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Assessment of Quality of Water in Kitui Sand Dams as Sources of Drinking Water

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Abstract

Kitui is a semi-arid region that experiences erratic and unreliable rainfall. The region also experiences a large fluctuation in precipitation over years with periods of drought. There is therefore a problem of water availability. In overcoming this challenge, sand dams have been constructed to store water. Sand dams, which are sub-surface reservoirs store smaller volumes of water compared to surface reservoirs. The advantage of sand dams is that the water quality remains more constant with fewer reduced biological contamination as compared to surface reservoirs. This study was therefore carried out with the objective of assessing the quality of water in the sand dams used as sources of drinking water. A total of fifteen (15) sand dam sites were assessed. Water samples were collected and analysed for chemical, physico-chemical and bacteriological parameters. In addition, information on methods of water abstraction and the human activities around the dams and their impact on water quality were also collected. Water samples were collected from the sites where the locals were abstracting their water from. The water was analysed at the Kenya Water Institute laboratory using the standard methods of water analysis. Except for two parameters (Iron and E-Coli), the water quality was within the WHO drinking water standards. About 50% of the sand dams had Iron levels higher than 0.3mg/l while E-coliform counts of more than 2400 were recorded. The E-coliform counts should be nil for drinking water. This therefore means that the water from the sand dams requires treatment before drinking to avoid outbreak of waterborne diseases.

1.0 INTRODUCTION

Kitui is a semi-arid region characterized by rainy periods that are highly erratic and unreliable. The region also experiences a large fluctuation in precipitation over years and sometimes rains fail completely (Lasage *et al.*, 2008). In addition, to the highly variable rainfall patterns, the evaporation rates are very high reaching up to 100% of the incoming monthly precipitation. There is however great potential for rainwater harvesting storage and distribution of the available water (Opere *et al.*, 2004). To overcome the challenge of variability in rainfall and water availability, many sand dams have been constructed in Kitui to store water.

Sand dams are impermeable concrete structures constructed across ephemeral rivers with the purpose of harvesting water. Coarse gravel and sand can store and retain up to 35% of their total volume as water. The sub-surface reservoir is recharged through periods of rainfall. When the reservoir is filled, surplus water passes the dam without infiltration. The stored water is collected by locals for use through digging a scooping hole, or constructing an ordinary well or tube well. (Lasage *et al.*, 2008; Borst & de Haas, 2006). Semi-arid areas such as Kitui are ideal for sand dams because of the presence of ephemeral streams with coarse sand. Secondly, the topography of the area allows for the construction of weirs and dam embankments. Lastly, there is minimal water loss through evaporation in such regions that experience high temperatures all year round.
Although the risks of water pollution of the sand dams is minimal as there is no direct contact with pollutants (Filho, & Gomez, 2018), there is need to continuously monitor the quality of water from these dams especially where the dam is a source of drinking water.

Although sub-surface reservoirs store smaller volumes of water compared to surface reservoirs, *(*Quilis *et al., 2009)* evaporation losses are lower (Borst & de Haas, 2006) since no water is subjected to direct solar radiation and also risks of contamination of stored water are reduced as direct contact is minimized *(*Quilis *et al.*, 2009*;* Lasage *et al.*, 2008). Therefore, water quality remains more constant with fewer effects by biological contamination and also as water flows, it is filtered and bacteria and other biological threats are reduced (Borst & de Haas, 2006). It is important to note that water stored in sand dam is of safe quality when it is protected against pollution. To check the water quality, a water sample should be taken from an observation well about 50 meters upstream of the dam in the center of the river on a yearly basis. The sample should

be for analysed for major ions (Cl, HCO_3, SO_4, NO_3, K, Na, Fe) and physical parameters such as Electrical Conductivity and PH (Rainwater Harvesting Implementation Network, n.d.). A study by Avis (2014) demonstrated that water stored by the majority of sand dams tested is safe according to WHO standards for human consumption. The number of faecal coliforms per 100ml of water was nil but recommended further work to evaluate which abstraction technique presents the least risk of contamination.

The main sources of pollution of sand dam water are the excreta from animals or dumping of other materials which may cause pollution of the water during run-off and infiltration. Protection measures should be taken to avoid pollution of the riverbed. These include keeping livestock away from the river about 100-200 m upstream of the dam, avoiding dumping of garbage and cleaning up during dry season just before onset of rains (Rainwater Harvesting Implementation Network, n.d.).

