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Efficacy Sand Filters In Removal Of Selected Bacteriological Parameters From Contaminated Water In Bomachoge Borabu Sub County - Kenya

C. J. Nyabayo

E. J. Chemoiwa

L. Mwaburi

Department of Biological Sciences,
University of Eldoret - Kenya

Abstract: The study aimed at investigating sand filters of different grain sizes and sand bed depths in removal of selected bacteriological parameters in water. Water samples were collected from reservoir and outflows of sand filters and examined in the laboratory. Data collected were analyzed using statistica and minitab statistical programs which compared the overall, among and within the bacteriological parameters such as faecal coliforms, Faecal Streptococcus and total coliforms. Results showed that sand bed depth, sand grain sizes influenced efficiency of removal of most examined parameters and the difference was significant (p<0.05. It was recommended that the use of sand filters in water purification is efficient and more studies to be done to ascertain ways of improving water quality using combination of sand with different grain sizes.

Keywords: Purification, bacteriological, coliforms, reservoir, sand filters.

I. INTRODUCTION

Contamination of water has been a world's concern (APHA, 2005). Major pollutants that get into water include chemicals, bacteria, viruses and protozoa. Bacterial organisms such as faecal coliforms, faecal *Streptococcus* and total coliforms among others are indicators organisms of faecal contamination (Wright *et al.*, 2004). Most water sources in developing countries are unsafe for domestic use and cannot support aquatic life because they are abundantly contaminated with chemicals and microbial agents due to poor management of wastes (APHA, 2005).

The high population of the study area is a limiting factor of the inhabitants' access to clean water and proper disposal of waste, this made the area an important area of study (Curtis *et. al.*, 2001). The study was important because it provided the water managers and water resource users with information on less costly, reliable methods of purifying water by use of locally available resource like sand.

The sand filter method is an environmental friendly waste treatment method, which is relatively simple and in expensive (Barret, 1989). Its principle involves percolating water through a sand bed (Ryan and Ray, 2004). Grains of sand form a layer which is penetrated by the water and which will stop larger particles in the intervals between grains acting like a simple sieve (Barret, 1989). Small particles will also be retained by the wall effect on the grain surface when they touch a grain as they pass through the filter. Generally, the smaller the diameters of the grains, and hence the longer particles remain in the filter, the higher the filter's stopping power will be (Muhhammad *et al.*, 1996).

The sand used for slow sand filters should preferably be rounded, and free from clay or traces of clay and soil organic matter. Sand must be washed before being used (Soper 2002). Some studies indicate coarse sand has low treatment efficiency in removal of bacteria, turbidity and colour, decreasing sand grain sizes was shown to increase treatment efficiency (Huisman and Wood, 1974). In practice, sand that is both finer and coarser still provides acceptable results in terms of filtration in continually operated systems (Barrett, 1989).

Research done by Jenkins *et al* .,2009 found that filters using finer sand performed significantly better in terms of bacteria and viruses removal than filters using coarser sand. Logan *et al.*, 2001, reported that intermittent sand filter columns of 0.6m sand revealed that fine grained sand columns effectively removed cryptosporidium oocysts than coarse-grained sand media column where the oocysts were observed in the effluents regardless of the conditions. It was also shown in the same study that grain size was an important variable that affected the oocyst effluent concentration in the intermittent filters (Jenkins *et al*., 2011; Mallin *et al.*, 2000).

The sand height can be reduced to 0.48m with no change in bacteriological removal efficiency (Bellamy *et al.*, 1985). However, some studies indicate that most bacteriological purification occurs within the top 0.4m of sand bed (Muhammad, *et al*., 1996). ASCE, 1991 also confirms that majority of biological processes occur in the top 0.4m of sand bed. Muhammad *et al.*, 1996 reported that, bacteriological removal efficiency does not become more sensitive to depth with large sand sizes because the total surface area within the filters is reduced in a sand bed with large grains, as well as a high flow rates going through the grains.

Ferdausi and Bolkland (2000) in their study reported that there was adequate faecal coliform removal to below 10 per 100mls in pond filters, which only had sand bed depths of about 0.3m.

Turbidity and colour removal improves as sand depth increases below 0.4m, this shows that adsorption occurs throughout the filter column in purifying water. Reduction in sand bed depth causes decrease in total surface area of the sand grain and ultimately total adsorption capacity is lowered (Muhhammad *et al.*, 1996).

II. MATERIALS AND METHODS

A. SITE OF THE STUDY

The study was conducted in Bomachoge Sub-county of Kisii County Kenya. The sub-county has a population of 107, 199 (National census 2009). In terms of topography, the Sub County is mainly hilly with several ridges, with excellent drainage system. The sub-county has a highland equatorial climate with annual average rainfall of 1,500mm that is reliable. Long rains occur from the month of February to June while short rains occur from August to November, December and January have moderate rainfall though seasons change occasionally and water contamination is a major challenge due to water runoffs and poor sanitary practices (KCDDP, 2002-2008).

