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Original Research Paper

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IMPACT OF CONSTRUCTING SEPTIC TANKS IN CLOSE PROXIMITY TO BOREHOLES (GROUND WATER): THE CASE OF KESSELLY BOULEVARD COMMUNITY IN MONTSERRADO COUNTY, LIBERIA

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ABSTRACT The discharge of effluent from septic systems into unsaturated zones creates threats to the physical environment that may result to ground water contamination depending on a number of factors including soil hydraulic conductivity, depth of water table and proximity of a septic system to borehole. Infiltration of septic waste into ground water may result into the transfer of disease causing microorganisms that may impact the environment and health of nearby receptors. The current study sought to determine contaminant levels in groundwater samples and enumerate the impact caused by the construction of septic tanks in close proximity to ground water sources in Kesselly Boulevard community, Liberia. Water samples were collected in triplicates from five sampling points (four wells and one hand pump) and transported to the Environmental Protection Agency Laboratory for analysis. pH, nitrate and nitrite levels were analyzed in the samples using spectrophotometry employing a DR 890 Colorimeter (Hach). Lead levels were analyzed using a DR 5000 Spectrophotometer (Hach). Bacteriological (E. coli & Fecal Coliform) analysis were done using Palintest Kit (wagtech) while turbidity levels were enumerated using a Turbidity Meter T-100 (Oakton). Furthermore, microbiological isolates were identified using API 20E assay. Results were compared with World Health Organization (WHO) and Liberia Water Quality (LWQ) standards. Fecal coliform and E-coli were present in all but one sample (Pump #2-situated 53ft from the nearest septic waste facility). Physicochemical parameters (pH, turbidity, nitrite, nitrate, lead) were below permissible limits in all of the samples analyzed. However, the detection of *Escherichia coli* and *Salmonella species in* four of the five samples analyzed suggests that water from those ground water sources may pose adverse health risks to consumers and are thus unfit for direct human consumption without treatment. Furthermore, there was a strong correlation observed between water quality and proximity of the source to septic facilities; with higher contaminant levels recorded in sources closest to septic facilities. The study, therefore, concludes that septic tank location adversely affect water quality in the study area with an even more pronounced consequences in boreholes that are in very close proximity to septic facilities. The study recommends that the public be informed about the risk of constructing septic tanks in close proximity (< 50 ft) to a drinking water source or vice versa. Onsite treatment interventions should also be mobilized in the study community to protect households from further possible consumption risks.

KEYWORDS : Groundwater, septic tank, water quality; Escherichia coli; Physico-chemical

INTRODUCTION :

Rapid urbanization and industrialization often leads to a stress on the water supply system especially in developing countries where water treatment facilities and pipe borne water supply are scarce. This paucity of piped borne water has caused most communities to find alternative water sources and groundwater is often seen as the best of the lot (Lu *et al*, 2018).

Groundwater is the largest reservoir of freshwater and is found in pores of soil, sediments and narrow fracture in bedrock. In order to access groundwater, boreholes are drilled in the earth using machineries. Hand dug wells are also common in some developing countries (Adelekan, 2010)

Anthropogenic activities may cause groundwater pollution depending on a number of factors including soil hydraulic conductivity, depth of water table and proximity of a pollution sources to borehole. Although water from boreholes can be polluted through other means, the most common cause of pollution is attributable to close proximity of septic tanks to boreholes especially where the adjoining geological formation is fissured (Mile *et al*, 2012).

A septic tank stores waste for a period during which it undergoes pre-treatment. About 70% of the waste contains germs and pathogens which pose real threat of contamination and diseases and is therefore very dangerous to human life (Yates and Yates, 1989). Septic tanks have been found to fail and leak profusely, causing environmental damage. This can serve as a vehicle for spreading illness caused by such microorganisms as *Vibrio cholera*, *Yersinia enterocolitica*, *Escherichia coli* and vector borne diseases such as guinea worm, schistosomiasis, Lymphatic Filariosis, parasitic and viral infections (US EPA, 2005; Jaboobi *et al*, 2014).

