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The impact of effluents from Woliso Soap and Detergent Factory on Werabo River, South West Shewa district, Oromia, Ethiopia

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ABSTRACT

The discharge of industrial effluents into water bodies poses significant risks to aquatic ecosystems and human health. This study examines how the Werabo River in Woliso town, Oromia, Ethiopia, is affected by wastewater from the Woliso soap and detergent factory. In this study the level of pollution caused by the factory's effluent and its effects on the ecological and socio-economic aspects of the local area were evaluated. To achieve this aims, water samples were collected at several points along the Werabo River, including the point where the manufacturing effluent joins the river. The samples were analyzed for various physicochemical parameters, and the water quality index (WQI) was calculated to assess the overall water quality. Additionally, socio-economic surveys and interviews were conducted to gather the local community's perspectives on the pollution and its consequences. The findings showed that the levels of nitrate, phosphate, sodium, potassium, oil-grease, electrical conductivity (EC), salinity, dissolved oxygen (DO), temperature, pH, and total dissolved solids (TDS) were significantly higher at site II (the effluent discharge point) compared to upstream water samples. Statistically significant differences ($p < 0.05$) were observed between the three sampling sites based on the measured parameters. The WQI results showed that the water samples collected during the rainy season (WQI = 179.5) and the spring (WQI = 231) were classified as poor and very poor water quality status, respectively. The socio-economic survey also highlighted the severe health, social, and economic impacts of the wastewater discharge on the local community, particularly to the users of the studied river. The environmental and socioeconomic effects of the wastewater discharge into the Werabo River from the Woliso soap and detergent industry are significantly highlighted by this study. The findings underscore the need for improved industrial waste management and offer important information for policymakers and stakeholders to develop effective pollution control measures and strategies for sustainable water resource management.

Introduction

Anthropogenic activities occurring within the drainage basins of rivers have a significant impact on the physical, chemical, and biological properties of these open, dynamic ecosystems (Mokaye et al., 2004). A number of rivers and streams flow through urbanized areas across the world and are profoundly impacted by changes associated with urbanization (Bernhardt and Palmer, 2007). High rates of population growth and ongoing economic development are the main causes of the sharp rise in the amount and diversity of household and industrial waste produced in many quickly expanding urban areas, particularly in developing nations (Fakayode, 2005; Gezahegn et al., 2025a). Studies have indicated that most of our rivers crossing big cities or towns are suffering from both anthropogenic and industrial wastes (Beneberu, 2010; Roy et al., 2003). Typically, Akaki and Sebeta Rivers were highly contaminated because of the discharge of partially treated or untreated industrial effluents into the river (Amare, 2019; Gezahegn et al., 2025b; Fekede et al., 2020).

Large volumes of thermally or chemically weakened water are released with diligence, disrupting the brackish ranges' biodiversity. Large amounts of synthetic and organic waste are dumped into gutters with little to no treatment, especially in developing countries (Roy et al.,

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2003). Poisonous essences like Cd, Cr, Ni, and Pb, fecal coliform, total dissolved solids (TDS), chemical oxygen demand (COD), Biological oxygen demand (BOD), and total suspended solids (TSS) all rise when high levels of adulterants are added to stream water systems (Ademoroti, 1996).

Despite being a significant industry, the soap and cleaner sectors only produce and discharge relatively small amounts of liquid waste into the environment. However, its products' discharge after use in homes, service facilities, and factories raises serious public concerns (Lawrence, 2014). The wastewater discharged from cleaner and soap manufactories is largely weakened in nature with largely variable characteristics: parentheses of temperature, color, total solids, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), anions, cations, and surfactants. The nonstop product and operation of cleansers are the origin of a type of pollution who is most significant impact is the conformation of poisonous or nuisance lathers in streams, lakes, and treatment shops (Ankesh et al., 2019). In numerous developing African countries like Ethiopia, the vacuity of water has turned into critical problem, and it is a matter of great concern to families and communities that depend on the non-public water force system. The expansion of diligence in Ethiopia, open water bodies similar as streams that are proximate to diligence are under pressure impacting on the hydrology of water, submarine life and mortal health (Amare, 2019).

Werabo River is under pollution pressure due to wastewater effluents from urbanization and industrial human activities. For instance, the stream receives regularly untreated effluent from Woliso Soap and Detergent factory and Woliso town, Ethiopia. These activities may cause water pollution to the river ecosystem that may further weaken the capacity of the river ecosystem to deliver ecosystem services and goods for the local community. To protect the river ecosystem from such a threat, it is crucial to establish regular physical, chemical, and biological monitoring programs that help as indicators for the possible interventions to sustainably manage the water ecosystem.

Few studies have specifically looked at the environmental effects of wastewater from soap manufacturing industries on freshwater ecosystems, despite the fact that industrial effluent discharge has been identified as a major contributor to riverine pollution. By thoroughly examining the physicochemical and biological properties of river water that is directly impacted by soap factory effluents, this study makes a novel contribution. This study examines the distinct makeup of soap effluents, specifically surfactants, phosphates, and fatty acids, and their ecological effects, in contrast to more general evaluations of industrial pollution. This study offers evidence-based suggestions for sustainable effluent management and policy formulation by utilizing both in-situ water quality monitoring and laboratory-based toxicological assessments. This gives new insights into the little-known role of the soap industry in deteriorating aquatic environments. To this end, this research was aimed at assessing the extent of pollution to the river caused by the effluent from the soap factory and its implications for the ecological and socio-economic aspects of the area. The key finding of the study contributes to the management and sustainable use of ecosystem goods and services delivered by Werabo stream for the local community.

