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Assessment of Drinking water Quality in El-Obeid City North Kordofan State, Sudan.

Loaey Emad Eldeen Abdalla Mohmed[1], Somia Ali Mohammed Ibrahim[2]

[1]Deparment of Environmental Health, Faculty of Public and Environmental Health, University of Kordofan.
[2]Deparment of Environmental Health, Faculty of Public Health, Al-Zaiem Al-Azhari University.

Abstract:
Background and Objective: Access to safe drinking-water is essential to health as water can become unsafe at any point between collection and consumption, this study aimed to assess the physicochemical and bacteriological quality of drinking water in El-Obeid City, North Kordofan State, Sudan (2022 – 2025). **Materials and Methods:** A descriptive cross-sectional study was conducted. Sample size determined according to World Health Organization (WHO) guidelines for water sampling measurement. The samples were distributed across three sources: households (20), animal carts (12), and pump/wells (8). water samples were collected and analyzed for parameters including (PH – Nitrite-Fluoride - Hardness – Calcium - Magnesium – Residual free chlorine and Total Dissolved Solids) and the presence of coliform bacteria Escherichia coli (E. coli). **Results:** The findings showed that 72.5% of water samples were contaminated with Escherichia coli, with the highest contamination from animal carts (83%), followed by households (70%), and pump/wells (62.5%). **Conclusion:** The findings emphasize the need for improved water treatment and targeted interventions to ensure safe drinking water and mitigate waterborne disease risks.

Correspondence to: Loaey Emad Eldeen Abdalla Mohmed loaeyemad@gmail.com

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Introduction:

Water is the basis of life and the central element of ecological balance [1]. Access to safe drinking-water is essential to health, basic human right. The importance of water, sanitation, and hygiene for health and development has been reflected in the outcomes of a series of international policy forums [2]. Much of the ill health that affects humanity, especially in developing countries, can be traced to a lack of safe and wholesome water supply. [3]. Recent studies in Africa and South America have shown that drinking water has been contaminated with Escherichia coli, Enterococcus, and various other bacteria. Fecal contamination of drinking water has been a major issue due to inadequate sanitation infrastructure [4]. Housing area contaminates groundwater through improper storage and disposal of household wastes into landfills, dump sites, latrines and grave yards where they decay and are moved into aquifers by rainwater [5]. Sanitation coverage has stagnated with more than 10.5 million people practice open defecation [6]. in the rural areas of the developing countries the great majority of water quality problems are related to bacteriological contamination [7].

In Sudan, there are different sources for drinking water supply, surface water from rivers and streams (mainly the River Nile) rain water and ground water. Federal Ministry of Health reported in 2011 the microbiological contamination levels were found to be 10.3 % in Mogran water as to Buri 21.6% while in 2014, 15.3% contamination in Mogran and 44.7% in Buri [8]. [9]. Even though water resources are available in Sudan, some parts of the country still continue to face significant water provision challenges [10]. Microbiological contaminates such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations and wildlife [11]. To assess microbial water quality, verification typically relies on analyzing faecal indicator microorganisms, with Escherichia coli or thermotolerant coliforms as the preferred

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organisms. The presence of Escherichia coli indicates recent faecal contamination and is unacceptable in drinking water [12].

Materials and Methods:

Study Design:

A descriptive cross-sectional study was carried out for assessment of the bacteriological quality of drinking water in El-Obeid City, North Kordofan State, Sudan (2022 – 2024).

Study Area:

El-Obeid city, the capital of North Kordofan State in Sudan, is located between latitudes 11° and 13° North and longitudes 30° and 90° East, with an average altitude of 650 meters (approximately 2,133 feet) above sea level. It encompasses an area of approximately 81 square kilometers and lies about 588 kilometers (365 miles) southwest of Khartoum. El-Obeid sources its drinking water from two main origins; surface water and groundwater. Surface water, located approximately 30 kilometers south of the city, includes three reservoirs and nine hafirs (Natural depressions). Water from these sources is collected from heavy rains in hafirs across a large area and then transported to the water treatment plant in El-Obeid to prevent pollution, as well as undesirable taste and smell. Khor Bagara, situated in the Wad El-Baga area, is also located 30 kilometers south of El-Obeid, with water conveyed through three pipelines: two iron pipelines approximately 10 inches in diameter and another pipeline about 12 inches in diameter made of asbestos for the stations of Elaine, located 22 kilometers south, and Banoh, 11 kilometers south of El-Obeid. Currently, surface water in El-Obeid city is inaccessible. Groundwater is found in northern El-Obeid, which is almost 50 kilometers away, but it is not available for access during the study time [13].