According to Fubara-Manuel & Jumbo (2014), properly function septic systems have the ability to attenuate micro-organisms, organic contaminants, most cations but not anions. Septic systems built in proximity to the zone of saturation are often not effective at attenuating micro-organisms, organic contaminants and phosphorus.

In Liberia, the lack of a centralized sewage and wastewater treatment system has resulted into a proliferation in the construction of private septic tanks. The Government is also greatly challenged when it comes to adequately suppling pipe borne water to an ever growing urban population. This has also resulted into a proliferation of private boreholes and hand dug wells to source portable water. The necessity of both a sewage facility and portable water facility often result into constructing both facilities in close proximity.

Infiltration of septic waste into ground water may result into the transfer of disease causing microorganisms that may impact the environment and health of nearby receptors (US EPA, 2005). There is very limited empirical data on the impact of septic waste on groundwater quality in Liberia. The current study therefore sought to determine contaminant levels in the samples and enumerate the impact caused by the construction of septic tanks in close proximity to ground water sources using the Kesselly Boulevard community in Liberia as a case study.

METHODOLOGY

The Study Area

This study was conducted Kesselly Boulevard Community, Montserrado County-Liberia. The community has a population of 3700 residents and is undergoing rapid expansion and population growth (LISGIS, 2009). The community is a peninsula-shaped landscape partially surrounded by the Mesurado wetland, a protected area under the RAMSAR convention. The nearby wetland is home to mangroves and other biologically important flora and fauna. Due to rapid expansion of the community, mangroves are being illegally harvested to make space for construction of new homes. This has resulted a corresponding decrease in some of the ecosystem benefits provided by mangroves - including serving as filtration bed for cleaning ground water (Olatunji and Charles, 2020). As a consequence, groundwater in the area may be vulnerable to contamination from other pollution sources including septic facilities.

The construction of septic tanks near groundwater sources is even more pronounced in Quarter 1502 of the study community. This Quarter hosting about a fourth of the residents in the study community, is the portion closest to the wetland and was the main focus of the study.

The soil quality in the study area is predominantly sand and silt. Sandy soils are known to have high permeability, which results in high infiltration rates and good drainage (Baysah *el al*, 2018). A preliminary survey of about 80 households in the study community revealed that about 72% of the residents cannot afford to purchase sachet water and use groundwater water from boreholes for drinking. There were septic tanks constructed in almost every living quarter in the study community while residents closest to the wetland use the swamp for fecal waste disposal. The sampling locations are represented in Figure 1.

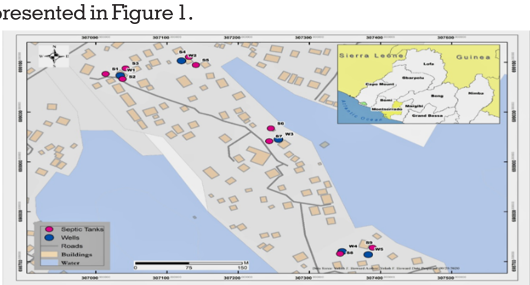

Figure 1: Sampling points and locations Kesselly Boulevard, Monrovia, Liberia

Sample Collection and Preparation

A total of five (5) water samples were collected from different locations in the Kesselly Boulevard community of Montserrado County, Liberia. At each sampling point, the distance from the borehole to the nearest septic tank was recorded. Four of the five sampling sources fell short of the 50ft distance requirement proposed by the United States Environmental protection Agency (US EPA, 2005). Samples were collected in clean 1.5L plastic bottles, properly labelled for easy identification and kept in a light-proof insulated box containing ice pack prior to being transported to the Environmental protection Agency' Laboratory in Sinkor for analysis

At the laboratory, samples were analyzed within 24 hours of sampling. The parameters considered in the study were pH, turbidity, nitrate, nitrite, lead, total bacteria count (TBC) and *E-coli*. The analytical method employed for each parameter is listed in **Table 1**. Furthermore, the microbiological isolates were identified using the Analytical Profile Index (API 20E) assay invented in the 1970s by Pierre Janin (Holmes *et al* 1978).