Materials and methods

Study area description

Woliso town is situated along the Addis Ababa-Jimma main road, 114 km from Ethiopia's capital, Addis Ababa, at location of 8.31°60″ North and 37.58°60″ East. The elevation of the town ranges from 1900 to 2000 m above mean sea level. The mean temperature of the town is 22.5 °C and the mean annual rainfall is 1200 mm.

Werabo River, which originates from the highlands of the country, Ethiopia, crosses Woliso town from southern side of the town (Fig. 1). The river is under the influence of contamination from urban wastes and effluent from soap and detergent factory known as Woliso soap and detergent factory (https://www.tadessefilateaplc.com/Soap.html), Ethiopia, as the factory releases its wastewater directly to the river water. Similarly, large quantities of untreated municipal sewage are directly discharged to Werabo River from Woliso town. During the dry season, when there is a water scarcity in the area, the local community uses the river water for domestic purposes, such as cooking food, cloth washing, watering livestock and irrigating their farmlands.

Reconnaissance survey: The southern highlands of Woliso, Ethiopia, are the source of the stream, which crosses the western area close to the soap factory. The study area located near a soap and detergent factory

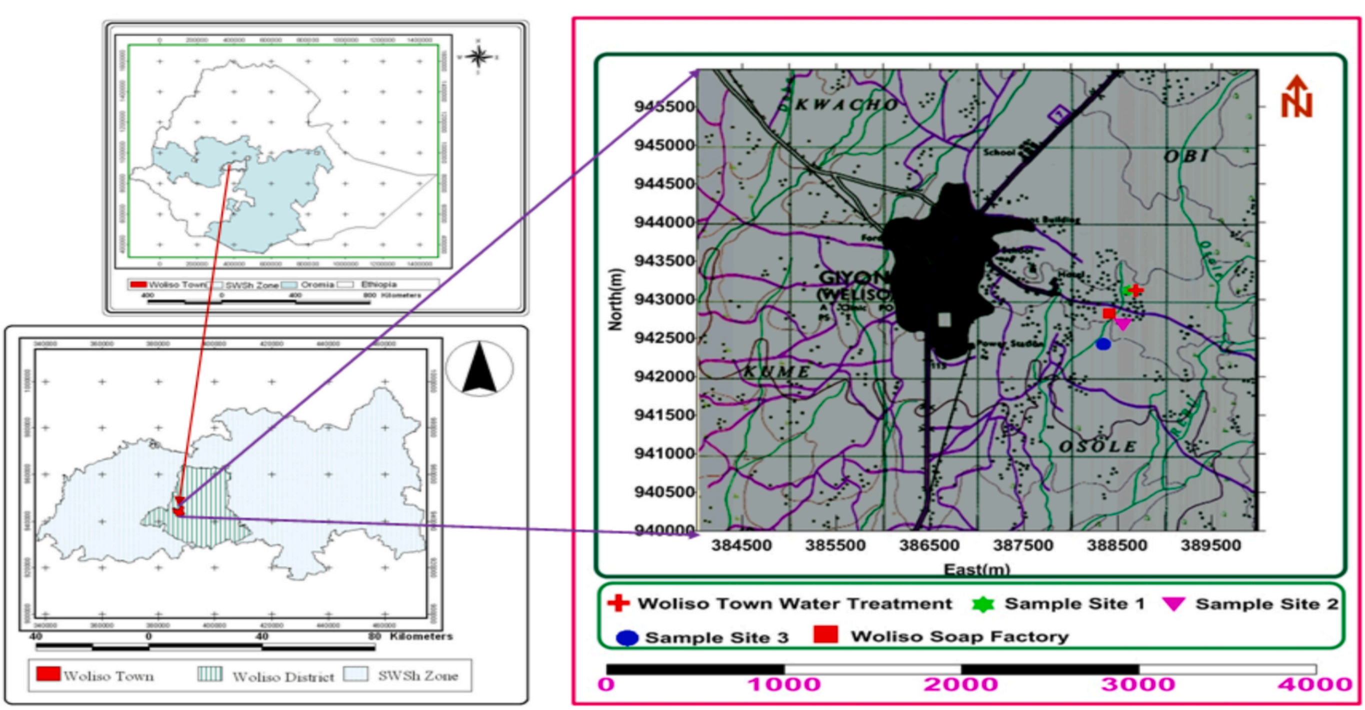

Fig. 1. Map of the three Study Sites in the vicinity of Woliso (created using EMA, 2005 and GPS readings).

that releases its effluent into the stream and is situated along the road between Korke and Gerbo towns. Before samples were taken from the designated sample sites, a reconnaissance inspection of the research area was conducted. The purpose of the survey was to identify the industrial effluent discharge locations where water samples would be taken and to determine the best sampling techniques to use.

Description of sampling sites

Every step of the production process releases waste fluids, including wash water, into the neighborhood via a small canal for open drainage. Because the facility lacks operational wastewater treatment facilities, untreated soap effluent is released into the environment. Three sampling stations were purposively selected (Fig. 1), and the features of each site has been characterized accordingly.

Characteristics of sampling sites

Station 1 (Site-I): This location is upstream of the point where the Werabo River receives wastewater from the Woliso Soap and Detergent factory. This site was taken a reference point, because at this site human activities are minimal as compared to the other two sites. At this site, the width of Werabo River exceeds 3 m, and the river flows fast. The substratum of the site was muddy.

Station 2 (Site-II): – This is the location where the river system receives the wastewater from the soap and detergent industry (Fig. 1). 500 m downstream of station 1 (sample site 1) is where it is situated. The substratum of the site is composed of gritty sand and pebbles. The south bank of the stream is muddy, and its width is less than one meter. At this location, surface runoff was high during precipitation, and the velocity of current was comparatively moderate.