1.1 OBJECTIVE

The overall objective of the study was to assess the quality of water and relate it with methods of water abstraction and human activities in the catchment area

The specific objectives were to;

1. Assess the quality of water in the sand dams,
2. Identify methods of water abstraction from the sand dams,
3. Identify human activities and their impact on water quality of the sand dams

2.0 METHODOLOGY

A field study was carried out to assess sand dams as sources of water for domestic use in Kitui. Fifteen (15) sand dam sites were visited and data collected. Fieldwork data collection was through the assistance from Water Resource Management Authority (WRMA) offices and district water offices in Kitui and also local guides. Water samples were collected during field visits while additional data on the methods of water abstraction from the sand dams and on the human activities and their impact on water resources was also collected. Water samples for analysis were collected from the sites where the locals were abstracting their water from. The water was analysed at the Kenya Water Institute laboratory using the standard methods of water and wastewater analysis.

3.0 RESULTS

3.1 Water Quality: Chemical parameters

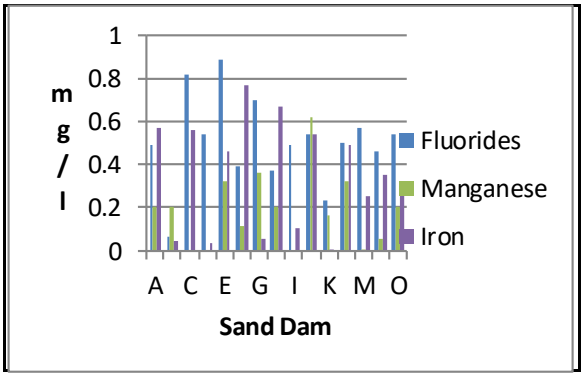

Figure 1:Fluorides, Manganese and Iron levels

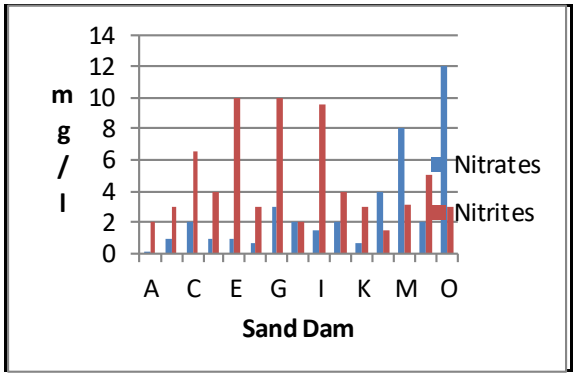

Figure 2: Nitrates and Nitrites levels

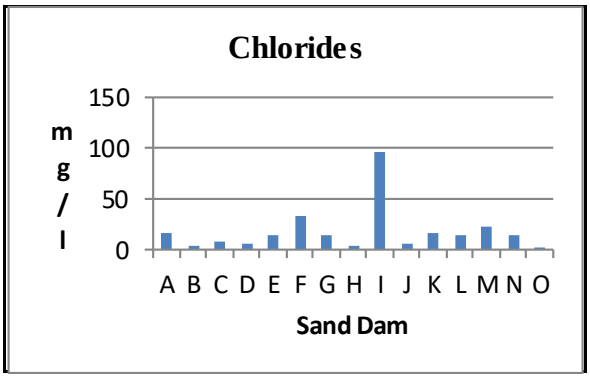

Figure 3: Chlorides Levels

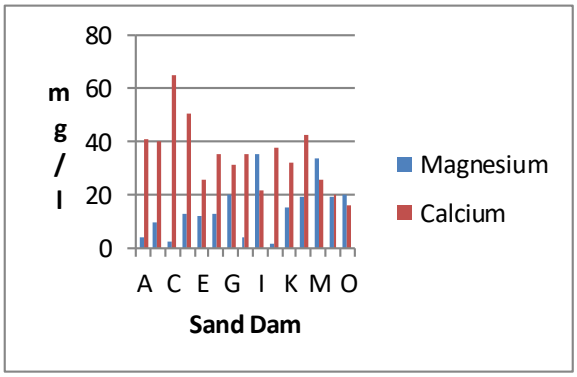

Figure 4: Manganese and Calcium levels

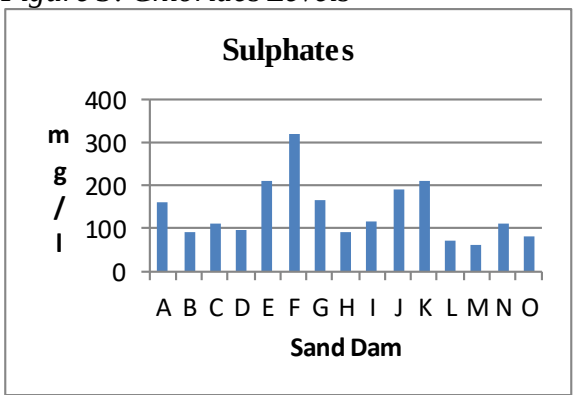

Figure 5: Levels of Sulphates in the sand dams

Sand Dam	**Key**
Mbavai Nguluni	A
Kaui	B
Kwa Nzamba	C
Kwa Mang'ethwa	D
Komu	E
Mutendea	F
Tiva	G
Mamole	H
Mwitasyano	I
Kiniva 1	J
Kyusi 1	K
Kiniva2	L
Kyusi 2	M
Mkongwe	N
Kavingoni	O

Figures 1-5 shows Kitui sand dams water quality for selected chemical parameters. Fluoride levels for all sand dams were within the recommended limits of 1.5mg/l. Only Kiniva 1 recorded higher levels (0.62) of Manganese than recommended drinking water limits. About 50% of the sand dams had Iron levels higher than 0.3mg/l while the rest were within the recommended drinking water limits. Most dams showed high levels of nitrite which is a reduction of nitrate from anthropogenic sources of fertilizer or decaying plants and animal residues.

