Experimental Investigation Of Temeke Groundwater Quality, Accessibility And Its Health Implications

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Abstract: Anthropogenic activities had significantly distressed the availability and accessibility of reliable domestic water with sufficient quality. Yet available improved sources are scarce living city slums and urban peripherals dependents of groundwater. The role played by anthropogenic activities upon nutrients, heavy metals and organic content of groundwater was the focus in order to establish the existing water quality and its health implications. Experimental investigation revealed that overall amount of nitrate was higher, 3.361 ppm than ammonia, 0.20 ppm and nitrite, 0.0697 ppm. While 0.541 ppm being the highest recorded amount of phosphorus, 53.64 ppm was the highest amount of COD recorded. Fair amount of heavy metals including Zn, Cr, Cd and Cu observed to range between 0 to within acceptable limits, however the amount of lead from residential deep well, 0.0369 ppm was above WHO guideline. Waterborne cases like diarrhoea increased annually from 2007 to 2010 whereby cholera cases were irregularly fluctuating. Computation of Water Quality Index revealed that observed water quality rarely departed from natural levels.

Index Terms: Groundwater; Nutrient Content; Heavy Metals; Organic Pollution; Temeke; Water Quality Index

1 INTRODUCTION

Accessibility to reliable domestic water supply is a global challenge highly affecting sub-Saharan countries. It is an economic hindrance, which interferes with hygienic activities as well as large-scale investments [1]. Insufficient water supply results from misbalancing between population growth rate and capital investment, improper sanitation and institutional capacity building [2], [3], [4]. About more than six million people across the world suffer and die from lack of enough and safe drinking water [5]. Morris L., *et. al*., [6] reported that Tanzania population experiences a substantial diminution in accessing both improved sanitation and safe domestic water supply. NBS [7] and Döll P., *et. al*., [8] reported about 56.2% households in Tanzania access improved water sources while the remained group relies on groundwater sources where Temeke has an average construction rate shown in Chart 4. Anthropogenic activities worth mentioning industrialization, waste storage and treatment facilities, agriculture and household wastes threaten and interfere with groundwater sanitation [7], [9]. Waterborne incidents including diarrhoea, cholera and worth mentioning chronic diseases caused by heavy metal contamination are obvious in these communities [3]. Apart from direct health effect, polluted water technically leaves behind water shortage problems [10], [11]. While Howard G. and Bartram [12] reported nearly 6% of Tanzanian had improved sanitary facilities. Some surveyed areas had collapsing pit toilets, no sewage system, no tap water supply and very shallow wells are located nearly 3 m from pit latrine that increases contamination risks.

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2 MATERIAL AND METHODS

2.1 Study Area

Three wards of Temeke municipal, Table 1 were studied due to their socio-economic activities and water quality challenges they are facing. Some households had no sewerage connection, fewer had septic tanks and most of them were pit latrines dependent. The study area was categorized into five zones where ten samples including tap water were collected during the dry season of 2010 as these sources were in continuous usage. Each one-liter polyethylene bottle used for collection of samples had previous washed then rinsed with distilled. Collected samples were placed in the cool ice jar, later stored in a refrigerator for analysis at UDSM chemistry lab through EPA [13] and UNEP [14] guidelines.