Station 3 (Site-III): This sampling location is roughly 500 m downstream from station 2. It flows down to the Rebu River and is made up of a small riffle that is less than two meters wide. With a few isolated clay spots, the substrate is coarse sand. During the rainy season, this site silted up a lot, and the current velocity is slow. In contrast to the two sample sites mentioned above (sites 1 and 2), the site's surrounding region is covered with grasses, shrubs, and eucalyptus trees.

Sampling design

The study was conducted using both qualitative and quantitative research designs. WQI and physicochemical parameters were examined quantitatively, but the community survey was presented qualitatively. Inhabitants of the surrounding Fodugora village (kebele) were selected purposively for the community survey. This is because the soap and detergent factory is located in this area. Moreover, the community of the selected kebele lives along the Werabo River and is assumed to be victims of wastewater discharge from the factory. Systematic random sampling technique was used to select the respondents for the questionnaire and key informants for interviews involved in the survey.

Two stages sampling technique was applied to determine the sample size of the respondents. Yamane formula (Yamane, 1967) was used to determine the sample size of the respondents for the house-to-house survey. In total, 144 households were included in the household survey questionnaire.

$$\frac{N}{1 + N(e^2)} \tag{1}$$

where, n = sample size, e = level of precision, and N = total population. Confidence level of 95 % with 5 % level of precision was considered.

Method of data collection

Twelve physicochemical characteristics of the receiving stream samples including pH, EC, temperature, DO, TDS, BOD, COD, nitrate, total phosphate, Na, K and oil grease were examined using standard techniques advised by APHA (1999) for the examination of water and wastewaters. The results were compared with the permissible limits set by the Ethiopian Environmental Protection Agency (EEPA), USEPA, and the World Health Organization (WHO). As discussed, laboratory analysis and household questionnaire were employed to generate primary data.

Laboratory analysis: To study the physico-chemical characteristics of the water system, water samples were collected from the above mentioned sampling sites (i.e., site 1, site 2, and site 3) as indicated in Fig. 2. The sampling collection campaign was carried out between June/July and September of 2023. This period was chosen for data collection due to rainy season in Ethiopia. Several water quality parameters including pH, water temperature, electrical conductivity (EC), nitrate ion (NO_3^-), BOD, DO, Ssalinity, potassium level, sodium level, oil-grease and total dissolved solids (TDS) were monitored. Water samples from the sampling locations were gathered and sent for laboratory analysis following standard procedures for ex situ parameters, while portable devices and laboratory equipment were used to measure in-situ parameters like pH and EC.

Field and household survey: Secondly, the collection of primary data was done by field survey and by interviewing respondents using questionnaires. Demographic, socioeconomic, local community opinion and perceptions of pollution, and associated environmental and human consequences resulting from wastewater emitted from soap and detergent factories in the area were all covered in the questionnaire designed for the household survey. Furthermore, key informant interview/discussion was performed to triangulate and validate the responses of respondents participated in household survey. The key informant interview was also used to extract detailed information. Therefore, in this process, socioeconomic value and perception of the community on pollution & its consequence on human health were addressed by participation of few workers from the factory, experts and local elders living in the area for long time.

The filed observation was undertaken in Fodugora kebele starting from site selected as reference until the point source during the field work. By observing the impact of waste discharged from soap factory on Werabo River, photographs were captured in order to avoid omission of data. Secondary data collection was carried out using different websites, published documents, etc.

Sample collection and analysis of physico-chemical parameters

Procedures prescribed in the standard methods recommended by APHA (1999) for the examination of water and wastewaters were followed for all analysis. For shallow and narrow rivers and streams, fewer locations are required, and sampling at three to five points is typically adequate (Bartram and Ballance, 1996). Using a clear plastic water sample vial, a composite one-liter sample of water was collected at each location and placed in an ice box before being transported to the laboratory for analysis. Within one to six hours, the samples were delivered to the water technology lab at Woliso Polytechnic College, where they were filtered using glass fiber filters (GF/F). To measure the overall water quality of sampling sites, sampling was done across different spatial variation of seasons with specific time frame of rainy and spring seasons.

Ex-situ parameters

The filtrate water sample were used for chemical analysis of nitrate (NO_3^-) and nitrite (NO_2^-), BOD, sodium, potassium, and oil-grease following standard methods as indicated in American Public Health Association (APHA, 1998).

Biological oxygen demand (BOD): Biochemical oxygen demand (BOD) samples were taken and placed in dark glass bottles for incubation. The Winkler's-Azide dilution method was used to measure BOD in accordance with the guidelines provided in the Standard Methods for the Examination of Water and Wastewater (APHA, 2001).

Oil-grease: The water samples that were collected in 2000 ml clean

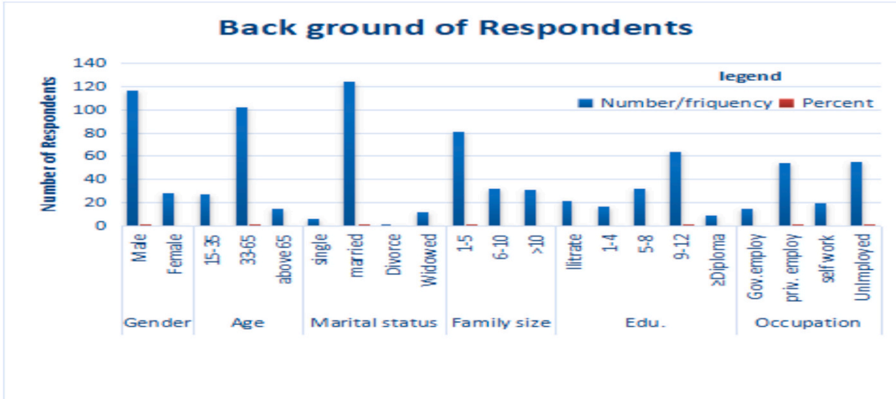

Fig. 2. Graph Depicts the back ground of the respondents during the study period.

plastic bottles were rinsed with distilled water and analyzed using D-3921TPH-Infrared absorption.

