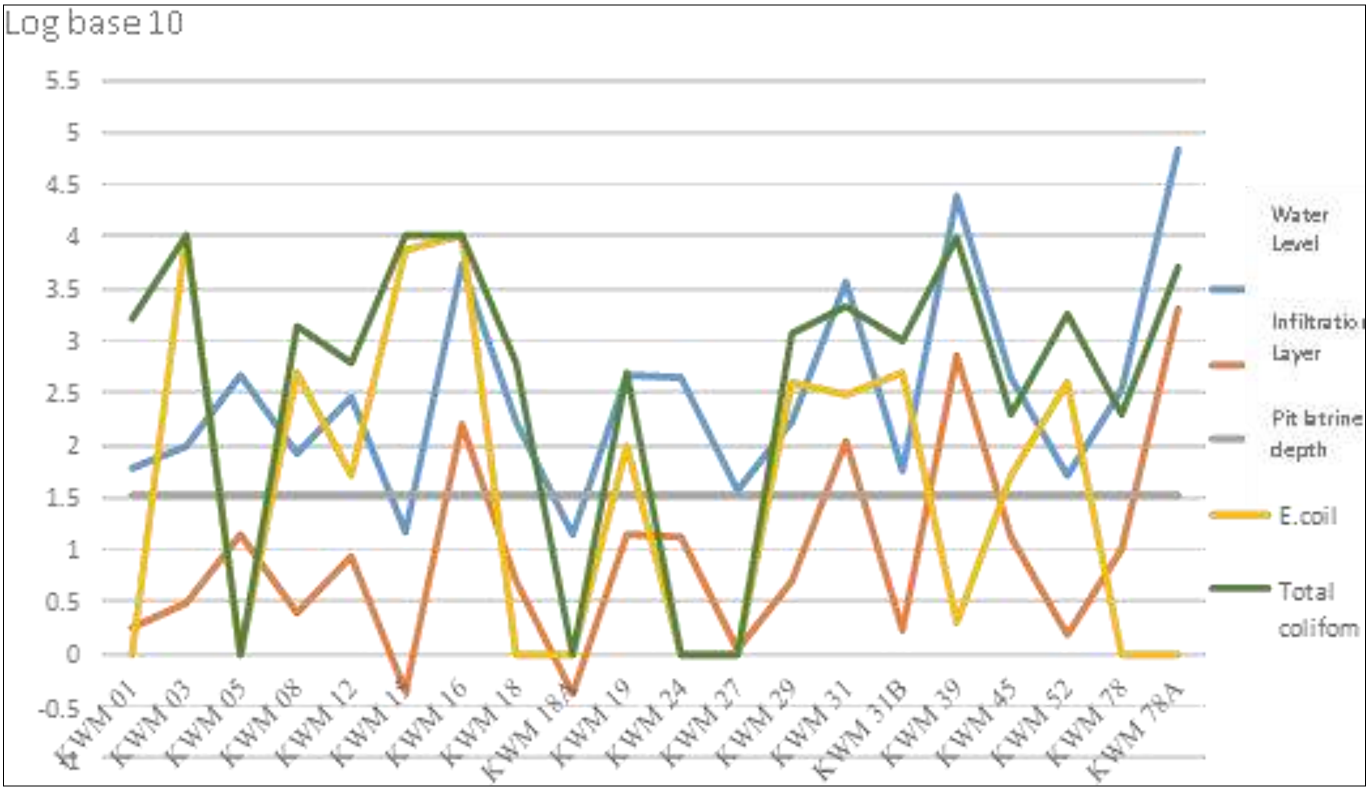
**Fig 2:** Total coliform & E.Coli presence and the distance requirement

The results of laboratory tests reveal that, only four (4) ground water extraction wells records satisfactory potable water quality level which is only 20%. And 80% of the wells are with unsatisfactory potable water quality level. Interestingly, all the four sampling locations which recorded the ‘Satisfactory water quality’ level do not reach the minimum distance requirement for the nearest latrine pit as indicated in Table (1).

And also all the locations which are within the 20% of 18 meter distant requirement of PHI Manuel Sri Lanka category and 10% of 30meter distance WHO standard requirement category has recorded ‘Unsatisfactory Water Quality’ Level. When considering the presence of Total coliform, 80% of the sampling locations exceed the water quality standard level and 40% of that 80% locations are the wells which are within or the minimum distance requirement category. And also according to the E.Coli presence standards 65% locations are unsuitable as potable water and 30% of these locations have met the minimum distance requirement.

Figure (2) is compiled as taking all the Sampling locations which are similar or above the minimum distance requirement standard of 15 meters/50 feet in to one category for the convenience of interpreting the results. The pattern of Total coliform presence distribution indicate that only 20% of the sampling locations bear the required water quality standard of potable water source while 0% of the locations which reach the minimum distance requirement are recorded as having the required water quality level. 35% of the sampling locations achieved the obligatory standards for E.Coli presence and 5% of those locations only included in the category of wells which reach the minimum distance requirement. According to the literature review 80% of the precedent studies have identified a negative strong co-relation of distance from the well to latrine pit and presence of Total coliform and E.Coli. It means when the distance between the two points increase the presence of pathogens decrease and vice versa. Yet this case study do not express such relationship.

The relationship between the water level and pit latrine depth also express an unpredictable behavior pattern. For an example, in the sample KWM15; Water level is below the Pit latrine depth, therefore the gap of infiltration layer is low and the presence of Total coliform and E.coli is high. At the same time, in the sample KWM 16; Water level is very high above the Pit latrine depth, therefore the gap of infiltration layer is longer but the presence of Total coliform and E.coli is high as same as in the sample KWM15. This chaotic pattern expresses that the sample locations are with poor similar combinations between the factors considered.




***Source:*** Compiled by author using the field survey data analysis results, 2017

**Fig 3:** Relationship between the considered factors

## Conclusion

The results reveals that maintaining the commonly accepted factors alone is not enough for preventing fecal contamination of the ground water extraction sources. Consequently, the analysis results highlight the presence of associated case specific reasons in each sample location are strongly significant for pit latrines correlated ground water contamination in Kalpitiya peninsula which may applied to the areas with similar geomorphological factors. Mainly the diverse characteristics of soil composition and features site specifically affect the mobilization of pathogens to ground water table. When considering the derived results, it can assume that the soil condition of the area, condition of the latrine pit, condition of the ground water extraction point (Dug well/ Tube well), adjacent land uses, pattern of the surface water flow and many other factors related to a particular area may have association in accelerating or minimizing the rate of ground water fecal contamination.

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