B. SAMPLE COLLECTION AND DESIGN OF SAND FILTERS

In construction of sand filters, two factors were considered, sand grain sizes and sand bed depths (Muhammad *et al*., 1996). Nine sand filters were constructed using plastic pipes tightly covered at the bottom and fitted with steel valves to regulate outflow of water. Each sand filters had a height of 2 meters each. The filters were raised and fixed firmly on a flat timber under a water proof roof to allow effluent flow freely. Different sand grain sizes were prepared using sieves of 2mm,1mm, and 0.5mm, the resultant grain sizes were sterilized in the oven at105^{o}c and put in the pipes in sterile conditions to form a complete and operational sand filters, whereby depths were adjusted using the amount of sand put in the pipes. The three different sand grain sizes were put in labeled pipes. The influent for sand filters was from reservoir. The water samples were collected from the reservoir using sterilized bottles in the oven at 105^{o}c from the filters after two weeks. In addition, sixteen samples were collected from the reservoir and sixteen samples from each of the nine sand filters at an interval of two weeks. These samples were transported within six hours University of Eldoret Biotechnology laboratories for bacteriological analysis.

C. LABORATORY BACTERIOLOGICAL ANALYSIS

TEST FOR FAECAL COLIFORMS

Testing for faecal coliforms in water samples was done using a modified membrane filtration method as described in APHA, (2005). Apparatus were used are dilution bottles, pipettes, graduated measuring cylinder, Petri dishes(60 x 15) membrane filters (0.45mm), filtration unit, absorbent pads, forceps, spirit lamps and incubators. Laboratory testing of faecal coliforms, sample water 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 bacteria suspension over the entire effective filtration surface. Sterile membrane filter paper was placed over a porous plate using sterile forceps to be sterilized by flaming. 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, 30-50ml sterile buffered water was used to rinse the filter between the samples. The funnel was unlocked after all the water was filtered and the forceps were used to remove the filter membrane which then was placed on M-ENDO medium with a rotating motion to avoid entrapment of air. The liquid medium was used and the culture sample was saturated with 1.8-2.0ml of prepared M-ENDO medium. The agar was placed directly on the Petri-dish then incubated for 22 to 24 hours at 37^{0}C $\pm$ 0.5 in incubators. After incubation, the number of bacteria colonies were counted and expressed as colonies in 100ml of sample water.

TEST FOR Faecal *Streptococcus*.

This was done by using Bile Esculine Azide Agar, a selective media for isolating faecal *Streptococcus* from water samples. One millitre of each tube containing different sample dilution was drawn into the Petri-dish using a sterile pipette and molten agar was poured into mixture and incubated at 37.0 ±0.5 ^{o}C for 48 hrs. Blackening colonies in the media denoted the presence of fecal streptococcus and fail of the media to form black colonies indicates negative results (APHA, 1998).

ENUMERATION OF TOTAL COLIFORMS

Colilert-18 detects total coliforms and E.coli in water; it is based on patented defined substrate technology (DST). When total coliforms metabolizes colilert-18 nutrient indicator ONPG, The sample turns yellow. Colilert-18 is capable of detecting total coliforms within 18 hours. Contents of 100mls of water sample was added in sterile water container, and the plastic bottle container was tightly sealed and shaken until it dissolved, reagent mixture was poured into quanti tray/2000 and tray sealed, the sealed tray was placed in 37±0.5 ^{o}C for total coliforms. Yellow equal to or greater than the comparator when incubated at 37±0.5 ^{o}C indicated the presence of total coli forms and absence of yellow color was negative result.

III. RESULTS AND DISCUSSIONS

BACTERIOLOGICAL WATER PARAMETERS

The results obtained from bacteriological parameters such as faecal coliforms, total coliforms and faecal *Streptococcus* were measured in cfu/100mls and all these parameters were significantly (P<0.05) removed from water, this was due to efficient filtration of bacteria by sand grain sizes ranging from 0.5 to 2mm and bed depths of 0.5 to 2m. Water in the control had higher levels of examined bacteria but after filtration there was reduction (Figures 1, 2 and 3). The Tukey Honestly significant difference test confirmed that the mean decrease in the levels of total coliforms were significantly lower after water passed through the 0.5 mm sand granules compared to water passing though the 1.0 mm and 2.0 mm sand granules, p<0.01, and <0.05 respectively. The average change in the levels of total coliforms, faecal coliforms and faecal *Streptococcus* were significantly high when water was allowed to pass to the 1.0 mm sand granules compared to when they pass through the 2.0 mm sand granules (p<0.01). These results are in conformity with results found by Muhammad *et al*. (1996) he reported that sand filters improve the removal efficiency of both bacteriological parameters in water. He further reported that there was increase in removal efficiency with decrease sand grain sizes. These findings were further echoed by Jenkins et al. (2009) his research revealed that sand filters using fine sand performed better in terms of bacteria removal than filters using coarser sand grains and they effectively removed variety of bacteria unlike the coarse grained sand in sand filters.

