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# Tracking Water Quality from Source to Home*:* A showed Case of *Elgorashi* Locality, Gezira State, Sudan

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**ABSTRACT**

**Water quality is recognized one of the greatest challenges to human life because water may become unsafe at any point between collection and consumption. This study was conducted in Elgorashi locality, Gezira State Sudan to investigate water sources physically and biologically. A number of 70 water samples were taken from various sources which include; irrigation canals, Haffir, Haffir Exit Basin (HEB), Slow Sand Filters (SSF), Clean Water Basin (CLB), homes taps and homes storage containers. The samples were collected from Elgorashi city, Galoka, Geneda, Maatoug and Hillat Babiker villages. The results were compared to WHO risk category. Statistical results revealed that physically, 86% of water sources were suitable for human consumption. Biological analysis showed 73% of water sources were polluted with bacteria. It has been found that (19/70) 27.14% of all water sources were safe, (28/70) 40% at low-risk, (14/70) 20% at intermediate risk and (9/70) 12.86% were at high risk. A long the water supply network, the main water sources of irrigation canals and Haffirs were unsafe. At home level, 70% of taps water were classified under low risk category and 55% of storage containers showed high risk sources. These results indicate leakage at the water distribution network. The study recommends immediate disinfection intervention at all sources to protect community from illness associated with poor water quality.**

KEYWORDS *Domestic water supply, Water quality, from source to home, Gezira state, Sudan*

## 1. INTRODUCTION

Although Sudan gives first priority to satisfaction of basic human needs for water, a greater percentage of population are without access to safe drinking water. Safe and accessible drinking water supply is one of the Sustainable Development Goals (SDGs) that we are only nine years far to achieve from now. However, quality of water is considered one of the world's major challenges, particularly in low income countries under recent situation of COVID-19, pandemics. Approximately 13.5% prevalence of diarrheal diseases in Sudan was recorded where people draw water from uncertified Hafirs [2]. Water quality is recognized as one of the greatest threats to human health [3] because poor water quality can negatively impact our overall life. In addition, the existing water sources are devoid of treatment. Even in developed regions, drinking water quality has been threatened by human activities and environmental changes [4]. Unsafe water and poor sanitation and hygiene have been reported to rank third among the leading risk factors for health burden in developing countries, including Sudan [2].

Most of population in Sudan are rural using surface water sources which are unprotected and susceptible to external contamination from surface runoff, human and animal faecal pollution and unsanitary collection methods [5]. Studies in the Sudan have clearly demonstrated the close association of the biological contamination of drinking water [6]. Recent statistics showed that, more than 20% of the Sudan populations are still drinking from unimproved water sources and 25% are using poor quality drinking water transported from unprotected sources (Haffirs) by donkey carts and tankers.In Gezira, more than 70% of populations in the villages are infected by waterborne diseases mainly because of the polluted irrigation canal water for their domestic water needs [7]. Great part of the community still using unimproved sources of water and traditionally carry water from source to homes [8]. Even if water was collected from a good microbial quality source, it may become contaminated during household's storage [9]. Even protected water sources can be deteriorated due to unhygienic management of facilities [10] and water may become unsafe at any point between collection and use [11].

Elgorashi community always claims that they use poor water quality however, the exact quality of water is not yet investigated and the location of the problem at the water distribution network is not well identified. Therefore, this research has been designed to track water quality from source to home at the Elgorashi locality in the Gezira state. The main objective of the present study is to investigate water quality physically and biologically in Elgorashi locality, Gezira State, and to categorize the water sources accordingly.

## 2. STUDY AREA

The study was conducted at Elgorashi locality, Gezira state, Sudan. Elgorashi is elevated 402 m above the mean sea level and located between latitude 14 °25¯ N and longitude 32° 78¯. E ((Figure 1). The rainy season in Gezira extends from June through December and the dry season from January through May. The mean annual maximum temperature ranges from 30°Cto 43°C, and the minimum temperature ranges from 11°C to 27°C. The soil of Elgorashi is part of Gezira clay. The total population of the locality are 460 thousand people according to (Sudan population census 2013). More than 90% of the population are practicing agriculture as main economic activity. The study covered Elgorashi city and Galoka, Geneda, Hilla Babiker, and Maatoug villages. In El Ghorashi locality, surface water source constitutes 58% and groundwater resources constitutes 42% of the total water resources. The main sources of domestic water in Elgorashilocality are irrigation canals of Gezira scheme, water harvesting structures (Haffirs), SSFs, Clean Water Basin (CLB), Haffir Exit Basin (HEB) and taps and storage containers at home level.