RESULTS AND DISCUSSION

This study assessed the impact of septic location on ground water quality within a total of five (5) groundwater sources (4 boreholes and 1 hand pump) in the Kesselly Boulevard Community of Montserrado County, Liberia. In order to adequately assess the impact, selected physico-chemical (pH, turbidity, nitrate, nitrite, lead) and microbiological parameters (TBC, *E-coli*) were analyzed in the samples and a correlation was drawn between the proximity to septic sources and the measured water quality. **Table 2** presents the results of physico-chemical parameters in the water samples assayed. pH levels in the study raged from 6.03 to 6.70 with all samples falling within both the WHO permissible limit of 6.0 to 9.0 and the Liberian Water Quality Standard (LWQS) Class I limit of 6.5 to 8.5. The pH values obtained in this study were largely in agreement to PH results recorded (5.96 to 6.64) from a study conducted by Charles *et al*, 2019 on groundwater samples from the Mesurado peninsula of Liberia. The results obtained in the current study were also largely in agreement with an investigation conducted in 2017 by Abong'o in Ongata Rongai, Kajiado County, Kenya; which reported pH values between 6.9 and 7.0 for samples collected from portable groundwater sources in the study area.

Turbidity levels in the samples ranged from 0.7 to 6.6 NTU with the lowest reading recorded in sample BH#5 which was the sampling point furthest (52.8 ft) away from a septic tank. The highest turbidity reading was recorded in sample BH#1, an open well located 25.7 ft from a septic tank to a portion of the wetland that had been recently backfilled. In general all but one (BH#5) of the samples fell above the WHO permissible limit of 1 NTU and the Liberian Water Quality Standard (LWQS) Class I limit of 5 NTU (UNDP, 1978).

Nitrate and Nitrite levels in all samples were below both the WHO and LWQS. BH#2, which was the closest water source to a septic facility, recorded the highest nitrate and nitrite values. Lead remained undetected in all of the samples analyzed (WHO, 2011).

The results of the bacteriological analyses (**Table 3**) revealed bacteria (TBC and *E-Coli*) presence in all but one (BH#2-furthest away from a septic source). The bacteria presence was even more pronounced in BH #2. This trend appears to be consistent with findings by Fubara-Manuel and Jumbo, 2014 which reported that water sources located near septic sources are more prone to microbial attack.

The microbes were isolated using API 20E assay. The results showed the presence of both *Escherichia coli* and *Salmonella* *species in* four of the five samples analyzed. *Escherichia adecarboxylata* and *Klebsiella pneumoiae* remained undetected in all of the samples analyzed. Sample BH#5 showed no presence of microbes during the assay. The detection of fecal contamination is an indication that a potential health risk exists for individuals consuming water from these boreholes. These findings support earlier assertions that septic tank location adversely affects the microbial quality of water and has a far reaching consequence on human health.

Table 1. Parameters and analytical methods

Parameter "Unit"	Analytical Method/ Instrumentation
pH	Multi parameter (in-situ)-pH Meter
Turbidity (NTU)	Absorptometric method (USEPA 8237)-Turbidity Meter (T100 Oakton)
Nitrite (ppm)	Diazotization method (USEPA 8507)-DR 890 (Hach)
Nitrate(ppm)	Cadmium reduction (USEPA 8192)- DR 890 (Hach)
Lead (ppm)	Spectrophotometry – DR 5000 (Hach)
TBC (ufc/100ml)	Microbiological Assay – Palintest Kit
E.coli (ufc/100ml)	Microbiological Assay – Palintest Kit