Nitrate and nitrite ions: Following HACH guidelines and utilizing a standard pillow, the concentration levels of nitrate and nitrite ions were measured using a spectrophotometer (DR/2800, Japan). For both nitrate and nitrite, 10 ml of water sample solution was used. For oil-grease, the sample collected in 2000 ml clean plastic bottles were rinsed several time with distilled water and twice with water which were being sampled, and transported to laboratory and to start further tests. To ensure the validity of the result blank water (Di-iodized water) were used as a control test.

Potassium and sodium: The nutrients were analyzed using Palintest photometer reagent tablets (phosphate, total hardness, and alkalinity). High-purity deionized water was used for making all working solutions. The study made use of multi-element standard solutions (1000 mg/l) from Perkin Elmer, USA, Ar (99.99 %), and HNO_3 (65 %). High-purity water (18.2 MΩ/cm) was used to make all working solutions in a 0.5 % HNO_3 solution.

In-situ parameters

The in-situ parameters were measured on site. The variables measured on site includes pH, electrical conductivity (EC), Total dissolved solutes (TDS), and temperature. Electrical conductivity was determined by portable conductivity meter (Elmetron, CC411 Model). A calibrated portable digital pH meter was utilized to monitor pH, and a temperature analyzer with probe was used to detect temperature. The Elmetron (Model CO-411) oxygen meter was used to measure DO.

Water quality index

Water quality index (WQI) is a rating that reflects the composite influence of different water quality parameters. It is a tool to evaluate water quality. WQI is determined by considering whether surface and ground waters are suitable for human consumption. In order to compare data from multiple sites, it numerically condenses the information from several water quality parameters into a single value. It is effectively utilized globally and provides a cumulative impact of different pollutants in water (Almeida and Schwarzbold, 2003; Lopes et al., 2008).

WQI was calculated according to the Eq. (1).

$$WQI = \Sigma q_n W_n / \Sigma W_n \quad (2)$$

While the Sub Index of Quality Rating (q_n) the Unit Weight (W_n)was calculated using Eqs. (2) and (3), respectively.

$$q_n = 100\ [V_n]/[S_n] \quad (3)$$

where, q_n = Quality rating for the n^{th} water quality parameters, V_n = Estimated value of the n^{th} parameter at a given sampling station, and Sn = Standard permissible value of the n^{th} parameters.

$$W_n = K/S_n \quad (4)$$

where: W_n = Unit weight for the n^{th} parameters, S_n = Standard value for n^{th} parameters, and K = Considered as 1.

Data analysis and interpretation

Descriptive statistics and basic statistical measures for the water quality parameters and indicators under study were part of the data analysis. Significant variations ($p < 0.05$) in physicochemical parameters between the study locations were observed using a one-way analysis of variance (ANOVA) and descriptive statistics results (mean and standard deviation). The correlation between the physico-chemical parameters was evaluated using bivariate Pearson correlation analysis. Analysis of data was carried out using IBM-SPSS program.

Results

Physico-chemical parameters

A summary of the results of physico-chemical analyses are presented in Table 1. These values were placed alongside with WHO (2008), Ethiopian guideline (ETH-EPA) and US-EPA standards for drinking water use. pH: The mean pH value of the river varied from pH 7.5 to 9.8. The maximum and minimum mean pH values were observed in water samples collected from site-2 (9.8 ± 1.19) and site-1 (7.54 ± 0.43), respectively. The mean pH values observed in waters from site-2 and site-3 exceeded the upper limit of the established guideline values (Table 2). The three sampling sites' mean pH values did not differ statistically significantly (F2, 3 = 2.2, P = 0.25) ($P > 0.05$).

Dissolved oxygen (DO): The mean DO value among the study sites was varied from 1.14 to 5.00 mg/l. The maximum DO value was recorded in site I (5 ± 1.13) than Site II (1.14 ± 1.1) and site III (2.35 ± 0.21), respectively (Table 2). There was a significant difference ($P < 0.05$) in the DO levels between water samples collected from the sampling sites ($F_{2,\,3} = 9.2$, $P = 0.05$).

Temperature: Temperature among the study sites varied from 16.15-18.4 °C with the highest value recorded at site II (18.4 ± 0.71) near the area where the soap factory discharges its effluent. The minimum mean value was recorded in the site I (16.15 ± 0.77) than the other sites. However, the mean water temperature in the study area did not change over time ($F2_{,\,3} = 5.6$, $P = 0.09$).

Electrical conductivity: Water's overall ionic composition and richness are measured by electrical conductivity. The water samples under study had mean electrical conductivities ranging from 151 to 1671 μS.cm^{-1}. The highest mean value of EC was recorded on site II (1671.5μS/cm^{-1}), while the minimum was observed in water sample collected from

Table 1
The three sample sites' mean and standard deviation (n = 3) for the physio-chemical parameters under study.