Sampling and Sample Techniques:

Sample size:

The sample size was selected according to (WHO) guidelines for water sampling measurement, which recommend taking one sample per 10,000 population, plus 10 additional samples [14]. Whereas calculated the sample size base on the number of population (300681) in El-Obeid city was division on 10.000 of population plus 10 additional samples and was taken the total number of samples.

Study population:

300681 division on 10,000 equals 30 and plus 10 additional samples equals 40.

Sample size:

30 samples + 10 additional samples.
Accordingly, a sample of 40 samples was obtained.

Sampling Techniques:

This was done according to the standard methods for the examination of Water and waste water American Public Health Association (APHA) Standard Techniques, were followed [15]. Methods analysis of samples by using laboratory protocols in ministry of water, all water samples were analyzed according to standard methods for water examination, and detection limit according to ministry of water.

Procedures:

For purposes of study; El-Obeid City was divided into four equal quarters (clusters). The different types of blocks are considered as cluster where 10 samples were selected from each quarter of El-Obeid City using a method of simple random sampling. Drinking water samples were taken from houses, animal carts (Karo), and pump/wells. Sampling was conducted equally across all quarters, with (5) samples from houses, (3) samples from animal carts (Karo), and (2) samples from pump wells. Hence, the total number of samples selected is (40) from all blocks. Table (1) shows sample distribution.

Table 1 ***Distribution the sample size according to clusters, El-Obeid City.***

Clusters	Numbers of sample

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Eastern	10
Western	10
Northern	10
Southern	10
Total	40

After sample size determined from each cluster, samples acquired has been distributed over blocks and a simple random sample technique was used to select sample units. Table (2) shows the final sample size.

Table 2 ***Sample size acquired from different sources, El-Obeid City.***

Source of samples	Number of samples
Houses	20
Animals' carts	12
Wells/Pumps	8
Total	40

Instrumentation:
Laboratory analysis was conducted using standard procedures, as illustrated the following [16].

- The samples were taken in 200 ml tubes analyzed for bacteriological (e.g., E. coli).
- Both Membrane Filtration (MF) technique and the multiple tube methods for water quality analysis was used to investigate the samples of water collected from the sources, transportation and storing vessels.
- Required; (Sterile filtration unit, sterile grid membrane filters, sterile 47 mm diameter cellulose pads, and sterile Petri dishes 50–60 mm diameter.

Steps in the membrane filter technique to E. coli examination:

1. Add an absorbent pad to a sterile Petri dish for the number of samples to be processed. A sterile pad was placed in the Petri dishes with sterile forceps.
2. Soak the pad in nutrient medium, which is dispensed with a sterile pipette. A slight excess of medium (e.g., about 2.5 ml) should be added.
3. Carefully remove a sterile membrane filter from the packet, holding it only by its edge.
4. Place the membrane filter in the filtration apparatus, and clamp it in place
5. Add sample to filtration apparatus.
6. Apply the motor to the suction flask.
7. Dismantle the filtration apparatus and remove the membrane filter using the sterile forceps, taking care to touch only the edge of the filter.
8. Remove the lip of a previously prepared Petri dish and place the membrane grid side uppermost into the pad (agar). Lower the membrane, starting at one edge, in order to avoid trapping air bubbles.
9. Label the Petri dish with the sample number. The sample volume should be also recorded.
10. Put the Petri dish inside the incubate immediately, and the membrane is going to be incubated at 44 or 44.5 °C, the bacteria on it may first require time to acclimatise to the nature media.
11. After 24 hours of full incubation evidence result for E. coli per 100 ml of sample.

Confirmatory test for E. coli examination:
For the examination of raw or partly treated waters, presumptive results may be adequate; however, in certain circumstances, it is important to perform conformity tests on pure subcultures. To confirm E. coli membranes, whether incubated at 35, 37, or 44°C, each colony (or a representative number of colonies) is subcultured into a tube of lactose peptone water and a tube of tryptone water. The tubes are incubated at 44°C for 24 hours. Confirmation of E. coli requires the addition of 0.2 - 0.3 ml of Kovacs reagent to each tryptone water culture. The production of a red colour indicates the

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synthesis of indole from tryptophan and confirms the presence of E. coli.

Statistical Analysis:

After taking samples and tested, data were processed and analyzed by the computer software; Statistical Package for Social Sciences (SPSS), Microsoft Excel and Master Sheet. It displayed or presented in tables and figures.

