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A COMPARATIVE ANALYSIS OF RAW AND TREATED NILE WATER QUALITY AT AL-MANARA WATER STATION, OMDURMAN, SUDAN

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ABSTRACT----------

*The River Nile is a vital water source for Sudan, but it is increasingly polluted. This study evaluated the physicochemical and bacteriological quality of Nile water at the Al-Manara treatment station in Omdurman. Samples were collected before (Sample A) and after (Sample B) treatment and tested for key factors including pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), turbidity, hardness, alkalinity, chloride, ammonia, nitrate, phosphate, major ions, and microbial counts (Total Coliform and E. coli). Results were compared to World Health Organization (WHO) and Sudanese Standards and Metrology Organization (SSMO) guidelines. A paired-sample t-test was used to compare means before and after treatment. The results showed that while most physicochemical parameters (pH, EC, TDS, hardness, major ions, nutrients) for both raw and treated water met acceptable limits, the raw water had dangerously high turbidity (31.9 NTU) and significant microbial contamination (Total Coliform: 2382 CFU/100ml; E. coli: 20 CFU/100ml). The treatment was highly effective, significantly lowering turbidity to 0.96 NTU ($p < 0.05$) and completely removing detectable coliform and *E. coli* bacteria ($p < 0.05$). The study concludes that treatment at the Al-Manara station effectively produces safe drinking water but highlights the serious pollution in the raw water source, requiring ongoing monitoring and protection measures.----------*

1. INTRODUCTION

Water is an essential natural resource, crucial for life and economic development. However, global water sources are under heavy pressure from population growth, industrial activity, and pollution (Chad, 2000). Contaminated water spreads diseases, causing millions of deaths each year, especially in developing countries (WHO, 2004).

Sudan, primarily an arid region, relies heavily on the Nile River for its water supply. Rapid urbanization, industrial discharge, and agricultural runoff have worsened the Nile's water quality (El-Monyiemy et al., 2021). This directly threatens public health, particularly when water treatment is insufficient.

Water quality relies on its physicochemical and biological traits. Factors like pH, turbidity, and nutrient levels reflect the water's chemical condition, while the presence of indicator bacteria such as *Escherichia coli (E. coli)* points to fecal contamination and the potential for waterborne pathogens (Ashbolt, 2004). Effective water treatment and sanitation management are therefore crucial to reducing these health risks (Qasim et al., 2000).

This study focuses on the Al-Manara water treatment station in Omdurman, a key part of Sudan's capital. The goal was to evaluate the effectiveness of the treatment process by comparing the quality of raw Nile water (inlet) with treated water (outlet) against international (WHO, 2005) and national (SSMO, 2008) standards, providing insights into both source water pollution and treatment performance.

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2. MATERIALS AND METHODS

2.1. Study Area and Sample Collection

The study was carried out at the Al-Manara water treatment station in the Al-Manara area of Omdurman, Sudan. A single set of paired samples was collected: one from the raw water intake (Sample A) and one from the treated water outlet (Sample B). Samples were gathered in sterile plastic bottles, pre-rinsed with the sample water. They were quickly transported to the lab on ice and analyzed for physicochemical and microbiological parameters within 24 hours.

2.2. Physicochemical Analysis

Standard methods outlined by the American Public Health Association (APHA) were followed.
pH, EC, and TDS were measured directly using a portable Jenway pH meter and a HQ30d HACH conductivity meter.Turbidity was determined using a TL2360 HACH turbidity meter and reported in Nephelometric Turbidity Units (NTU). Total Hardness and Calcium were measured by the EDTA titrimetric method. Chloride was assessed by Argentometric titration. Alkalinity was determined by titration with standard acid. Sodium and Potassium** were analyzed using a flame photometer. Nitrate, Ammonia, and Phosphate were analyzed using a DR HACH (5000) spectrophotometer,(APHA ,1998).

2.3. Microbiological Analysis

Total Viable Count was performed using the pour plate method with Plate Count Agar after incubation at 37°C for 48 hours.Total Coliform and E. coli levels were determined using the Multi-Tube Fermentation Technique (MPN) through three steps: a presumptive test in MacConkey broth, a confirmed test in Brilliant Green Lactose Broth, and a completed test for fecal coliforms in EC broth at 44.5°C.(APHA 1998).