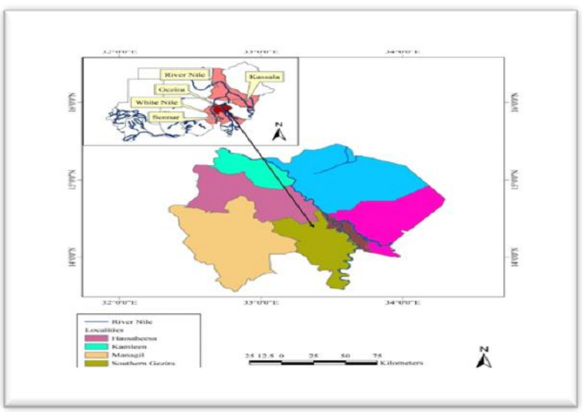


**Figure.1 Location of El Ghorashi locality, Gezira state, Sudan**

## 3. WATER SOURCES AND DISTRIBUTION NETWORK IN ELGORASHILOCALITY

Irrigation canal used to transfer raw water to Haffirs. Haffir is the main water source used to store water from the irrigation canal and then through the HEB to SSF and or to CLB. CLB used to store clean water (treated water). HEB is the basin built outside Haffir and linked with it via pipelines. It used to transfer water to slow sand filters, and sometimes to the distribution network if SSF is not existed. Zeer is a traditional clay pot used to store drinking water at home level. Plastic containers (Jerrcans) also used to store water at home. Taps are used to carry water from the distribution network to homes. Sometimes water stored at home was taken directly from irrigation canal and from Haffir (Figure 2).

## 4. DATA COLLECTION

Water samples were collected during autumn season of August and September, 2019 where minimum and maximum temperatures were 26°C and 39°C respectively. A total number of 70 water samples were collected from different water sources of irrigation canals, Haffirs, SSFs, CEBs, HEBs, home taps and home storage containers.

The samples were collected from Ghorashi city, Galoka, Geneda, Maatoug and Hilla Babiker villages. Home taps and storage containers were selected along the distribution networks system. Water samples were collected by using sterilized bottles. For taps samples; water was allowed to run at least three minutes to wash any contaminants in the pipe, then flame is used to sterilized the air around the tap and the bottle was then filled with water and closed immediately and then the sample clearly labeled with date and time of collection.

For samples taken from CLBs, SSF, HEBs and storage containers, samples were taken using sterilized beaker cup. Samples from irrigation canals and Haffir were taken using sterilized bottles which totally submerged in water, filled with water and closed below the water surface to ensure that the bottles were filled without any air. All samples were put at a cooler and ice packs to store them before taking to the laboratory. Table 1 showed the number of samples taken from water sources from each town/village.

## 5. METHOD OF ANALYSIS

The analysis of water samples includes physical analysis which indicted by temperature, pH, turbidity, taste, odour and appearance, and biological analysis which indicated by coliform bacteria. The analysis of water samples was done at the laboratories of Managil City Health Center (MCHC) and Elbasha laboratory. The material used for physical analysis include a pH meter, a thermometer and a terbiditmeter (nephleometer). The microbiological analysis was done by using Membrane Filter Technique (MFT). A measured volume of water sample was drawn through MF under vacuum. Bacteria was retained on the surface of the membrane which placed on a membrane sulphate broth (MLSB) medium in a sterile container and incubated for 18-24 hours at 37°C for culturing. The bacterial results were then reported as the number of colonies per 100 ml of water. Then the reading values were compared with WHO and Sudan guidelines (Table 3) of Water Quality. Table 2 illustrates the biological standard adopted by WHO and SSMO [12]. Table 3 illustrates the physical standard. The biological results of water samples were read against WHO health risk category (Table 2) and water sources in Elgorashi were categorized accordingly .