Physio-chemical parameters	Unit	Measured values (mean ± SD)			Guideline values			P-value
		Site 1	Site 2	Site 3	ETHEPA	USEPA	WHO (2008)	
pH	–	7.54 ± 043	9.8 ± 1.19	9.37 ± 1.5	6–9	6–9	6.5–8.5	$p > 0.25$
DO	mg/L	5 ± 1.13	1.14 ± 1.1	2.35 ± 0.21	4–6	4–6	4–6	$p < 0.05$
Temperature	℃	16.15 ± 0.77	18.4 ± 0.71	17.25 ± 0.49	–	40	24–30	$p > 0.09$
EC	μs/cm	151.3 ± 39.95	1671.5 ± 577.7	1604.5 ± 509.8	1500	1500	1500	$p < 0.000$
TDS	mg/L	81.75 ± 11.38	988.5 ± 504.2	882.5 ± 372.6	250–500	250–500	500	$p < 0.000$
Salinity	mg/L	78.5 ± 10.88	936 ± 439.8	884.5 ± 382.5	3000	2100	600	$p < 0.000$
BOD	mg/L	8.05 ± 1.91	33.5 ± 3.25	33.5 ± 3.25	30	–	300	$p < 0.0008$
Phosphate/TP	mg/L	1.41 ± 0.29	20.5 ± 3.25	17.46 ± 1.6	1	0.5	0.5	$p < 0.005$
Nitrate	mg/L	11.05 ± 11.8	188.4 ± 147.1	98.65 ± 39.6	10	10	10–50	$p < 0.03$
Sodium	mg/L	3 ± 0.28	69.2 ± 4.1	60.5 ± 2.68	20	20	200	$p < 0.0003$
Potassium	mg/L	7.9 ± 1.9	120.3 ± 11.17	102.8 ± 9.05	–	–	12	$p < 0.001$
Oil-grease	mg/L	11.6 ± 1.13	590 ± 42.4	454 ± 16.97	–	–	100	$p < 0.004$

Table 2
Reported literature values of physico-chemical parameters from different countries.

Country	Water type	Physico-chemical parameters												Reference/ Source
		pH	DO (mg/ l)	Temp. (°C)	EC(μS/ cm)	TDS (mg/l)	Salinity (mg/l)	BOD (mg/l)	TP (mg/ l)	NO_3^-(mg/ l)	Na (mg/l)	K (mg/ l)	Oil-grease (mg/l)	
India	GW	6.8	6.25	NI	971.56	428.21	NI	NI	NI	42.9	NI	NI	NI	Inayathulla and Paul, 2013
Nigeria	River	6.85	3.18	2.66	155.23	57.9	NI	18.05	NI	0.67	NI	NI	NI	Imoobe and Koye, 2011
Egypt	SW	8.2	NI	NI	NI	1423	NI	30.65	1.46	0.184	NI	NI	8.25	Fatma and Sohair, 2018
Cameron	River	10.53	1.10	23.61	9490	5362.86	NI	5037	NI	0.14	167.46	22.02	NI	Zoyem et al., 2021
Ethiopia/ Sebeta/ AAT	SW	7.85	NI	30.4	5705	42.65	NI	36.5	0.25	33.5	NI	NI	NI	Fekede et al., 2020
MAB	SW	6.55	NI	20.9	5425	140.15	NI	209	11.55	166.5	NI	NI	NI	Fekede et al., 2020
HT	SW	6.25	NI	21.45	10,460	673.25	NI	462	16.65	47.5	NI	NI	NI	Fekede et al., 2020
ALF	SW	4.6	NI	25.5	2389.5	185.65	NI	NI	1.8	635	NI	NI	NI	Fekede et al., 2020
AGI	SW	7.7	NI	30.4	5489.5	40.6	NI	45.5	0.2	29.5	NI	NI	NI	Fekede et al., 2020

NB: GW (Ground water), SW (Surface water), NI (Not indicated), AAT (Ayika Addis Textile), MAB (Meta Abo Brewery), HT (Hafe Tannery), ALF (Alcohol & Liquors Factory), AGI (Agro Industry).

Site I (151.3 ± 39.95 $\mu S.cm^{-1}$). With the exception of sites II and III ($F_{2,3} = 1.7$, $p = 0.06$), the results of the one-way ANOVA showed a significant difference in EC between the sample site I and the impacted site ($F_{2,3} = 5738.1$, $P = 0.000$) ($p < 0.05$).

Total dissolved solid (TDS): The three study sites had different mean TDS values. The water sample taken from site I had the lowest mean TDS value (81.75 ± 11.38 mg/l), while site II had the highest mean value (988 ± 504.2 mg/l) (Table 1). There was a significant difference in TDS between sites I and II ($F_{2,3} = 3325.5$, $p = 0.000$) and sites I and III ($F_{2,3} = 3034$, $p = 0.000$), despite sample site II having the highest mean TDS over the course of the study. However, there was no difference ($p > 0.05$) between site II and site III ($F_{1,4} = 3.14$, $p = 0.15$).

Salinity: The mean value recorded in sample site I (78.5 ± 10.8 mg/l) was lower than the impacted site II (936 ± 439.8 mg/l) and that of Site III (884 ± 382.5 mg/l) (Table 2). The salinity of the affected site and site I differed significantly ($P < 0.05$). The AVONA result showed that during the study period, there was a difference in salinity between sites I and II ($F_{2,3} = 3475$, $p = 0.000$) and between sites I and III ($F_{2,3} = 3553.5$, $p = 0.000$). However, there was no difference in salinity between sites II and III ($p > 0.05$) ($F_{2,3} = 0.769$, $p = 0.13$).

Biological oxygen demand (BOD): There are notable differences across samples when it comes to the organic pollution values indicated in BOD. The measured BOD values range from a low of 8.05 mg/l to a maximum of 33.5 mg/l (Table 1). Sites II and III had the highest BOD values, indicating a high organic matter discharge to the river from the soap and detergent business. The BOD values at sites I, II, and III also differed significantly ($P < 0.05$) ($F2, 3 = 35.12$, $p = 0.008$).