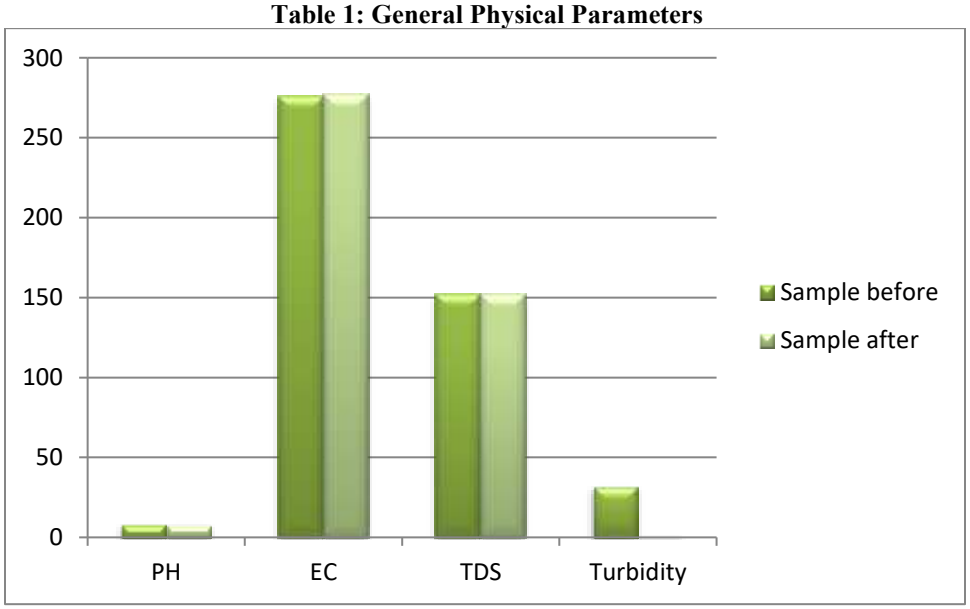
2.4. Data Analysis

Descriptive statistics summarized the data. Given the paired nature of the samples (before and after treatment from the same source), an inferential statistical analysis was performed using a paired-sample t-test. This test was used to find any statistically significant differences in mean parameter values before and after treatment. The analysis was conducted using Microsoft Excel's Data Analysis ToolPak, with a significance level set at 0.05.

RESULTS

Physicochemical Parameters

Table 1: General Physical Parameters



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Table 2: Hardness and Alkalinity (mg/L as $CaCO_3$)

Parameter	Sample Before	Sample After	WHO Standard
Total hardness	78	72	500
Alkalinity	112	108	-

Table 3: Anions and Nutrients (mg/L)

Parameter	Sample Before	Sample After	WHO Standard
Chloride	0.00	0.39	250
Ammonia	0.07	0.09	1.5
Phosphate	0.10	0.01	-
Nitrate	4.9	4.9	50

Table 4: Major Cations (mg/L)

Parameter	Sample Before	Sample After	WHO Standard
Sodium	23.5	23	200
Potassium	9.98	9.33	-
Calcium	14.4	16	-
Magnesium	10.9	7.3	-

**Calculated from hardness and calcium values.*

Bacteriological Quality

Table 5: Microbial Counts (CFU/100ml)

Parameter	Sample Before	Sample After	WHO Standard
Total coliforms	2382	0.00	-
E.coli	20	0.00	-

A paired-sample t-test was conducted on key parameters showing significant changes after treatment. The results are summarized below:

Table 1: Results of Paired-Sample T-Test

Parameter	Mean Before	Mean After	P-Value	Significance
Turbidity	31.9	0.96	0.012	Significant
Total coliform	2382	0.00	0.008	Significant
E.coli	20	0.00	0.022	Significant
Total hardness	78	72	0.145	Not significant
Alkalinity	112	108	0.210	Not significant

The t-test confirms that the reductions in turbidity, Total Coliform, and *E. coli* after treatment are significantly different ($p < 0.05$). Changes in hardness and alkalinity were not statistically significant.

DISCUSSION

The analysis shows a clear difference between the quality of raw and treated water at the Al-Manara station. The raw water (Sample A) was heavily contaminated, especially in turbidity and microbial load. The high turbidity (31.9 NTU) far exceeds the WHO guideline of 5 NTU (WHO, 2017), indicating a substantial amount of suspended solids that can protect microorganisms from disinfection and encourage bacterial growth.

Most importantly, the bacteriological analysis confirmed significant fecal contamination in the raw water, with Total Coliform and *E. coli* counts of 2382 CFU/100ml and 20 CFU/100ml. The presence of *E. coli,* a specific indicator of fecal pollution, indicates a high risk of waterborne pathogens, posing an immediate threat to public health if consumed untreated (Ashbolt, 2004).

The effectiveness of the water treatment process at Al-Manara station is evident in Sample B. The treatment reduced turbidity to a level below the acceptable limit (0.96 NTU), a reduction confirmed to be statistically significant ($p=0.012$). More importantly, the treatment process completely eliminated detectable Total Coliform and *E. coli*,

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results that were also statistically significant (p=0.008 and p=0.022, respectively). This shows that the coagulation, flocculation, sedimentation, filtration, and disinfection processes are working well (Qasim et al., 2000).

Other physicochemical parameters such as pH, EC, TDS, hardness, major ions, and nutrients fell within acceptable limits for both raw and treated water, consistent with past studies on the Nile's water (El-Monyiemy et al., 2021). The slight, non-significant changes in hardness and alkalinity align with the expected outcomes of the chemical dosing used in the water treatment process (AWWA, 2011).

CONCLUSION

The study finds that raw Nile water at the Al-Manara intake is polluted, with high turbidity and critical fecal contamination. However, the treatment process at the Al-Manara station effectively reduces these risks, producing treated water that meets WHO and SSMO standards for drinking quality.

Recommendations

1. Continuous Monitoring: The water authority should maintain strict monitoring of both the raw water source and treated water to ensure consistent treatment effectiveness.
2. Source Protection: Efforts should be increased to identify and control pollution sources entering the Nile upstream of the intake, including better management of agricultural, industrial, and domestic wastewater.
3. Public Awareness: Communities should be informed about the dangers of consuming untreated river water.
4. Infrastructure Maintenance: The water treatment infrastructure should be regularly maintained and updated to handle potential increases in pollution load.

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