A Physico-Chemical and Bacteriological Investigation of Groundwater Quality for Domestic Supply, A Case Study of Temeke Municipal

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Abstract - The access to adequate, clean and safe domestic water in major cities remains a challenge. To meet the current water demands, both shallow and deep wells are vigorously increasing. However, the quality of abstracted water was still unknown. This study focused in assessing the role of anthropogenic activities in the physico-chemical and bacteriological quality of groundwater for domestic supply in Temeke Municipal.

It was found that groundwater temperatures range between 29.5°C and 36 °C, while wastewater was far 38 °C, which was above World Health Organization (WHO) allowable value. Water hardness, nitrate, nitrite and ammonia content were in conformity with WHO and TBS standards. Heavy metals and TSS were within permitted limits. On the contrary, turbidity in deep well from agricultural area was 7 NTU which was above WHO regulations. It was also revealed that total coliform and *E. coli* counts of deep wells were notably high. The total coliform in industrial wastewater was much higher than any source because of high amounts of organic wastes. Furthermore, a significant amount of electrochemical properties beyond standard guidelines was observed in all sources. Despite the quality of water found to be fairly acceptable for domestic use, thorough and continuous monitoring is important to account for any change in water quality parameters.

Index terms - Groundwater, Wastewater, Water quality, Coliforms, Temeke

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1. INTRODUCTION

Today's global safe and adequate water crisis is not only pronounced as a case of its scarcity but also its accessibility. Until 2004 there were at least 1100 million people across the world without access to safe and sustainable drinking water [1]. The adverse impacts have been reported in Sub-Sahara African countries where water borne diseases, accessibility and sanitation are now becoming a global burden [1], [2], [3]. It is reported that about 80% of all diseases in developing countries are related to water and sanitation [4]. These illnesses are estimated to cause nearly 2.2 million deaths and over 72 million disability adjusted life years [5].

Large number of industries depends on the groundwater that is the world's most extracted resource . It is supporting about 2.0 billion people across the world with agricultural sector being the largest consumer. Consumption of groundwater in Africa is nearly 211.3 km^3 per year with an estimate recharge of 2061 up to 2032 km^3 per year since year 1961 to 1990 [6]. However the quality of this water is currently threatened by industries, waste treatment facilities, agro-chemicals, failing septic systems, household chemicals as well as acidic rainfall [7, 8]. Contaminated water sources leave behind effects to the host organisms as well brings scarcity of safe water supply [9]. Around 80% of the populations in the largest cities in Africa have on-site sanitation, such as septic tanks, pour-flush, Ventilated improved pit latrines or simple pits. For Tanzania nearly 6% of her citizen had improved sanitary facilities. In some cases, the distance from pit latrine to abstraction well is nearly 3 m and there is then a real risk of abstracting pathogens [10]. It was also reported that only 23% of Tanzania mainland population had access to improved toilet facilities [8].

A decrease in the population accessing both improved sanitation and safe drinking water sources is clearly visible in Tanzania with a significant impact [11]. NBS 2005 reported that nearly 56.2% of the households in Tanzania mainland had access to improved water sources within 15 minutes distance. The remained 43.8% relay mainly on groundwater sources vigorously constructed in Dar es Salaam region [12].

This study therefore presents findings on the role of anthropogenic activities towards physico-chemical and bacteriological quality of groundwater for domestic supply in Temeke municipal.

2. MATERIAL AND METHODS

2.1 Study area

Temeke district shown in the map below is in the southernmost of three municipals in Dar es Salaam region.

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The 2002 Tanzania National Census reported that Temeke municipals has a population of 768,451 with an area of 786.5 square km [13]. It is administratively divided into 3 divisions having 24 wards.