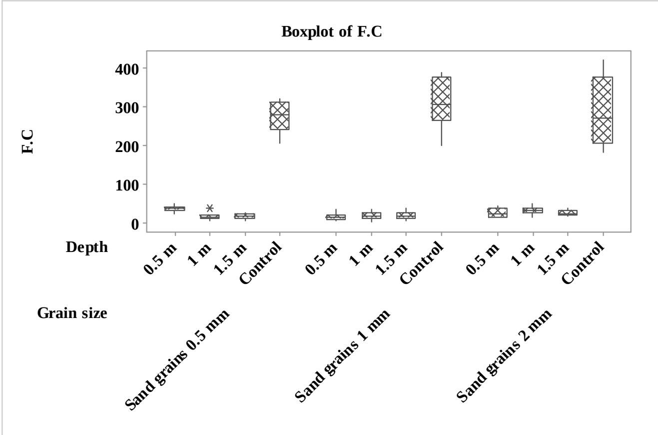

Figure1: Levels of faecal coliforms (F.C) removal at different sand grain sizes associated with depths and controls.

The removal of faecal *Streptococcus* at different depths of sand grain sizes in relation to controls were significant (p<0.05). Faecal Streptococcus removal with sand grain sizes of 0.5mm, 1mm, 2mm and depths of 0.5m, 1m, 1.5m were not significantly different (p<0.05).

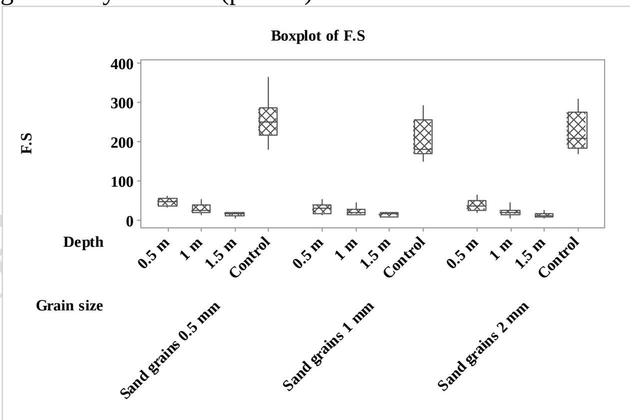

Figure 2: Removal of faecal streptococcus at different depths of sand grain sizes in relation to controls

The removal of total coliforms at different depths of sand grain sizes in relation to controls were significant (p<0.05). Total coliforms removal with sand grain sizes of 0.5mm, 1mm, 2mm and depths of 0.5m, 1m, 1.5m were not significantly different (p<0.05).

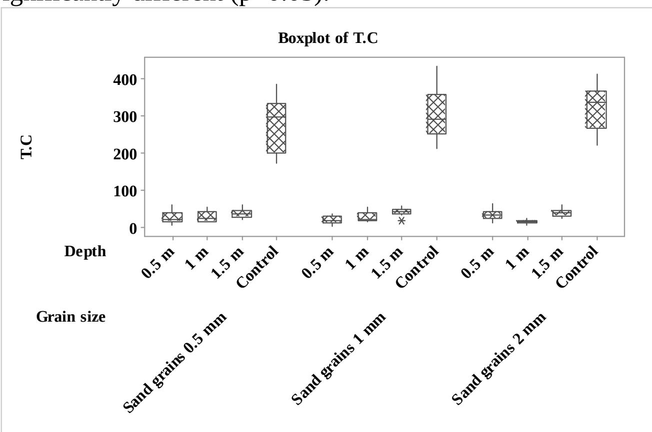

Figure 3: Removal of total coliforms at different depths of sand grain sizes in relation to controls

The removal of total coliforms at different depths of sand grain sizes in relation to controls were significant (p<0.05).

Total coliforms removal with sand grain sizes of 0.5mm, 1mm, 2mm and depths of 0.5m, 1m, 1.5m were not significantly different.

IV. CONCLUSION

Different sizes of sand grain used and varied sand bed depths significantly reduced bacteria in water outflow in all bacteriological parameters that were under investigation. Nevertheless, the filtrates did not meet the WHO and Kenyan drinking water standards. The reduction however needs to be improved so as to remove all the bacteria to 0cfu/100mls.

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