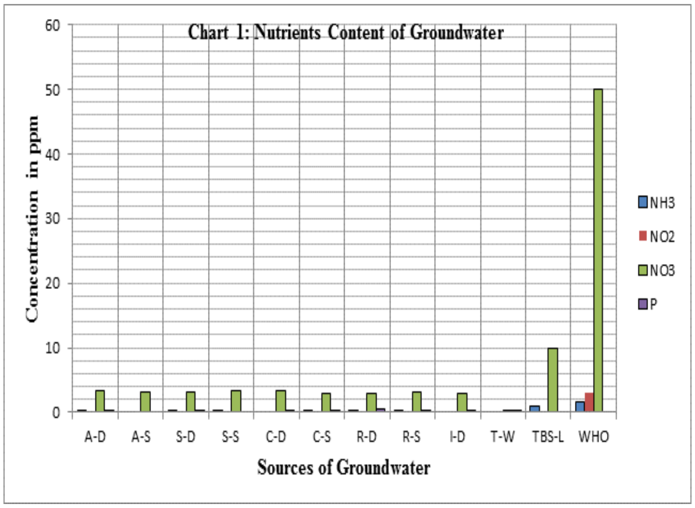
Table 1: Sampling Sites

Ward	Street	Zones	Depth of well
Keko	Keko Mwanga B	Industrial	Deep
	Keko B	Residential	Deep and shallow
Charambe	Kilungule	Agricultural	Deep and shallow
	Majimatitu B	Stressed-free	Deep and shallow
Tandika	Tandika	Commercial	Deep and shallow
Deep well > 6.7 m and a shallow well is < 6.7 m			

3 RESULTS AND DISCUSSION

3.1 Nutrients Content

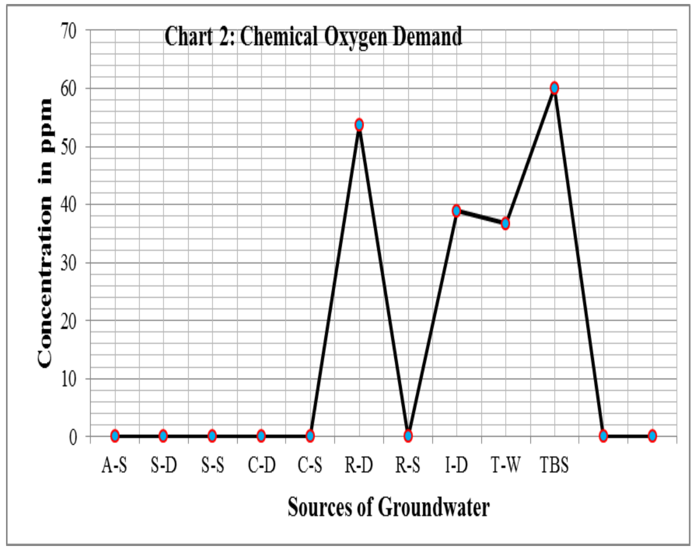
Human body requires optimal nutrients supply in order to avoid health problems like blue baby syndrome [15]. Results from Chart 1 depict nutrient content of groundwater with leading amount of nitrate followed by phosphorus, nitrite and then ammonia. Recorded amounts of all samples agreed with WHO [16] and TZS 789 [17] standards for portable water. It is obvious that metallic wall of a shallow well from residential area minimized possibility of nutrients contamination as it allowed water to percolate only from the bottom where surrounding sand filter surface contaminated water. The low amount of phosphate suggests that shallow wells received no loads of phosphates through leaching from pit latrines, sludge drains, solid waste dumps, animal waste and dumps. These small amounts of measured nutrients are highly associated with hydro-geological origin as well as from chemical precipitation of atmospheric gases.



Nitrite and ammonia were lesser than nitrate because nitrate is in the stable form while nitrite and ammonia only exist in the equilibrium form. Despite various anthropogenic activities in this area, nitrogenous and phosphorous waste contaminations were minimal.

3.2 Organic Pollutants

Assessment of Chemical Oxygen Demand, COD conducted to establish the amount of oxygen demanding organic pollutants as per Chart 2. Decomposition of organic matter can cause increased levels of bacteria, which in turn reduces oxygen levels in water affecting taste, smell and viability of aquatic organisms. Observed that organic waste content of all shallow wells were below 1 mg/L. These findings support the fact that wastes from households and commercial establishments had less impact on organic pollution of groundwater. Contrary to deep wells in agricultural, stress-free and commercial area, tap water had high amount of organic pollutants than residential and industrial deep wells. It is certain that contamination occurred in these aquifers via leachates from subsurface structures such as petroleum storage tanks and waste drains passing along these areas. Features such as fractures, worn out pipes, back flows, uncovered storage tanks and storage time contributed to organic wastes contamination in the tap water. Commercial, agricultural and stress-free areas were safer as routine activities in these areas impose fewer risks that call less attention.



