VOL 5(1), 21-28
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ISSN: 2523-1901 (Online)
URL: http://jessd.mwu.edu.et/
Email: JESSDeditorials@mwu.edu.et
Journal of Equity in Sciences & Sustainable Development
DOI: https://doi.org/10.20372/mwu.jessd.2022.1528

Full Length Research Paper

Investigating the Appropriateness of Treated Water for Domestic Use: A Case Study of Madda Walabu University Treatment Plant, Robe, Ethiopia

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Article Info

Article History
Received: 4 Oct. 2021
Accepted: 10 Jan. 2022

Keywords:
Biological parameters, domestic uses, physicochemical parameters, treatment plant, treated water

Abstract

To reuse effluent water for domestic uses, this investigation was conducted to measure the physicochemical and bacteriological excellence of treated water. To attain this research objective, the quality of effluent water treated by the treatment plant of Madda Walabu University was investigated. In this investigation, fluoride, pH, iron, electrical conductivity, sodium, total dissolved solids, sulfate, total hardness, chloride, calcium, magnesium, potassium, and biological oxygen demand were the physicochemical parameters studied, and the biological parameters analyzed included faecal coliforms and total coliforms. The results showed that parameters such as fluoride (0.26 mg/L), iron (0.2 mg/L), chloride (151.91mg/L), sulfate (53.99 mg/L), pH (7.50), and magnesium (24.48 mg/L) are within the maximum permissible limit of the World Health Organization (WHO) and Ethiopian Standard (ES) of water for domestic use. Another investigated parameters such as electrical conductivity (1153.07mg/L), total dissolved solids (636.11 mg/L), total hardness (350.75 mg/L), sodium(139.77mg/L), calcium(113.09 mg/L), potassium(35.87 mg/L), biological oxygen demand (53.32 mg/L), faecal coliforms (230 per 100 mL) and total coliforms (3200 per 100 mL) are above the permissible limit of both WHO and ES. As most of the parameters investigated above in this research were the allowable permissible limit for domestic uses. The treated water by Madda Walabu University. The Treatment Plant is not suitable for domestic uses. Hence, it should be recommended to construct tertiary treatment structures to improve the quality of treated water to use for domestic uses mainly for drinking.

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1. Introduction

Water is the most important natural resource which is essential for the survival of all living things (Prasanth et al., 2012; Awol, Adugna, and Ma, 2021). However, protecting the quality of water from pollution is a challenging issue as it affects the whole world (Berhe, 2020). Due to water shortage, the treated effluent water reuse for different purposes is gaining a global attention (Bixio et al., 2006; Huertas et al., 2008; Kaboosi & Esmailnezhad, 2018). Effluent water is already being widely used throughout the world for different purposes (Hamilton et al., 2007; Jeong, Kim, & Jang, 2016). In the context of Ethiopia, the required amount of rainfall is not available at the right time for effective use (Shiferaw & Sulaiman, 2017). Therefore, a sustainable solution to such problems necessitates effective management of available water resources and the reuse of effluent water for domestic uses. However, the use of this effluent without appropriate management and checkup of its quality for use may cause risks (Goel & Kulkarni, 1994; Shiferaw & Sulaiman, 2017; Bhatia et al., 2018). Therefore, it would be beneficial to study the quality of effluent water before recommending it for domestic uses (Ramadan et al., 2017).

Madda Walabu University treatment plant has been treating wastewater at a rate of 160 to 215 m3/day since 2015. According to information obtained through interviews of technicians of the treatment plant; even though this plant releases a large amount of effluent water each day, the quality of the effluent water has not yet been determined, whether it is surely appropriated for reuse as domestic water mainly for drinking. As a result, information is required on quality to assess the appropriateness of the effluent water for domestic uses. To understand the characteristics of effluent water quality, this research was undertaken to investigate the quality of the treated water produced from the Madda Walabu University treatment plant and to assess its appropriateness for domestic purposes as an alternative water source.

2. Materials and Methodology

2.1 The Study Area of Research

The investigation site is found in Bale-Robe town, Oromia regional state, Ethiopia, at Madda Walabu University. Madda Walabu University is a large university with an area of more than 100 ha that is located 430 kilometers from Addis Abeba at a latitude of $7^0$8"50" N and a longitude of $39^0$59"55" E. Madda Walabu University is one of the public universities in Ethiopia which was established in 2005. The elevation of the study area varies from 2460 m up to 2473 m above sea level. The mean annual temperature of this area is 15^0C. It experiences cool temperatures and has a mean annual rainfall of up to 1100 mm. The university is found in the climatic subtropical zone (“weynadega”). According to the data of the Robe meteorology station, the main rainy seasons are from June to September and the dry season is from January to March. The origin of the raw waste is from toilets and restaurants. This plant was launched in 2015 with a capacity of 216m^3/day.