Ten samples collected from study area was categorized into industrial-IND (Keko Mwanga B), residential-R (Keko B), agricultural-A (Kilungule), stress-free-S (Majimatitu B) and commercial-C (Tandika) area. In addition, one source of wastewater-WW (Chjang'ombe) and tap water-TW were analyzed too in the presence of distilled water as a referencing sample. 'S' was used to abbreviate shallow well with less than 6.7 m, meanwhile 'D' was used for deep wells with greater than 6.7 m.

Some households had no sewerage connection, fewer had septic tanks and most of them were pit latrines dependent. Infrastructures were in verge of collapsing due to poor construction and lack of maintenance. Frequency of water borne diseases was as in the year 2006, 2007, 2008, 2009 2010 and 2011, 452, 13, 21, 32, 149 and 20 water borne diseases cases respectively were reported [14]. The overall physico-geography of these areas had a considerable influence on the quality of ground water.

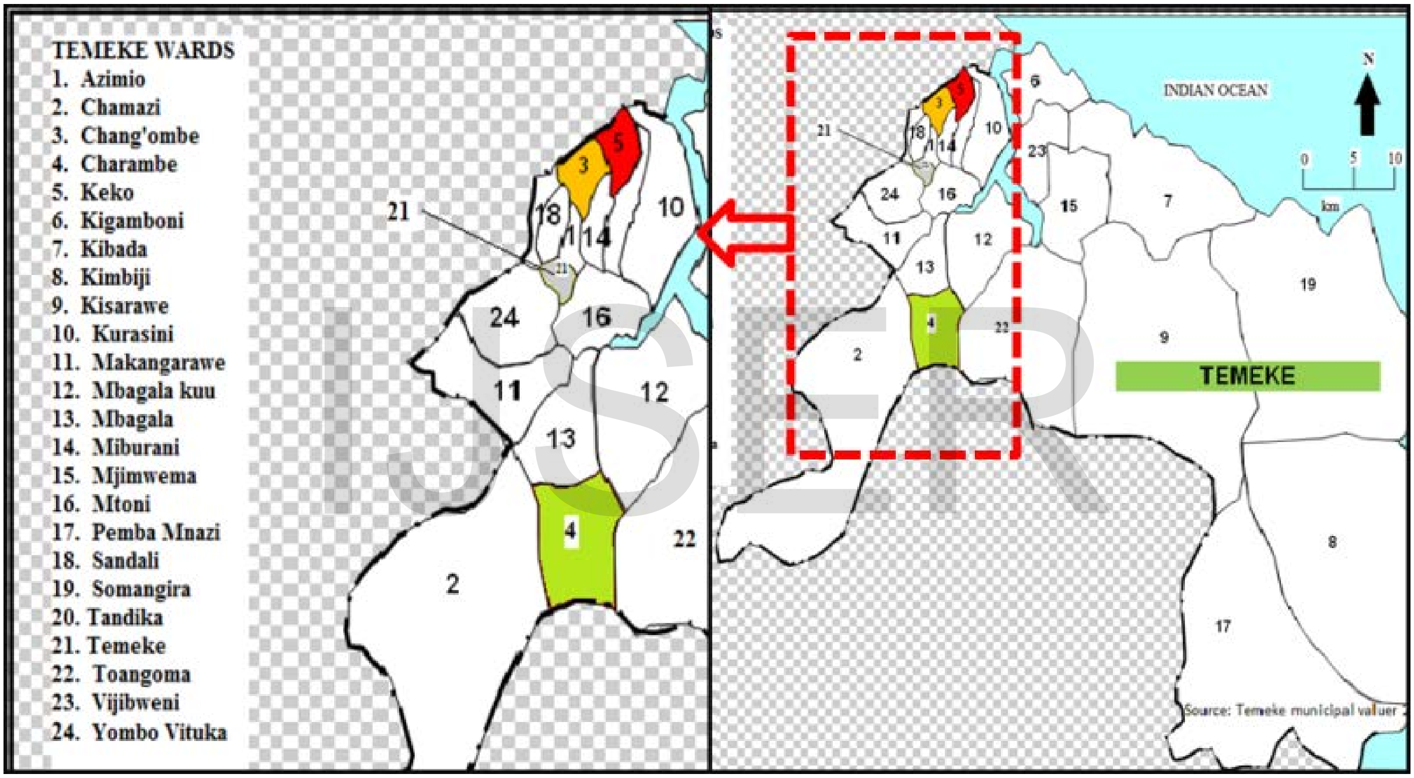


Figure 1: Temeke municipal map showing sampling sites 3, 4, 5 and 20

2.2 Sample Collection and Preservation

Representative samples were collected during the dry season of February and March 2011. It permitted greater accessibility in most of the areas, as well as making it more likely that ground water sources used on a dry seasonal manner would be in irregular use.