Table 2: Results of physico-chemical quality of water samples collected from the sampling points

Sample code	Description	Distance from source to septic tank (ft)	PH	Turbidity (NTU)	Nitrate (ppm)	Nitrite (ppm)	Lead (ppm)
BH#1	Open well	25.7	6.45	6.6	2.11	0.12	BDL
BH#2	Borehole	17.5	6.03	6.2	7.27	0.20	BDL
BH#3	Hand pump	20.2	6.21	2.9	4.57	0.14	BDL
BH#4	Borehole	22.4	6.29	2.1	2.40	0.11	BDL
BH#5	Borehole	52.8	6.70	0.7	0.10	0.05	BDL
WHO Standards			6.0 - 9.0	≤1	≤ 50	≤3	ND
LWQS Class I			6.5 – 8.5	≤ 5	≤40	≤ 3	≤ 0.001

LWQS = Liberian Water Quality Standard; Class I = drinking water; BDL = below detection limit; ND = not detected

Table 3. Bacteriological quality of water from boreholes

Well code	Total bacteria count (CFU/100ml)	E.coli (CFU/100ml)
BH#1	TNTC	13
BH#2	TNTC	TNTC
BH#3	TNTC	TNTC
BH#4	22	16
BH#5	0	0
WHO Standard value	ND/ 100ml	ND/ 100ml
LWQS (Class I)	ND/ 100ml	ND/ 100ml

TNTC = too numerous to count; Non detectable; LWQS = Liberian Water Quality Standard; Class I = drinking wate

Table 4. Results of micro-organism isolated using API 20E assay.

Microbes isolated	BH#1	BH#2	BH#3	BH#4	BH#5
Escherichia Coli	Pos (+)	Pos (+)	Pos (+)	Pos (+)	Neg (-)
Escherichia adecarboxylata	Neg (-)	Neg (-)	Neg (-)	Neg (-)	Neg (-)
Samonella chloleraesuis	Pos (+)	Pos (+)	Pos (+)	Pos (+)	Neg (-)
Samonella pullorum	Neg (-)	Neg (-)	Pos (+)	Pos (+)	Neg (-)
Samonella typhi	Pos (+)	Pos (+)	Pos (+)	Pos (+)	Neg (-)
Samonella parathyphi	Pos (+)	Pos (+)	Pos (+)	Neg (-)	Neg (-)
Klebsiella pneumoiae	Neg (-)	Neg (-)	Neg (-)	Neg (-)	Neg (-)

CONCLUSION

This study assessed the impact of septic location on ground water quality within a total of five (5) groundwater sources (4 boreholes and 1 hand pump) in the Kessely Boulevard Community of Montserrado County, Liberia. In order to adequately assess the impact, selected physico-chemical and microbiological parameters were analyzed in the samples and a correlation was drawn between the proximity to septic source and the measured water quality.

Results were compared with World Health Organization (WHO) and Liberia Water Quality (LWQ) standards.

Fecal coliform and E-coli were present in all but one sample (BH#5-situated 53ft from the nearest septic waste facility). Physicochemical parameters (pH, turbidity, nitrite, nitrate, lead) were below permissible limits in all of the samples analyzed. However, the detection of both *Escherichia coli* and *Salmonella species in* four of the five samples analyzed suggests that water from those ground water sources may pose adverse health risks to consumers and are thus unfit for direct human consumption without treatment. Furthermore, there was a strong correlation observed between water quality and proximity of the source to septic facilities; with higher contaminant levels recorded in sources closest to septic facilities.

The study, therefore, concludes that septic tank location adversely affect water quality in the study area with an even more pronounced consequences in boreholes that are in very close proximity to septic facilities.

RECOMMENDATIONS

The study recommends that the public be informed about the risk of constructing septic tanks in close proximity (< 50 ft) to a drinking water source or vice versa. Onsite treatment interventions should also be mobilized in the study community to protect households from further possible consumption risks.

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