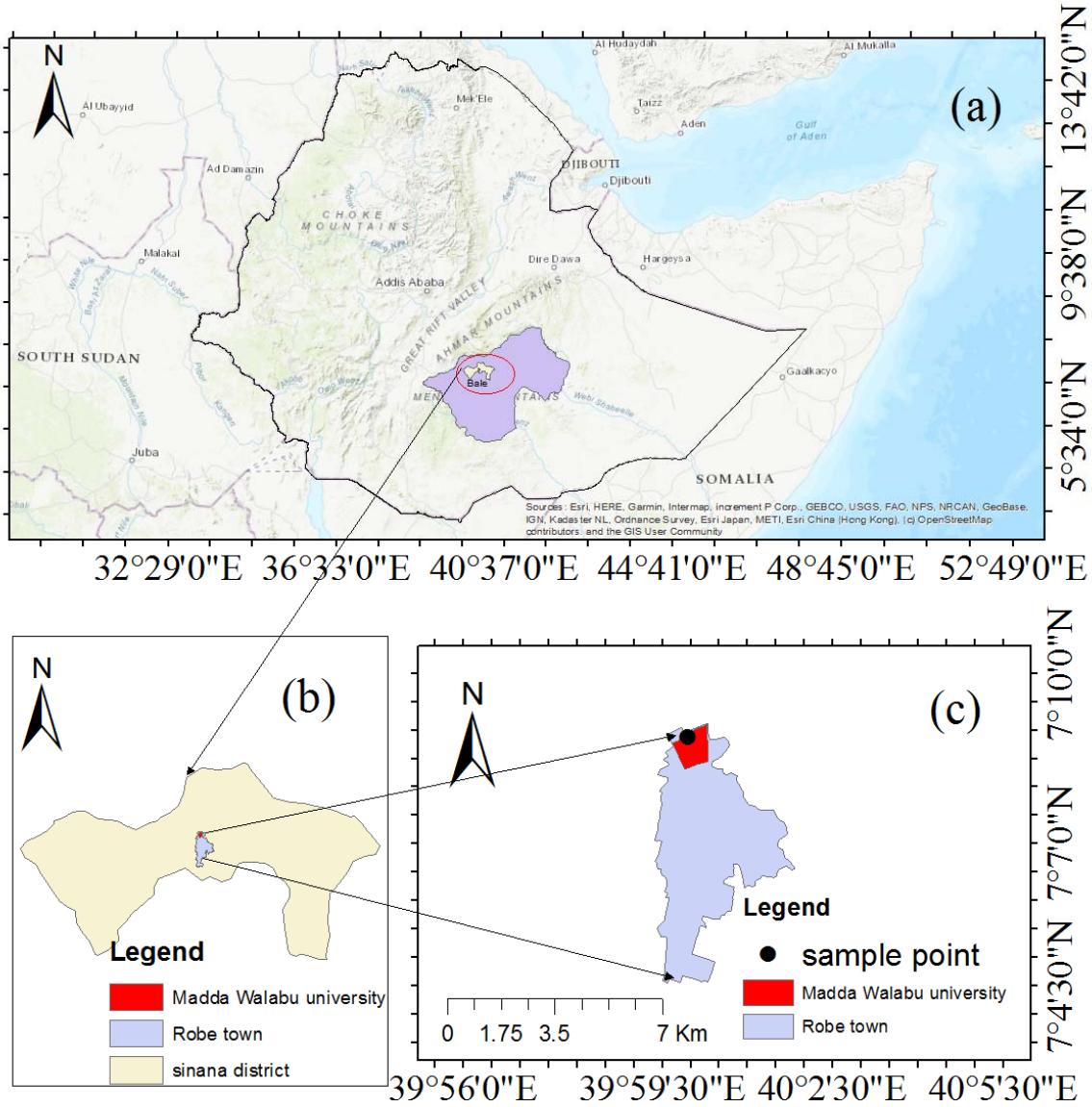

Figure 1: study area: a) Ethio-boundary and Bale zone on world Topomap b) Sinana district and Robe town c) Madda Walabu University in Robe town