Total Phosphate (TP): The amount of TP varied from 1.41 to 20.5 mg/l; the lowest concentration was measured in the site I & and higher mean values were observed in water samples collected from site II (20.5 ± 0.29 mg/l) and Site III (17.46 ± 1.6 mg/l) (Graph 3). These mean values were found above the standard limits established by the ETHEPA (1 mg/l), WHO (0.5 mg/l) and USEPA (0.5 mg/l) for drinking water. The result obtained from ANOVA revealed that, there was significant difference ($p < 0.05$) between the sampling sites in their phosphate concentration levels ($F2, 3 = 47.25$, $p = 0.005$).

Nitrate: Higher nitrate concentration values were recorded in the in water samples collected from site II (188.4 ± 147.1 mg/l) and site III (98.65 ± 39.6 mg/l) of Werabo River, however the minimum nitrate concentration was observed in waters collected from site I (11.05 ± 11.8 mg/l) as summarized in Table 2. The ANOVA result showed that the concentration levels of nitrate were significantly ($p < 0.05$) varied between the study sites ($F_{2,3} = 200$, $p = 0.0001$).

Sodium: The mean concentration values of sodium recorded were in the range of 3.0–69.2 mg/l. The water samples taken from the effluent receiving sites Site II (69.2 ± 4.1 mg/l) and Site III (60.5 ± 2.68 mg/l) had higher mean salt concentrations. But according to Table 2, the water taken from site I had the lowest sodium concentration (3 ± 0.28 mg/l). According to the one-way ANOVA result, the sampling areas differed significantly ($p < 0.05$) in relation to the variable ($F_{2,\ 3} = 321.9$, $p = 0.0003$).

Potassium: The study found that potassium concentrations were higher at sample sites II and III (120.3 ± 11.17 & 102.8 ± 9.05 mg/l) compared to site I (7.9 ± 1.9 mg/l), which exhibited the lowest mean value. The ANOVA analysis result revealed that, the mean potassium values across the sampling sites varied significantly ($p < 0.05$) ($F_{2,\ 3} = 104.1$, $p = 0.001$).

Oil − grease: The mean concentration among the study sites ranges between 11.6–590 mg/l. Higher mean values were obtained in water samples collected from site II (590 ± 42.4 mg/l) and site III (102.8 ± 9.05 mg/l), while low oil grease mean value was measured at site I (11.6 ± 1.13 mg/l). The three study sites' mean oil grease values differed significantly ($p < 0.05$) ($F_{2,\ 3} = 262.6$, $p = 0.004$).

Pearson-correlation analysis

Pearson's correlation analysis was used to look at the relationship between the physicochemical parameters, and the results are displayed as a correlation matrix (Table 3). Significant correlation is defined as any correlation value ($r = 1$) "r" greater than or equal to one, whereas non-significant correlation is defined as r values below the specified critical value. Only BOD, phosphate, nitrate, sodium, potassium, and oil-grease showed a strong correlation with pH (r values of 0.9679, 0.9668, 0.9722, 0.9707, 0.9735, and 0.9191, respectively). There was a positive correlation of temperature with all parameters so it has a determinate effect on characteristic of the water. Phosphate ($r = 0.9999$), nitrate ($r = 0.994$), sodium ($r = 0.9978$), potassium ($r = 0.9969$), and oil-grease ($r = 0.9676$) all showed strong correlations with BOD. DO was directly correlated with all parameters but EC inversely/negatively correlated with BOD (−0.278), phosphate ($r = -0.282$), nitrate ($r = -0.246$), sodium ($r = -0.264$), potassium ($r = -0.257$), and oil-grease ($r = -0.221$) respectively.

Water quality index analysis

Water quality data are essential for policy conformation, and the water quality indicator (WQI) is the most accessible way to transmit the quality of drinking water coffers (Oni & Fasakin, 2016; Singh et al., 2020; Tokatli, 2019). In order to estimate the quality of water in different ambients, public or transnational associations have developed a number of water quality indicators over time. The WQI has been calculated based on the quality standards established for drinking water by the World Health Organization (WHO), ETHEPA, and USEPA. The twelve physiochemical water quality criteria utilized in this study were examined in order to determine the level of water contamination in the Werabo River. The weighted arithmetic indicator system listed below was used to calculate WQI.

Results of questionnaire analysis

Personal background of the respondents: For this study one hundred forty-four (144) respondents were randomly selected to undergo the study. About 80.5 % the respondents were males and the remaining 19.5 % were females. Those who engaged in preparation of soap from soap factory and dwell near to the factory which was more likely affected from effluents discharged. As far as they have no idea about the risks associated with such process, majority of the respondents (86.1 %) were victim of waste water discharge.

The majority of the respondents (44.4 %) were reached secondary school, whereas (22.2 %) of them were reached primary level. Based on the occupational status, 37.5 % of the respondents were private employed (daily workers) in the factory and the rest were government employed as well as unemployed. From observation of the researcher, all of the selected respondents were living at the tributary of the stream and more susceptible to be affected from effluent discharged from Woliso soap and detergent factory.

Perceived impact of wastewater pollution on the Werabo River and human health: All of the respondents (100 %) were agreed that there was change in the color (cloudy with foam) and smell (having bad and fouling smell) of the stream due to waste released from the factory. Majority of the respondents (58.3 % & 29.2 %) were fetched water from wells and tap water, while 12.5 % of them could get from werabo stream. Among all, 131 (90.97 %) of them could not satisfied by the quality of the stream because of pollution from nearby factory.