3.2 Water Quality: Physico-chemical parameters

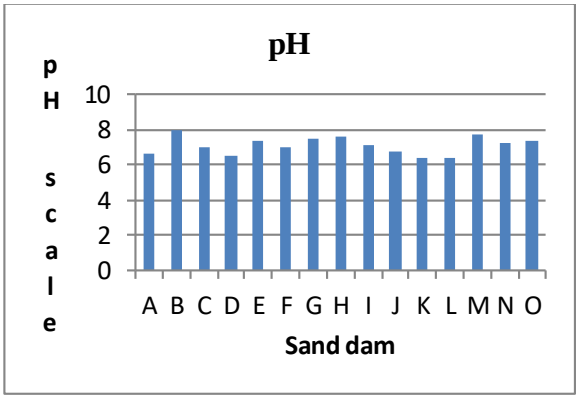

Figure 6

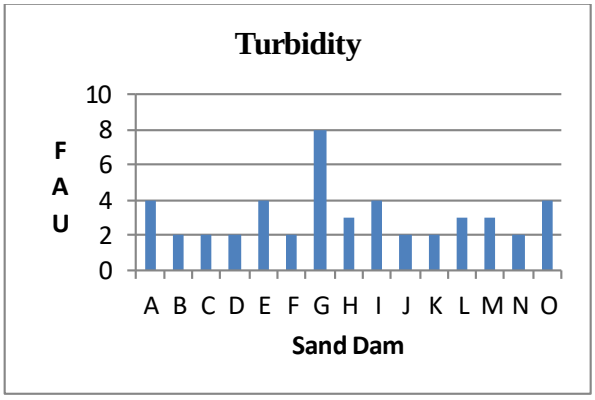

Figure 7

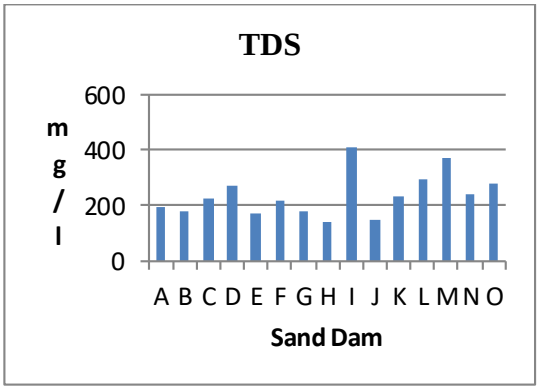

Figure 8

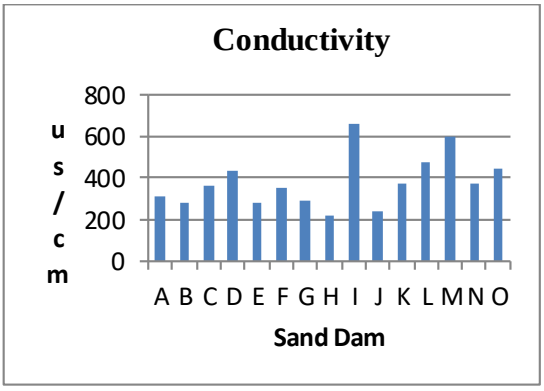

Figure 9

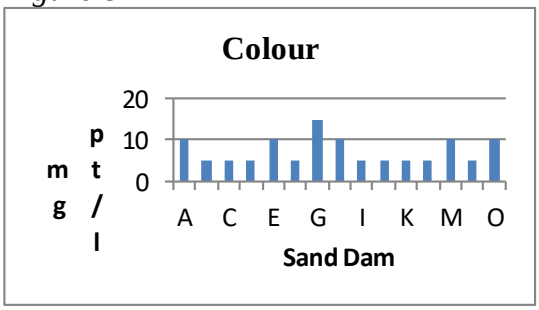

Figure 10

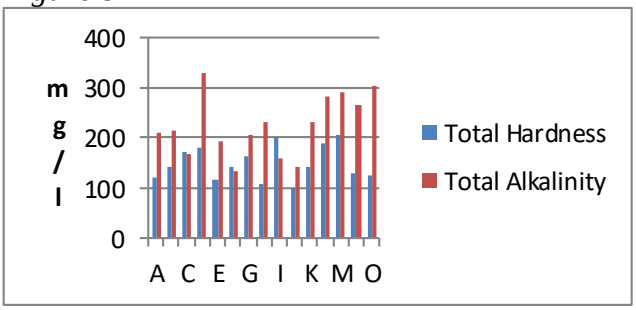

Figure 11

Figures 6-11 shows selected physico-chemical parameters for Kitui sand dams. All sand dams water pH was within the recommended drinking water standards of 6.5-8.5 with the lowest pH of 6.3 being recorded in Kyusi 1 and Kiniva 2 while the highest pH of 7.9 being recorded at Kaui. Tiva sand dam, recorded turbidity of 8 while the others were less than 4

Table 1: Kitui sand dams water quality microbial parameters

Water quality: Bacteriological parameters		
Sand Dam	**Total coliform Counts**	**E.coliform Counts**
Mbavai Nguluni	>2400	1100
Kaui	>2400	>2400
Kwa Nzamba	>2400	1100
Kwa Mang'ethwa	>2400	1100
Komu	>2400	460
Mutendea	>2400	210
Tiva	>2400	93
Mamole	>2400	4
Mwitasyano	>2400	>2400
Kiniva 1	>2400	>2400
Kyusi 1	>2400	210
Kiniva2	>2400	210
Kyusi 2	>2400	28
Mkongwe	>2400	>2400
Kavingoni	>2400	>2400

The samples from all sand dams had total coliform counts higher than 2400. The Ecoliform counts should be nil for drinking water. From the analysis it shows that all the sand dams are contaminated with the Escherichia Coli; the feacal coliforms presence indicator.