2.2 Samples collection

Effluent water samples from the Madda Walabu University treatment plant were collected in the morning. Triple sampling is representative and enough for one point of quality analysis (APHA, 2005; Kaur, Bhardwaj & Arora, 2017). To do so, three representative samples were collected in February and September 2020 from one sampling point in the morning time (see Fig.1). During effluent sample collection, the control and protection of samples were done by standard techniques suggested by the American Public Health Association to confirm data quality and reliability (Alpha, 1976; APHA, 2005). Samples were engaged in clean glass bottles to avoid any unplanned pollution. Each sample was carried out in sterile flasks by labeling them with the sample code and transporting them to the laboratory. Collected effluent samples

were kept in a cooler flask and at that moment transported to the research laboratory called Ethiopian construction design & supervision works corporation on the same daytime for investigation.

2.3 Physicochemical and Bacteriological analyses

Subsequently as the samples moved to the laboratory, the examination started instantly. The standard methods suggested by the American Public Health Association were used for the examination of various physicochemical and biological parameters (APHA, 2005). The samples were investigated in triplicate for physicochemical and biological content. Electrical conductivity (EC) was measured by an electric potentiometer. The *pH* value was measured by a potentiometer. The calcium (Ca^{2+}) concentration and magnesium (Mg^{2+}) concentration was examined by using the titrimetric method(Yang *et al.*, 2017). Chloride (Cl^{-}) was determined by Mohr Argentometric titration. Fluoride was determined by SPADNS. Sodium (Na+) and potassium (K+) were examined by the flame photometry method and sulfate (SO_4^{2-}) was analyzed by the turibidmetric method (Fawy *et al.*, 2018). Total Dissolved solids (TDS) was determined by gravimetric method (dried at 105 ^{0}c) (Aksever, Davraz and Bal, 2016). Biological Oxygen Demand (BOD) was examined by the 5 Day BOD test using Modified Winkler-Azide dilution technique/incubation. TH was determined by titrimetric method. Iron was determined by the 1, 10. phenochroline method. Biological analysis for total coliforms and fecal coliforms were investigated by using membrane filtration method.

3. Results and Discussion

The testes result and statistical analyses of the physicochemical and biological parameters, as well as the permissible limits of WHO and Ethiopian standards, are presented in Table 1. The pH of the collected effluent sample from the outlet of the treatment plant was analyzed and its test result varied from 7.42 to 7.58, which indicates as the treated water is to some extent basic. According to the WHO and Ethiopian standards, the normal pH range for domestic use is from 6.5 to 8.5. Domestic water using a pH outer the standard variety could cause a nutritional inequality or might contain contaminants. Hence, the current effluent is at the bounds of both WHO and Ethiopian standards for domestic water uses. EC is the significant factor for assessing the appropriateness of treated effluent water for domestic use, and it is directly associated with the concentration of dissolved constituents (ions) in the water. The EC values of the investigational samples varied from 732 to 1377 µS/cm (mean value = 1153.07µS/cm), which is beyond the allowable limit of the WHO and Ethiopian standards of domestic water.

Another key factor that specifies the excellence of water for domestic uses is TDS. The present analysis result of TDS varied from 398 to 758 mg/L (mean value = 636.11 mg/L), which designates a minor amount of constraint on the use of this effluent water for domestic purposes as it is beyond the acceptable limit set by WHO and the Ethiopian standard of water for domestic use. This investigation shows; the treated water samples may have a hazardous TDS content for domestic use. The hardness in water is mainly due to the availability of bicarbonates, chlorides, and sulfates in the water (Berhe, 2020). In the present investigation, the test result for TH was various from 314.08 mg/L to 376.98

mg/L (average of 350.75). These tests outcomes were beyond the standard bounds of drinking water quality agreed by the WHO (200 mg/L) and the Ethiopian standard (300 mg/L). Hence, the treated waterfalls under the hard water class. So that, treated effluent water is not appropriate for domestic uses.