One liter volume polyethylene plastic bottles were used for collection of 12 samples including distilled water for physico-chemical and bacteriological parameters analysis. These containers were soaked with 1:1 nitric acid for 24 hours after washing them with detergent and rinsed with distilled water. Finally they were re-rinsed with distilled water. At each location, two sampling bottles were filled with water samples. Samples for biological tests were collected in the glass containers sterilized at 120 °C for 24 to 48 hours [15].

2.3 Laboratory analysis

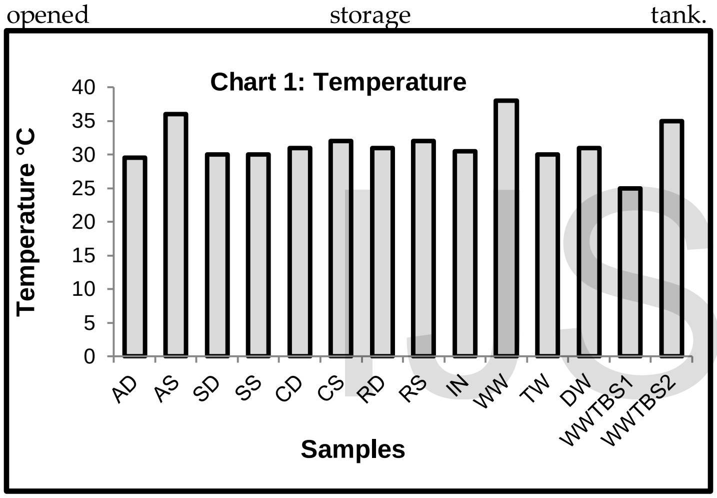
Turbidity was measured by using turbidimiter, TDS and TSS were gravimetrically measured, alkalinity was quantified by titration of the sample with a standard solution of a sulfuric acid, hardness was measured by using EDTA method [16], total coliform and E. Coli by using Most Probable Number method [15, 17].

3. RESULTS AND DISCUSSION

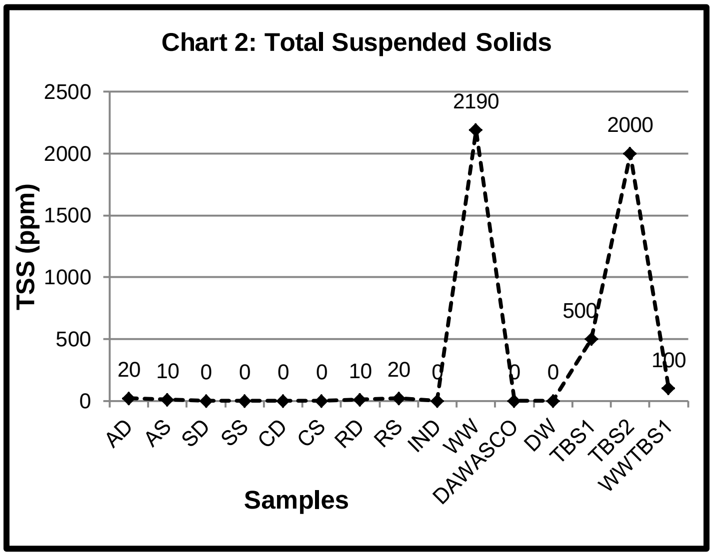
The range values for pH and temperature were between 5.06 to 7.81 and 29.5 to 36 °C respectively. In average shallow wells had high values for electrical properties compared to deep wells. This was because surface water is highly affected with surface contaminations. All the samples from deep wells had coliform counts ranging between 240-4300 MPN/100 ml with which some showing presence of E. coli and contrary there were no detection of E. coli in all shallow wells likely contributed by intensive abstraction of water from shallow wells.