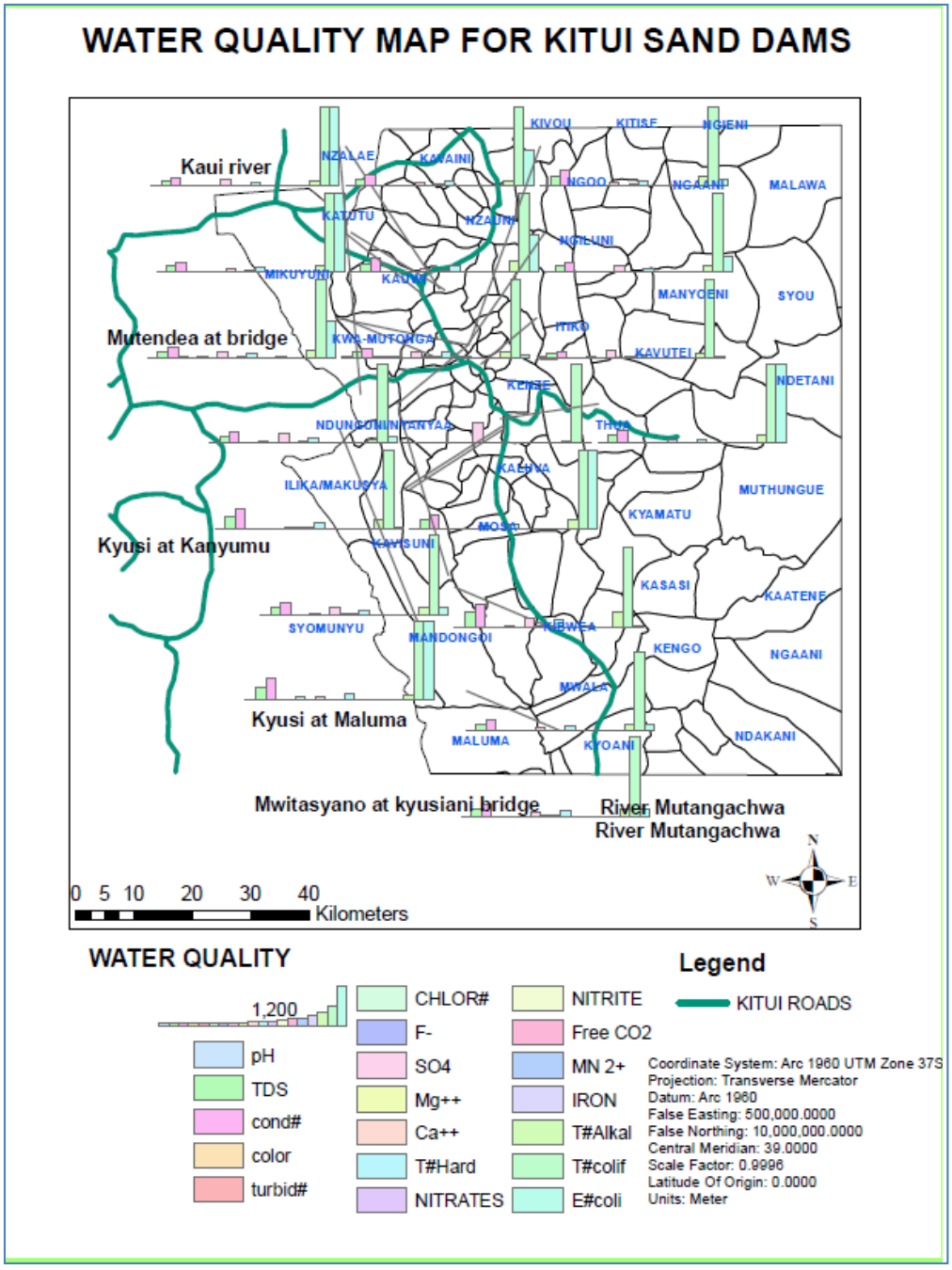

Figure 12: Water quality map for Kitui sand dams

3.3 Methods of water abstraction from the sand dams

The major methods of water abstraction from the sand dams observed include;

1. Scoop holes: when the river has stopped flowing sub surface water is still present. Locals therefore dig holes on the river beds so as to collect water. The holes fill up with sand and so they have to be dug out again.
2. Shallow wells close to the stream some have hand pumps while others the water is fetched manually with aid of a bucket and rope
3. Pipes from the dam sand storage dams
4. Water sumps: Sand dam water is also used for small scale irrigation. Water sumps were observed close to the sand dams

3.4 Human activities and their impact on water quality of the sand dams

Several human activities that impact on water quality were noted. They include;

1. Washing, swimming and bathing in the river
2. Farming near the river with no soil erosion control measures.
3. Livestock watering, irrigation, and collecting water for domestic use.
4. Scooping and sale of sand harvested from the river.
5. Leaking or unrepaired dams / walls

4.0 Conclusions

1. The analysis done showed that most of the dams' physico-chemical composition is within permissible levels in WHO standards for drinking water. However, most samples showed high levels of nitrite which is a reduction of nitrate from anthropogenic sources of fertilizer or decaying plants and animal residues. The samples also showed contamination with with general enteric bacteria and the Escherichia Coli; the faecal coliforms presence indicator.
2. Due to farming near the dams and lack of soil erosion control measures, most dams were found to be highly silted therefore not storing enough water. Also water pollution from swimming, washing and fertilizer use in nearby farms were human sources of water pollutants observed and they impact on water quality
3. The major methods of water abstraction from the sand dams observed include; sand scooping, shallow well either at the river bed or close to the stream, pipes from the dam and water sumps.

The sand dams are sources of drinking water for the locals and also used for small scale irrigation.

4.1 Recommendations

The major challenge facing sand dams as sources of drinking water was noted to be contamination with E.Coli; the feacal coliforms presence indicator. This was possibly due to contamination from human activities described above. The methods of water abstraction were also observed to be playing a greater role in contamination of the water. It is therefore recommended that the water is treated before drinking to avoid outbreaks of water borne diseases.

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