3.3 Heavy Metals

Some of heavy metals are nutritionally important in small quantities. For some reasons it is important to quantify them to avoid over exposure as they are fatal once over exposed. Ingestion of metallic lead can substitute calcium in the bone that chiefly affect children because developing skeleton requires high amount of calcium. There is no evidence indicating the essentiality of cadmium to human healthy rather than being both toxic and carcinogenic.

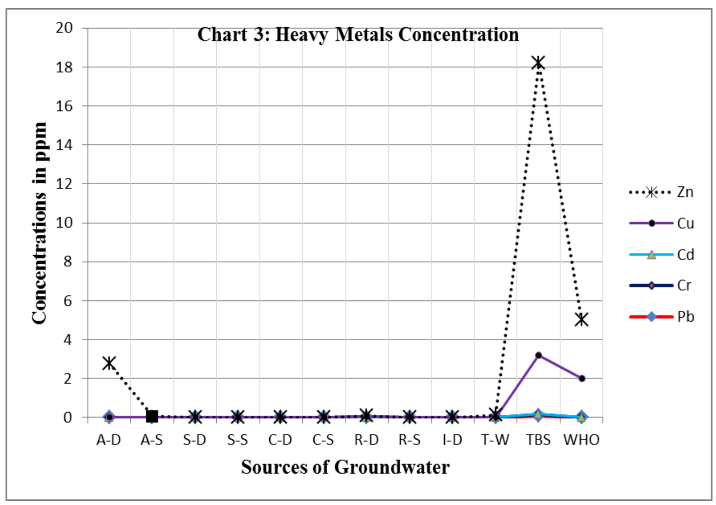


Chart 3 show that the average amount of zinc and copper from deep wells was higher than shallow wells. Water sample from residential deep well had high amounts of lead than WHO standards. These amounts obviously arise from paints, dusts, lead pipes and gasoline. The observed concentrations of some heavy metals available in the domestic water were within TBS and WHO acceptable levels. These levels are seldom high enough to cause acute health effects since these metals are excretional. However, there is still a risk of bioaccumulation predominantly in children that may cause chronic effects at old ages. Trace amounts of heavy metals present in the assessed water might have originated from dissolved natural minerals, corrosion of pipes, surface overflows, leachates, contamination through non-point-sources and sometimes being geological origin. Heavy metal contamination of this area was very small because water was temporarily stored in either plastic or concrete tank with plastic piping systems that less contributes to heavy metal pollution.

3.4 Waterborne Diseases

Survey revealed that most areas of Temeke had no connection to tap water supply.