Table 1 statistical summary of tested samples

No.	Parameters	Unit	Samples					Maximum permissible level (WHO, 2006) (mg/l)	Maximum permissible level (ES261, 2001)
			Sample 1	Sample 2	Sample 3	Mean	SD		
1	Total hardness	mg/L	376.98	361.2	314.08	350.75	32.72	200	300
2	Chloride	mg/L	199.79	190.35	65.6	151.91	74.90	250	250
3	Sulfate	mg/L	64.35	55.4	42.21	53.99	11.14	200	250
4	EC (µS cm^{-1})	µS cm^{-1}	1377	1350.2	732	1153.07	364.90	750	1000
5	pH		7.58	7.5	7.42	7.50	0.08	7 – 8.5	7.5 – 8.5
6	Fluoride	mg/L	0.25	0.25	0.27	0.26	0.01	1.5	3
7	Fe	mg/L	0.33	0.2	0.07	0.2	0.13	0.3	0.4
8	TDS	mg/L	758	752.34	398	636.11	206.23	500	1000
9	Potassium K^+	mg/L	53	45	9.6	35.87	23.10	12	-
10	Calcium Ca^{+2}	mg/L	153.36	140.4	45.5	113.09	58.89	75	75
11	Mg^{+2}	mg/L	32.63	30.1	10.7	24.48	12.00	30	50
12	Na^+	mg/L	196	180.8	42.5	139.77	84.58	200	200
13	Biological Oxygen Demand	mg/L	70.86	50.09	39	53.32	16.17	30	-
14	Total coliform per 100 mL		3300	3300	3000	3200.00	173.21	0	-
15	Fecal coliform per 100 mL		330	330	30	230.00	173.21	0	-

Chloride is the most known and common ion in water (Brindha et al., 2014). In this investigation, the chloride test results varied from 65.6 to 199.79 mg/L. Both the WHO and Ethiopian limits of water for domestic use should have chloride concentration of less than 250 mg/L and hence the investigated samples were within the permissible limits. Mg^{+2} and Ca^{+2} are significant issues in water hardness, and their occurrence remarkably influences the chemistry of water. The Mg^{+2} concentrations varied from 10.7 to 32.63 mg/L (average = 24.48), which is within the permissible limit, and Ca^{+2} ranged from 32.63 to 153.36 mg/L (average = 113.09 mg/L), which is above the maximum permissible limit of the WHO and Ethiopian standards of water quality for domestic uses. The range of Na^+ and K^+ in the treated water varied from 42.5 to 196 mg/l (average=139.77 mg/L) and 9.6 to 53 mg/l (35.87 mg/l), respectively. This shows that; both Na^+ and K^+ concentrations in treated water were above the maximum permissible limit set by WHO and the Ethiopian standard of water for domestic uses.

Fluoride and sulfates are other parameters that govern the quality of water for use. As

WHO and Ethiopian limits for drinking water quality, sulfate content should be less than 250 mg/L. Fluoride is critical for the normal mineralization of bones and the development of dental enamel. The range of F^- and SO4−2 in the treated water were varied from 0.25 to 0.27 mg/l (average = 0.26 mg/l) and 42.21 to 64.35 mg/l (35.87 mg/l), respectively. This shows that fluoride concentrations did not violate the guidelines set by the WHO (1.5mg/L) and concerning the Ethiopian drinking water limit of fluoride, it is below the value (3mg/L) and sulfate concentrations in treated water were within the permissible limits set by WHO and the Ethiopian standard of water for domestic uses.

Coliforms commonly occur in all water sources and are not harmful to humans, but their existence is a pointer of water impurity with disease-causing germs and pathogens (Mimouni *et al.*, 2019). In this investigation, total coliform was 3000/100mL to 3300/100mL, which is above the maximum permissible limit of the WHO and Ethiopian standards of water for domestic use. The test result of the effluent sample for fecal coliform was 330/100mL to 30/100mL (average=230.00/100ml), which is above the permissible limit of the WHO and Ethiopian standards of water for domestic use. Hence, the present treated water has more contamination than the permissible limit. So that it is not recommended to use this effluent water for domestic purposes.

4. Conclusion and recommendations

It is fundamental to investigate the status of effluent water to ensure its suitability for domestic use. The quality assessment of treated effluent water from Madda Walabu University treatment plant for domestic purposes showed that effluent water has salinity as it has EC and TDS values beyond the allowable limit of WHO and Ethiopian standards of water for domestic use (drinking). This treated water has also high total hardness, cations such as Ca+2, Na+, and K+ contents, and biological parameters such as total coliform and fecal coliform concentration beyond the maximum limit fixed by WHO and Ethiopian standard water for domestic uses. Hence, it can be concluded that; treated water by the treatment plant of Madda Walabu University is not appropriate for domestic uses (drinking) and it needs the intensive treatment to be used for domestic purposes. So, it can be recommended to install tertiary structures which improve the quality of treated water. Hence, it is not recommended to use this treated water for domestic purposes at this moment.

Declarations

Conflict of interest, author declares that there is no competing interest.

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