The findings revealed that wastewater discharged from Woliso soap and detergent factory were negatively affects the economy, social structure and way of life of the community near to the factory. More of the respondents (90 %) were agreed that the effluent discharged indirectly affects their economy, social and way of life through affecting the health and environment. Different illnesses were mentioned by the respondents' leads to economic and social dispute.

Discussion

pH – The highly alkaline hydrogen potential (pH) of the industrial effluents under analysis ranged from 7.4 to 13.2 (Table 1), which is over the acceptable threshold (WHO, 2008). This suggests that the release of industrial effluents downstream of the factory caused the river to turn alkaline. The use of chemicals like nitric acid and caustic soda (NaOH) and cations like CO_3^{2+} and palm oil in the production of soap and the cleaning and disinfection of machinery and facilities have a significant impact on these pH variations (Rodier, 2005).

Comparing to literature values, the pH values measured in this study are slightly lower that the pH values reported for Bafoussam River, Cameron (pH = 10.53) by Zoyem et al. (2021) and effluents from soap and detergent industry in Egypt (pH = 8.2) by Fatma and Sohair (2018). While, the pH values recorded in Sebeta River, Ethiopia by Fekede et al. (2020) which receives effluents from different factories were low as compared to the pH values recorded in this study for Werabo River

Table 3
Pearson correlation matrix analysis among the studied physico-chemical parameters.

Parameters	pH	DO	Temp.	EC	TDS	Salinity	BOD	PO_4^{3-}	NO_3^-	Na^+	K^+	Oil-grease
pH	1											
DO	0.217	1										
Temp.	0.309	0.599	1									
EC	−0.22	0.525	0.767	1								
TDS	0.352	0.481	0.699	0.246	1							
Salinity	0.379	0.477	0.693	0.231	0.674	1						
BOD	0.968	0.176	0.251	−0.278	0.302	0.331	1					
PO_4^{3-}	0.967	0.172	0.245	−0.283	0.296	0.325	0.999	1				
NO_3^-	0.972	0.204	0.291	−0.246	0.338	0.366	0.995	0.994	1			
Na^+	0.971	0.188	0.268	−0.264	0.318	0.346	0.998	0.998	0.991	1		
K^+	0.974	0.194	0.277	−0.257	0.326	0.354	0.997	0.996	0.992	0.998	1	
Oil-grease	0.919	0.215	0.307	−0.221	0.351	0.378	0.968	0.966	0.972	0.97	0.973	1

(Table 2). The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected (Nadia and Mahmood, 2006).

Dissolved oxygen (DO) – The value of DO recorded in the study sites II and III were below the permissible limits of WHO, ETH-EPA and USEPA (4–6 mg/L) than site I. Because of less intervention of anthropogenic activity, the value of DO in site I was higher than the rest sites. High levels of degradable organic and inorganic materials led to a tendency to be more oxygen demanding, which reduced the amount of oxygen available to the desirable organisms (Mateo-Sagasta et al., 2017). This is why the recorded DO mean of 1.14 mg/l (Site II) was found. Comparative to the study done on Eruvbi stream, Nigeria, the amount of DO recorded was 3.18 ± 1.01 mg/l (Imoobe and Koye, 2011). Similarly, the DO value recorded in the Gonder shinita River were 1.04 ± 0.47 mg/l (Ambachew, 2020) while the maximum DO was seen in Werabo River (5 ± 1.13 mg/l) in the downstream site. This illustrated that as more organic matter enters a body of water due to an overabundance of effluents, the number of decomposers will similarly rise. Because of their rapid development and high oxygen consumption, these decomposers cause oxygen levels to drop during the breakdown process, which can kill aquatic life. These circumstances further reduce the amount of oxygen in the air.

Temperature – The solubility of salts and gases, especially oxygen, in water, as well as the measurement of pH and the rate of chemical reactions, are all significantly influenced by temperature, thus it is an important factor that affects the quality and DO of water (Khan et al., 2016). The discharge of warm water from soap factory rises water temperature (Rangarajan et al., 2019). Similar to this, Bahirdar town's industrial effluent receiving water bodies have been found to have higher temperature values, with ranges of 15–20 °C (Milkiyas et al., 2011), Modjo River (21.5–24.93 °C) (Mulu et al., 2013), and Kebena River (17–21 °C) (CES/Compulsory Ethiopian Standard, 2013).

In addition, higher temperature was recorded on Sebata River from Ayika Addis Textile and Agro industry processing, which was 30.4 °C (Fekede et al., 2020). The lower temperature on site-I of the river was due to vegetation cover along on both riparian zones. An elevated temperature causes more pollution, which impacts biological cycles by decreasing dissolved oxygen activities (Gueddah, 2003). This can lead to major issues with sewage disposal (Shivsharan et al., 2013).

EC – The mean EC values measured in both water samples from Site 1 and Site 2 exceeded the minimum allowable limit (1500 mg/L) established by USEPA for aquatic life. This might be because the factory's effluent inflow contains ionic materials like phosphate, nitrates, and other salts. Since EC is affected by the presence of inorganic dissolved salts like chloride, nitrate, sulphate, phosphate, sodium, magnesium, calcium, iron and aluminum ions (Pleto et al., 2020; USEPA, 2009); the more ions in the water, the higher EC. Due to discharge from soap factory, the value of EC was beyond the recommended value of Ethiopian EPA, USEPA and WHO. With turbidity values ranging from 355 to 1859 $\mu S.cm^{-1}$, these values were higher than those reported by Gouafo et al. (2021) for industrial effluents from the SCS. Factors like wastewater from point source, runoff from non-point source, geological aspects of watershed, atmospheric inputs are that induce EC of water (Pal et al., 2015).