3.1 Physico-Chemical Water Quality Parameters

Anesthetically all samples were colorless except sample from deep well in agricultural area which was an indication of surface contamination through infiltration and through the opened storage tank.

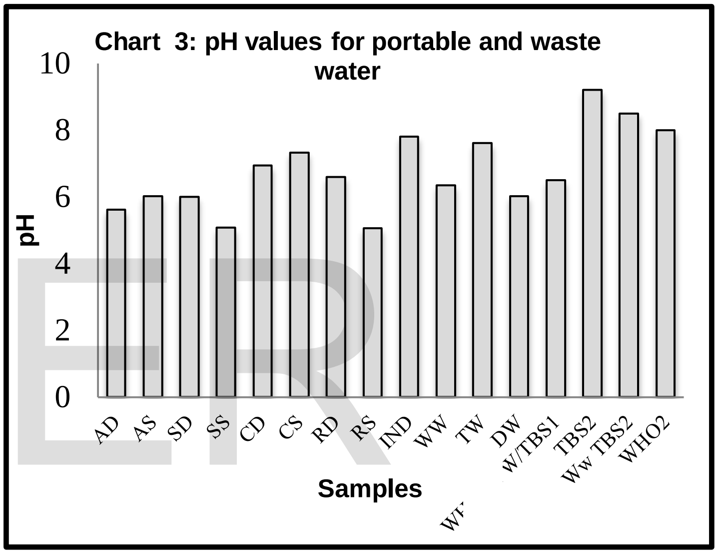


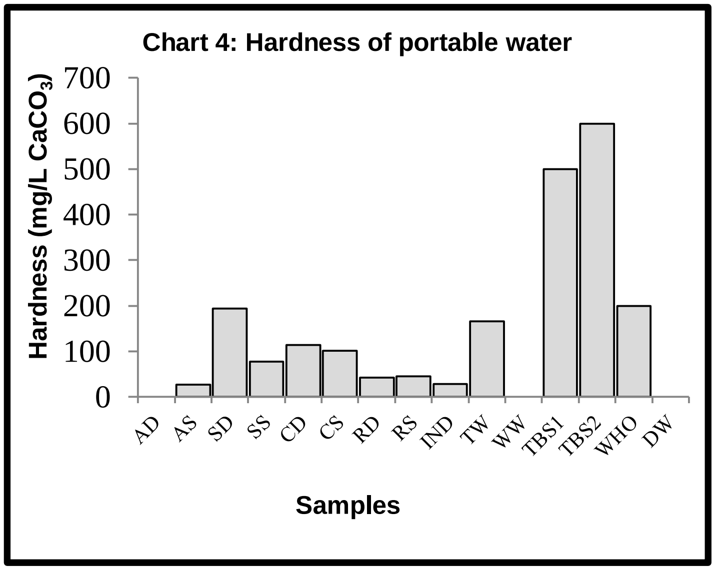
Colourless, odourless and tasteless attributed by both effective utilization and enough sanitation practices. The salty taste observed might contributed by seawater intrusions.



Wastewater was stinking with high amounts of visible decayed suspended particulates that were an indication of severe water pollutions. Abnormal high water temperature observed in Chart 1 associated with high contents of suspended particles in Chart 2.