**Table.2 Health risk categories based on WHO guidelines**

| Health risk category | Total coliform cfu /100 ml |
|---|---|
| Conformity | Less than 1 |
| Low | 1 – 10 |
| Intermediate | 10 – 100 |
| High | 100 -1000 |
| Very high | greater than 1000 |

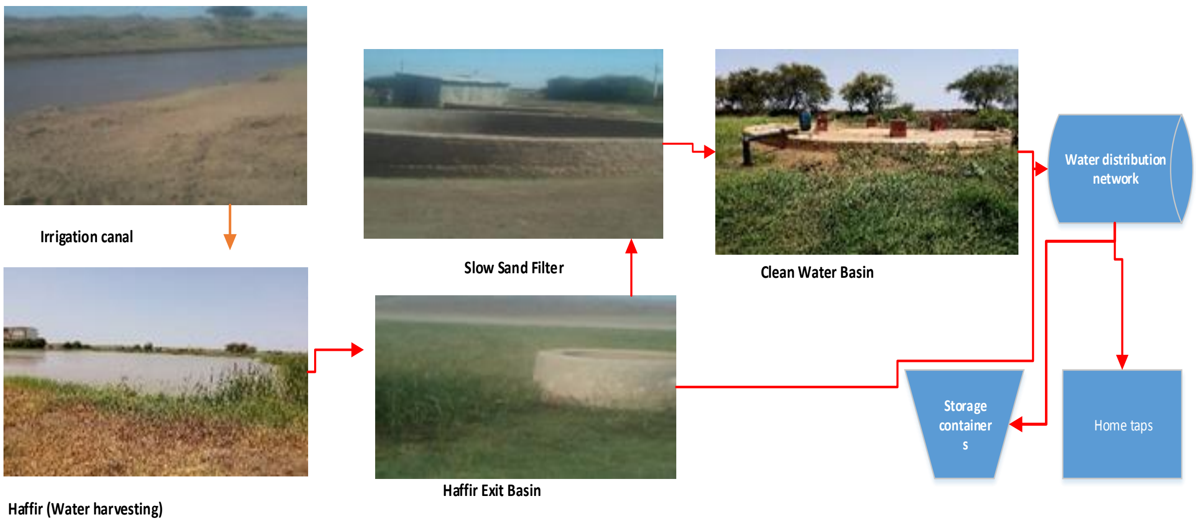


**Figure.2 Water sources and distribution network in Elgorashi locality**

**Table.1 Samples collected from the different water sources**

| Water Source | *El Ghorashi* | *Galoka* | *Geneda* | *Maatoug* | *Hilla Babiker* | Total |
|---|---|---|---|---|---|---|
| Irrigation Canal | 1 | 1 | 1 | 1 | 1 | 5 |
| Haffir | 1 | 1 | 1 | 1 | 1 | 5 |
| Haffir Exit Basin (HEB) | 1 | na | na | 2 | na | 3 |
| Slow Sand Filter (SSF) | Na | 1 | 1 | na | 1 | 3 |
| Clean Basin (CLB) | 1 | 1 | 1 | na | 1 | 4 |
| Home taps | 5 | 5 | 5 | 5 | 5 | 25 |
| Home storage containers | 5 | 5 | 5 | 5 | 5 | 25 |
| **Total** | **14** | **14** | **14** | **14** | **14** | **70** |

***na****= not available*

**Table.3 WHO, and SSMO standards for water quality**

| Parameter | Unit | Who Guideline Value | SSMO Guidelines Value |
|---|---|---|---|
| Ph | | - | 6.5-8.5 |
| Taste and odor | | Un objectionable | Acceptable |
| TDS | mg/l | no guidelines value | 1000 |
| Temperature | | no guidelines value | Acceptable |
| Total coliform and E.coli (no/100 ml) | | Absent | Must not be detectable in any 100 ml sample |
| Turbidity | NTU | Less than 5 acceptable to consumers, less than 1 effective disinfection | 5 |
| Parameter | Unit | Who Guideline Value | SSMO Guidelines Value |