Ethical Consideration:

To obtain permission to conduct the study is very important for data collection. The researcher will contact and receive approval from the appropriate management authority and will take.

Results:

The study showed that about more than half (72.5%) of samples of drinking water from all sources were containing faecal- E. coli, (Figure 2). Whereas samples were taken from house, animals cart and wells/pump were contained E. coli in 100 - ml of samples; (70%), (83%) and (62.5%); respectively. Figure (3) and Table (1) reveal that the positive tests founding in eastern cluster; house (50%), animals cart (30%) and wells/pump (20%). Only (20%) of samples had contained faecal E. coli in western cluster. As contamination founding in northern cluster; house (80%), animals cart (20%) and wells/pump (10%). In southern cluster the positive test discovered in house (10%), animals cart (30%) and wells/pump (20%).

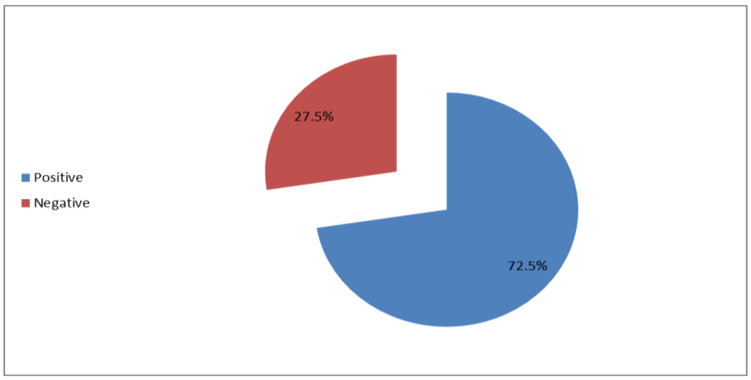

Figure 1 ***The distribution of faecal E. coli among drinking water samples in El-Obeid City. n=40***

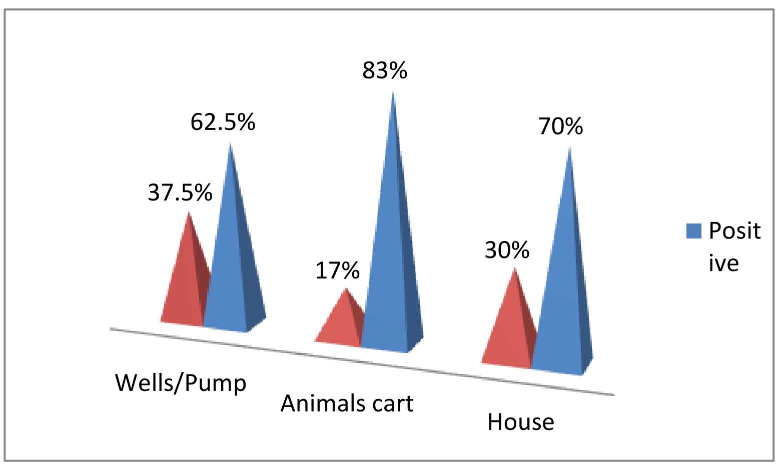

Figure 2 ***The distribution of faecal E. coli according to secondary sources, El-Obeid City.***

Table 3 ***The distribution of total samples according to contaminated with faecal E. coli in different clusters, El-Obeid City.***

Clusters/sources	House	Animals cart	Wells/Pump	Total

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Eastern clusters	Positive	5	50%	3	30%	2	20%	10/25%
Western cluster	Positive	0	0%	2	20%	0	0%	2/5%
	Negative	5	50%	1	10%	2	20%	8/20%
Northern cluster	Positive	4	80%	2	20%	1	10%	7/17.5%
	Negative	1	10%	1	10%	1	10%	3/7.5%
Southern cluster	Positive	5	50%	3	30%	2	20%	10/25%
Total		20	50%	12	30%	8	20%	40

Table 4 ***The Means statistics tested for compare differences across water sources of faecal E. coli and fluoride in drinking water samples, El-Obeid City.***

F/SSMO* - F/WHO*		**E. coli - House**	**E. coli - Wells/Pump**	**E. coli - Animals cart**
Standard	N	-	1/2.5%	1/2.5%
	Mean	-	1.0000	1.0000
	Std. Deviation	-	0.0	0.0
Less than standard	N	19/47.5%	6/15%	7/17.5%
	Mean	1.3158	1.3333	1.1429
	Std. Deviation	0.47757	0.51640	0.37796
Above standard	N	1/2.5%	1/2.5%	4/10%
	Mean	1.0000	2.0000	1.2500
	Std. Deviation	0.0	0.0	0.50000
Total	N	20/50%	8/20%	12/30%
	Mean	1.3000	1.3750	1.1667
	Std. Deviation	0.47016	0.51755	0.38925