The pH of analyzed groundwater in Chart 3 were within range and could not cause adverse health effects for domestic uses based on TBS [18] and WHO [19] guidelines that recommend a pH range of 6.5 to 9.2. These sources experienced only minimal influence from the natural deposits and point and non-point sources of contamination. Furthermore, this was a sign of well-aerated water bodies and the underlined rocks may have a significant buffering capacity that maintains the pH of water [20].

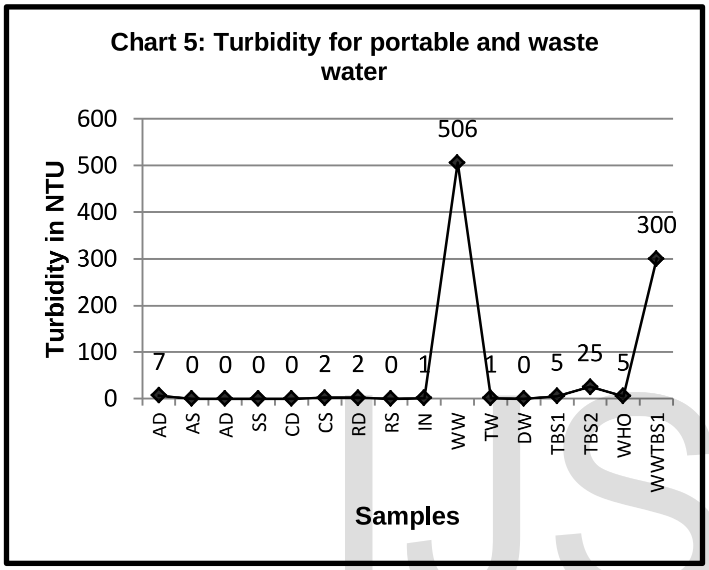




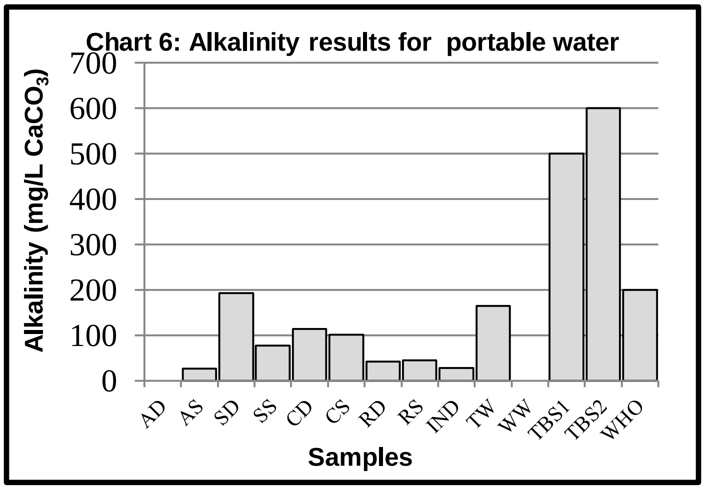
Field study realized that hardness of water in Chart 4 was less affected by environmental sanitation integrity that indicated minimal environmental pollution as all samples were within

WHO and TBS recommended limits. This explains that soil profile in the respective areas contains very small amounts of dissolved calcium and magnesium minerals.

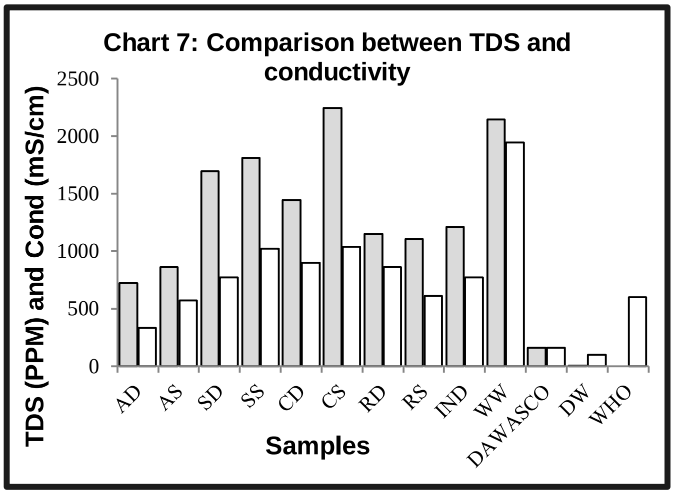
The low turbidity content (1 NTU) observed in Chart 5 was highly attributed to by enough water settling time and effective natural filtration of percolating groundwater. Likewise, there had been minimum vegetation coverage that could be the source of suspended organic matters. Turbidity higher than 5 NTU may also implicate lack of enough and real-time sanitary practices.