***Source****: WHO guidelines for drinking water quali*

## 6. RESULTS

### A. Physical Parameters of Water Sources

Turbidity, pH and temperature were tested in-situ to indicate physical quality of water. It has been found that 86% of collected water samples were physically suitable for human consumption while the remaining 14% of samples were out of the turbidity acceptable range of WHO and SSMO. Table 4, showed that the mean pH values for all water sources was ranged between 7.5 to 7.7. Irrigation canals registered the highest value and CLB registered the lowest value of pH. All pH values of water sources were found within the standards of SSMO, 2002 of 6.5 to 8.5. The mean temperature of water samples found between 200C to 230C. Home taps water registered the highest value and irrigation canals water registered the lowest one. Temperature values falls within the acceptable limits of SSMO, 2002. It has been found that the mean turbidity of water samples ranges between 4.6 to 550 NTU. Irrigation canals having the highest value and HEBs having the lowest value of turbidity which indicate that for all water sources excluding HEB, turbidity was higher than the limit of 5 NTU of SSMO and WHO. The other physical parameters such as; taste, odour, and appearance were tested by sense, and found within the acceptable level according to SSMO and WHO standards

**Table.4 Physical parameters of water sources**

| Water Source | PH Mean | PH Min | PH Max | Temp Mean | Temp Min | Temp Max | Turbidity Min | Turbidity Max | Turbidity Mean |
|---|---|---|---|---|---|---|---|---|---|
| Channel (no=5) | 7.7 | 7.7 | 7.7 | 20 | 20 | 20 | 550 | 550 | 550 |
| Haffir (no=5) | 7.6 | 7.5 | 7.7 | 21 | 20 | 22 | 10 | 150 | 38.7 |
| HEB (no=3) | 7.6 | 7.6 | 7.6 | 22 | 21 | 23 | 4.5 | 4.7 | 4.6 |
| S.S. filter (no=3) | 7.6 | 7.5 | 7.7 | 22 | 21 | 23 | 10 | 130 | 36.1 |
| Cl. basin (no=4) | 7.5 | 7.5 | 7.5 | 21 | 20 | 22 | 4.5 | 15.3 | 8.3 |
| Home taps (no=25) | 7.6 | 7.5 | 7.7 | 23 | 22 | 24 | 3.5 | 10.8 | 6.1 |
| Home storage (no=25) | 7.6 | 7.5 | 7.7 | 21 | 20 | 22 | 4.5 | 10.2 | 6.8 |

### B. Biological Quality of Water Sources

Results showed that 51(73%) of water samples registered positive coliform bacteria (figure 3). The results indicate that irrigation canals and SSFs sources were fully polluted with bacteria. The results showed that 80% of the Haffirs water were contaminated with coliforms. Generally, 75% of CLBs were contaminated with coliforms and this might be due to inadequate treatment and disinfection procedure. This indicates the deficiency of collection system due to the potential of environment contamination as confirmed by WHO, (2011).

The results showed that 92% of the home taps were contaminated with coliforms which indicate leakages in the distribution network system. The results found that about half of the home storage containers (Zeers and plastic containers) were contaminated with coliforms. Drinking water of poor rural communities, even if it is obtained from safe source, it may be contaminated during storage in the house under non hygienic and non-sanitary conditions [13]. Factors contributing to greater risks of microbial contamination of stored water are higher temperature, increased storage times, higher levels of airborne particulates (dust storms) and inadequate handwashing [14].

The results show that the highest level of contamination with coliforms of water sources was observed at irrigation canal and SSF, followed by home taps, then Haffir water, followed by CLB, and homes storage containers, and HEB source which contained least contamination (Figure 3).