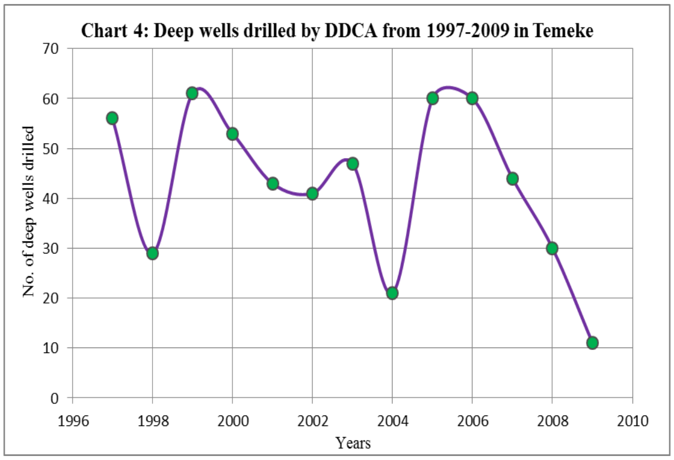


Chart 4: Deep wells drilled by DDCA from 1997-2009 in Temeke

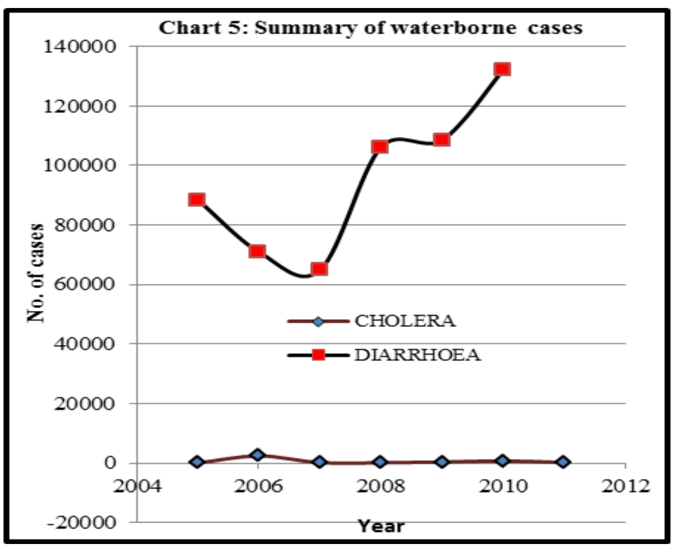


Chart 5: Summary of waterborne cases

The only existing groundwater wells are private. Infrastructures were in a marginal collapse due to deprived construction and shortage of maintenance. Frequency of waterborne cases as per chart 5 is highly linked with undermined water quality that was also supported by Pritchard M. et. al., 2008. It is however that chronic diseases related to bioaccumulation of heavy metals are less reported and difficult to acknowledge their causative agents.

3.5 Acceptability based on Water Quality Index (WQI)

Computation of WQI reflects the quality of water for both acceptability and health that enables mathematical decision making regarding water quality [18].

Table 2: Water Quality Experimental Results

Site	Agricultural		Stress-free		Commercial		Residential		Industrial	Standard	Tap water
source	A-S	A-D	S-S	S-D	C-S	C-D	R-S	R-D	I-D	WHO/TBS	T-W
NH_3	0	0.2	0.02	0.15	0.08	0	0.03	0.17	0	1.5	0
NO_2	0.002	0.009	0.005	0.07	0	0.013	0.014	0	0.015	3	0.003
NO_3	3.15	3.37	3.36	3.2	2.87	3.45	3.11	2.87	2.94	50	0.2
P	0	0.07	0	0.06	0.01	0.01	0.02	0.54	0	6	0.02
COD	0	0	0	0	0	0	0	53.6	38.9	60	36.7
Pb	0	0	0	0	0	0	0	0.0369	0	0.01	0
Cr	0	0	0	0	0.001	0.002	0	0.001	0	0.005	0
Cd	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0.00498	0	0	0.00375	0	0.01694	0	2	0.00125
Zn	0.065	2.786	0	0.006	0	0	0	0.037	0.003	3	0.124

From table Canadian Water Quality Index (CWQI) Equation;

$$WQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right)$$

$$F_1 = \left(\frac{numberoffailedparameter}{tota\ln umberofpaarameters} \right) * 100$$

F1=10

$$F_2 = \left(\frac{numberoffailedtests}{tota\ln umberoftests} \right) * 100$$

F2=1

$$excursion = \left(\frac{failedtestvalue}{guidelinevalue} \right) - 1$$

excursion=2.69

$$nse = \frac{\sum excursion}{tota\ln umberoftests}$$

nse=0.0269

$$F_3 = \left(\frac{nse}{0.01nse + 0.01} \right)$$

F3=2.6195

WQI=94

The obtained WQI value is a good indication that observed water quality rarely departed from natural or desirable levels.

4. Recommendations

It is important to conduct a study on lateral movements of pollutants along wastewater drainage system and leaching contribution of industrial facilities to understand their environmental pollution contributions from the studied area.

5. Conclusion

Although groundwater sources for domestic supply in studies area are prone to contamination its quality conformed to national and international standards. However, it is strongly advised to carry out a continuous water quality monitoring.

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