In the polluted environment, alkalinity is caused by rainwater washing and reacting with atmospheric CO2 to form weak carbonic acid, H2CO3. The acid formed dissolves carbonate contained rocks that make up most of the total alkalinity. In this study only small amounts of total alkalinity (108.93 ppm) observed Chart 6 had little sanitary and health effects associated with both direct and indirect consumption. However, this should not taken as a grant to consume these water without treatments.



Most samples indicated high deviations in TDS from standard values in Chart 7, which was an indication of presence of high contents of dissolved salts that contributed by seawater intrusions and some anthropogenic activities. Also this chart reveals a perfect relationship between TDS and electrical properties of groundwater. These facts need isotopic studies to identify exact sources of salinity content of groundwater.



3.2 Bacteriological Content

Bacteriological results indicated in Table 1 show that deep water wells located in agricultural, stress-free and commercial areas, as well as wastewater had coliforms that exceeded recommended standards. Wastewater had extreme amounts because of lack of effective treatment techniques. This results in the deterioration of nearby groundwater sources [21]. E. coli were found in the mentioned sources with the exception of stress-free area though the present counts were within accepted levels. In the case of first time renewed agricultural area deep well, its water possibly swiped various contaminants including coliforms. Stress-free deep well had microbes perhaps because of direct contamination through open top wide cover. In commercial area, it was observed that concrete underground storage tank covered with iron sheets might play a role as a route for surface contaminations. A deep well from industrial area had no coliforms since the medium was slightly alkaline.

Water wells and storage tank cover's that allow dust, rain, bird droppings and insects to enter them and wells located in areas where surface water covers groundwater source during wet periods, as well as defected steel well-casing seals, improper well construction can contaminate groundwater.

Table 1: Bacteriological counts

Type of source	Total Coliform (counts/100ml)	E. Coli (counts/100ml)
Shallow wells	n.d	n.d
Deep wells	1365	131
Tap water	n.d	n.d
Wastewater	930.0×10^4	15.0×10^4
TBS (Low)	10	2
TBS (High)	n.m	n.m
WHO	0	0
WW- TBS(Low)	10000	n.m
WW- TBS(High)	n.m	n.m

Furthermore, since microbes can exist freely in the soil, these areas might be the source of microbes count too. There have been more than 1800 coliform counts reported from deep wells of other related study compared to 1365 recorded in Table 1. Also three out of four samples collected from deep wells were reported to be positive for total coliforms [22]. Shallow wells sampled in this study had no coliform counts. Also reported approximately 20% of the shallow wells tested in the dry season were reported to be free from total coliforms [23].

4. CONCLUSION AND RECOMMENDATIONS

In many cases, it is clearly that anthropogenic activities interfere with groundwater quality. Agricultural activities had minimal contribution in the pollution of groundwater due to fact that fertilizers were less uses. Stress-free and commercial activities had a medium contribution. Apart from wastewater, observed industrial activities had minimum effects since they are located at highlands that favor sanitation of groundwater. Thus, although groundwater sources for domestic supply in Temeke municipality supply water of moderate quality, further studies are important because these sources are prone to contamination.

Further studies also recommended on the extent of seawater intrusions along the coast regions, community satisfaction in water quality and services, sustainability of sanitation infrastructures in DSM and life-cycle assessment of water and wastewater sanitation approaches.

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