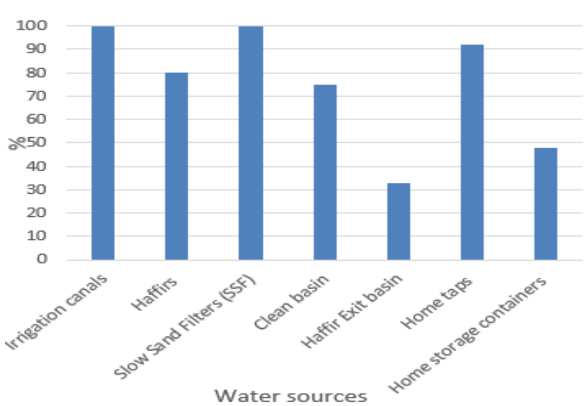


**Figure.3 Percent of positive samples**

### C. Biological risk category of water sources

The biological results were compared with WHO water risk category. The results revealed that (19/70) 27.14% of all water sources were safe, (28/70) 40% at low risk, (14/70) 20% at intermediate risk and (9/70) 12.86 % were at high risk (Figure 4). It has been investigated that the all canals water and 80% of Haffirs water were unsafe. The result showed significant relation between the high turbid sources of canals and Haffirs and the presence of coliform bacteria. It has been analyzed that 67% of SSF waters were at intermediate risk. The results illustrated that 75% of clean water basins were at low risk and 25% safe. These types of basins were well covered and protected from surrounding pollutants. Home taps water constitutes major indicator of the quality of water at homes. Analysis illustrated that only 8% of home taps water were safe, 72% at low risk, and 20% were at intermediate risk category. The study found that 52% of the home storage containers were safe, 24% at low risk and 24% were at intermediate risk.

Water quality in the locality cities and villages illustrated in figure 5. The results showed that 43% of water sources in Maatoug were safe, 50% of sources in Hillat Babiker were at intermediate risk, 65% and 58% of sources in Galoka and Geneda were at low risk respectively. A long the water distribution network from the sources to home, the irrigation canals and Haffirs were more polluted. Intermediate and low risks categories at home level indicate leakages at the water distribution network.