**N=Number of samples, *SSMO: Sudanese Standard Measurements Organization and *WHO: World Health Organization.*

Table 5 ***The means statistics tested for compare differences across water sources of faecal E. coli and Total dissolved solids in drinking water samples, El-Obeid City.***

TDS/SSMO - TDS/WHO		**E. coli - House**	**E. coli - Animals cart**	**E. coli - Wells/Pump**
Less than standard	N	12/30%	4/10%	1/2.5%
	Mean	1.4167	1.2500	1.0000
	Std. Deviation	0.51493	0.50000	0.0
Above standard	N	8/20%	8/20%	7/17.5%
	Mean	1.1250	1.1250	1.4286
	Std. Deviation	0.35355	0.35355	0.53452
Total	N	20/50%	12/30%	8/20%
	Mean	1.3000	1.1667	1.3750
	Std. Deviation	0.47016	0.38925	0.51755

Discussion:

The present study demonstrated that 72.5% of drinking water samples collected from all sources were contaminated with fecal *Escherichia coli*, indicating substantial microbiological pollution. This prevalence is higher than that reported in previous studies conducted in El-Obeid city, Sudan, where contamination rates of 57% [17] and

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51.4% [18] were documented. Comparable findings have been reported in neighboring regions; for example, a study in the Eastern Zone of Tigray, Ethiopia, identified *E. coli* as the predominant contaminant in 62.4% of water samples [19]. In contrast, considerably lower contamination levels (18%) were reported in the Arida mountainous region [20], reflecting geographic variability in water safety.

International guidelines emphasize that drinking water should be free from pathogenic microorganisms and indicators of fecal contamination [3]. The high proportion of *E. coli* detected in the present study therefore represents a significant public health concern. Similar contamination patterns have been observed in other low-resource settings. A study conducted in Lesotho reported the presence of total coliforms and *E. coli* in 97% and 71% of drinking water samples, respectively [21], while research from Jepara Regency found *E. coli* contamination in 72.7% of samples [22]. Moreover, an earlier investigation in El-Obeid city reported universal *E. coli* contamination across all sampled sources, with the highest levels observed in hafirs, gerabs, and household storage containers throughout different seasons [23].

Conversely, the contamination rate observed in the present study is lower than that reported in certain regions. In Nepal (Kathmandu Valley), widespread bacterial contamination was identified, with 94% of water sources testing positive for total or fecal coliforms [23]. Similarly, a study in Northern Nigeria documented *E. coli* contamination in 100% of drinking water samples, indicating severe microbiological deterioration of groundwater sources [24].

Analysis by water source revealed that *E. coli* contamination was present in 72% of household samples, 83% of animal cart (karo) samples, and 62.5% of well/pump samples. These findings exceed those reported in a previous El-Obeid study conducted in 2017, which documented contamination rates of 62% in household samples, 52% in tankers and gerbas, and 81% in animal cart samples [17]. Another study from the same city reported contamination rates of 59.3%, 27.3%, 72%, 44.9%, and 52% in samples from households, tankers, animal carts, gerbas, and wells/pumps, respectively [18]. The consistently high contamination levels across studies highlight persistent challenges in water handling, storage, and distribution systems within the region.

Conclusion:

Based on cluster analysis and comparison with national (SSMO) and international (WHO) drinking water standards, this study evaluated the physicochemical and bacteriological quality of water samples collected from households, animal carts (karo), and wells/pumps in El-Obeid city. Although most physicochemical parameters were within acceptable limits, bacteriological quality was notably poor, with widespread *E. coli* contamination across all water sources. These findings underscore the urgent need for improved water treatment, safer distribution practices, and enhanced public health interventions to reduce fecal contamination and associated health risks.

Recommendations:

The findings of this study highlight an urgent need for comprehensive and targeted interventions to improve the microbiological quality of drinking water in the study area. The following measures are strongly recommended:

- Strengthening chlorination practices by ensuring effective and consistent chlorination at central water collection, treatment, and storage points.
- Maintaining adequate residual chlorine concentrations throughout the entire water distribution system to prevent microbial recontamination before water reaches households.
- Routine monitoring and control of physicochemical parameters in water treatment plants to ensure continuous compliance with national and international drinking water standards, thereby safeguarding public health.
- Implementation of community-based water safety programs to enhance public awareness of safe water handling, storage, and hygiene practices, and to reduce contamination risks at the household level.

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