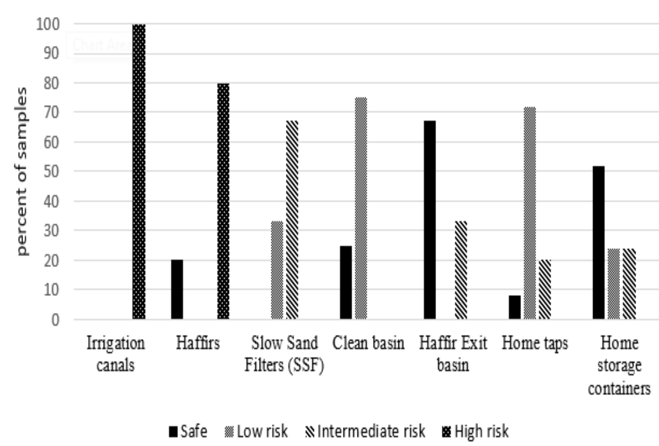


**Figure.4 Water sources categorization in Elgorashi locality**

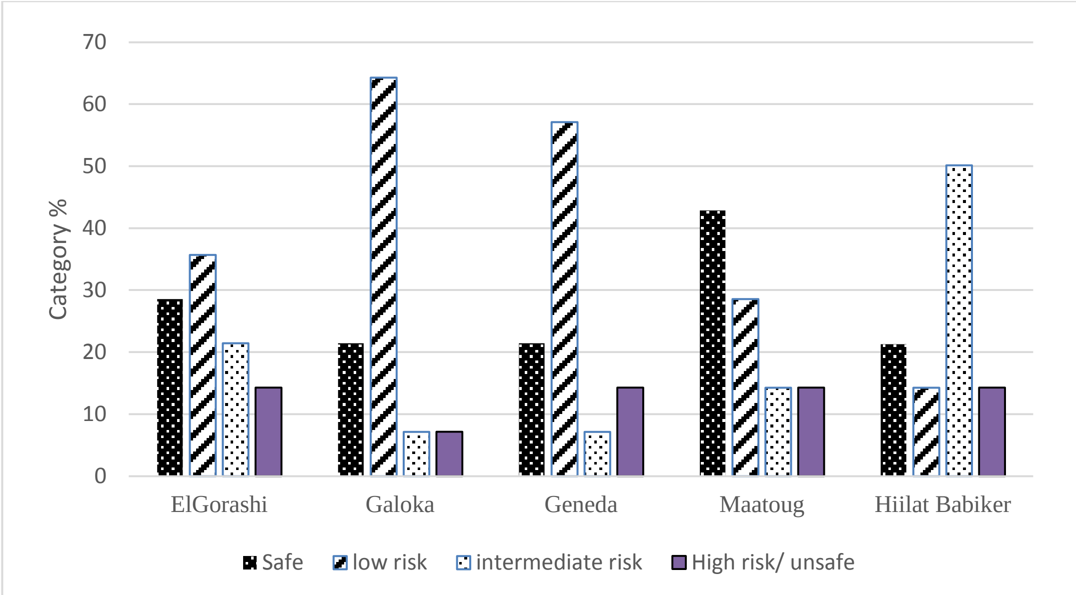


**Figure.5 Water sources risk categories per towns/villages in Elgorashi locality**

## 7. DISCUSSION

The water sources of Elgorashi locality was physically fits the human consumption because PH and temperature values falls within the acceptable limits of SSMO, 2002. The result is in line with Edberg, et: al, [15] who concluded that the survival of microorganisms such as bacteria in water environment depends on the present of nutrients and the water temperature. In spite of the turbid time the study was conducted (rainy season of August and September), the turbidity values of water sources were found within the WHO and SSMO standards. Turbidity is good indicator to physical quality of water. The physical quality of drinking water can be measured by its turbidity level; high turbidity can result in increased microbiological contamination [16].

The main water sources of irrigation canals and Haffirs showed full contamination because of Gezira scheme land use practices (fertilizers, pesticides, livestock). These sources are open and exposure to continuous turbidity. The more turbid sources are the most microbiologically contaminated [17]. Haffirs were designed to directly takes raw water from canals which were highly contaminated with coliforms. The SSF sources showed pollution of bacteria. SSF filled from Irrigation canals and or from Harrirs water harvesting. SSFs depends on the fluctuations of the water level of canals and Haffirs however, SSFs were disinfected continuously. SSFs were disinfected and this is why it gave negative bacteria test. These results are in agreement with Eltigani et, al; who mentioned that greater qualitative efforts were needed to make water source safe to use in Gezira [18].

Greater amount of home taps water in Elgorashi locality showed coliforms bacteria which indicate leakages in the distribution network system. This result is against [19] Sarra et. al, who assessed the drinking water quality of Kosti City in Sudan and found that most of the home taps water were suitable for human consumption. This disagreement because at Elgorashi some storage containers were filled directly from irrigation canals and Haffirs. Elgorashi locality is pre-urban area with old and poor water distribution network compared with Kosti city which is the capital of the White Nile State. Fortunately, no unsafe water at home level, however the percentage of 72% low risk is an alarming category under poor community setting.

The results found that about half of the home storage containers (Zeers and plastic containers) were contaminated with coliforms. It has been observed that the home storage containers were not clean. Intrusion of contamination to storage containers may be via contact with hands because of poor sanitary culture of the community. Drinking water of poor rural communities, even if it is obtained from safe source, it may be contaminated during storage in the house under non hygienic and non-sanitary conditions[13]. Black et al, concluded that factors contributing to greater risks of microbial contamination of stored water are increased storage times, higher levels of airborne particulates (dust storms) and inadequate handwashing [1]. [8, 20] both of them concluded that even if water was collected from a good microbial quality it may be contaminated again during household storage. The result of Elgorashi case is in agreement with [20] and [21], who found that the highest level of household water contamination found in stored water. The plastic vessel which used to store water at household use in Venda, South Africa have higher levels of coliform bacteria over time [22]. The locality water corporation is spending great efforts to supply safe water to the community but unfortunately safe water will not be available from all sources at all time. It has been observed that there are many problems and obstacles in Elgorashi locality to supply safe water continuously. These problems are; the water sources are not well protected from animals and other pollutants, some of the water sources not well covered and there is no regular maintenance. Some sources were poorly located and exposed to direct waste water of rainfall run off. Rainfall can greatly increase the levels of microbial contamination in source waters, and waterborne outbreaks often occur following rainfall [23].

The study recommends immediate disinfection intervention at all sources to protect community from illness associated with poor water quality. Direct use of water from irrigation canals, Haffirs, and slow sand filters should be avoided. Slow sand filters and Haffirs should be well fenced and protected from different pollutants. The land near clean water basins should be sloped in the opposite direction to take polluted runoff water away. Leakages in the distribution networks system should be maintained and water storage containers should have kept clean.

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