TDS – The value of TDS among site II and site III were exceeds from limits set by WHO and USEPA. According to Sisay (2000), wastewaters with high carbon content are among the high BOD wastes that contain animal fat released from soap factories, which raises the TDS in affected areas. Therefore, increased conductivity, temperature, oxygen depletion, and poor habitat quality may be caused primarily by a greater amount of total dissolved solids entering the river. TDS in drinking water should not exceed 500 mg/l according WHO guideline for drinking water (WHO, 2008).

EC and TDS are directly correlated (Singh et al., 2020). It influences the extent to which water dissolves both organic and inorganic salts and minerals. High TDS levels in rivers can be caused by salts and organic waste and sewage from factories (Matta, 2014), which can alter the water's flavor and taste (Howlader et al., 2017). Maximum TDS (675.25 mg/l) was recorded due effluents from Hafde Tannery on Sebeta River (Fekede et al., 2020).

According to Nadia and Mahmood (2006) discharge of wastewater with a high TDS level would have adverse impact on aquatic life, render the receiving water unfit for drinking and domestic purposes, reduce crop yield if used for irrigation, and exacerbate corrosion in water networks. The average value of TDS do not fit with standard value of WHO for drinking water (500 mg/l) (WHO, 2008; USEPA, 2009). High TDS water was unpalatable and potentially unhealthy for especially for human.

Salinity – Because of the chemical effluents from the factory, higher salinity values were found at the affected sites. As Gao et al. (2022) mentioned that untreated high-salinity wastewater discharge has the potential to seriously pollute the environment and harm terrestrial, aquatic, and wetland ecosystems which is leads to water mineralization, soil salinization, and water eutrophication. Khodapanah et al. (2009) stated that excess salt increases the osmotic pressure of the soil solution that can result in a physiological drought condition. Even though the field appears to have plenty of moisture, the plants wilt, because of insufficient water is being absorbed by the roots to replace the water lost from transpiration.

BOD – The mean BOD values the water samples collected from Site II and Site III were significantly above the maximum permissible value (30 mg/l) established by EEPA (2003). Compared with BOD value from Bahirdar Tannery (342 ± 52.5 mg/l) (Wosnie & Wondie, 2014) and Shinita River of Gonder (99.2 ± 18.58 mg/l) (Ambachew, 2020), it become much lower in Werabo River.

The quality of receiving surface water and the pollution caused by organic loading are both commonly assessed using the biochemical oxygen demand. It stands for the quantity of oxygen needed for the aerobic biological breakdown of organic matter at a standardized temperature (20 °C) and incubation period (often 5 days). It expresses the amount of oxygen required for microorganisms to oxidize a specific amount of organic matter. Nevertheless, even without decomposers, organic matter will oxidize chemically. Aquatic life suffers from low dissolved oxygen caused by high BOD (Jha et al., 2008).

TP – Higher mean values were observed in water samples collected from site II (20.5 ± 0.29 mg/l) and Site III (17.46 ± 1.6 mg/l) (Table 1). High TP concentrations harm water bodies by causing eutrophication, which ultimately results in the extinction of aquatic life. An increase in algae and aquatic weed development causes surface water to become eutrophic, which results in a scarcity of oxygen. The majority of attention has been on phosphorus inputs even though nitrogen and carbon are equally necessary for the growth of aquatic biota. Controlling phosphorus which is frequently the limiting element, is crucial to slowing the rate at which fresh waters are becoming eutrophic (Merian et al., 2004). High phosphorus intake disrupts calcium metabolism and causes bone loss in both humans and animals. Therefore, these factories ought to endeavor to decrease the amount of PO_4^{3-} that they discharge into the environment.

Nitrate – The measured mean values of nitrate in this study were higher than the permissible limit required by ETHEPA, USEPA and WHO (50 mg/l) for drinking water quality. In contrast to previous studies, the nitrate concentration levels found in the present study were higher than the nitrate value (4.99 ± 2.88 mg/l) found downstream of the BaleZaf Alcohol & Liquor and soap factory (Admasu, 2007) and the mean nitrate concentrations of 4.17 mg/l & 8.27 mg/l found in the Sebeta River, which was severely affected (Getachew, 2009).

Study conducted by Fekede et al. (2020) on Sebeta River revealed that the concentration of nitrate from effluent discharged Meta Abo Brewery (635 mg/l) were above the value of nitrate recorded in Werabo River. Nitrate value in both mentioned rivers were exceeding the standard value of WHO for drinking water. The nitrate contaminations were causes eutrophication and algal blooms (Jehan et al., 2020) which leads to deprive of oxygen. It also harm to human and animals which can causes methemoglobinemia, cancer, and abortion (Singh et al., 2020).

Sodium – The usage of sodium soaps and salts may be the cause of the sodium content. Certain drinking water naturally contains the mineral sodium. High blood pressure has been linked to excessive sodium intake; twenty milligrams of sodium per liter is recommended as a safe level. It is a significant cation that occurs in nature. One of the main sources of sodium in fresh water is sewage. High sodium water is also unsuitable for farming since it tends to degrade crop soils (Tekade et al., 2011). Water containing sodium chloride and sulfate is unfit for human consumption.

Potassium – The concentration of potassium was higher at sample sites II and III (120.3 ± 11.17 & 102.8 ± 9.05 mg/l). The mean potassium value was different from the WHO's maximum acceptable level (12 mg/l) for drinking water. Due to the soap factory's use of NaOH, KOH, silica, and oil as ingredients, the concentrations of potassium, sodium, and oil in samples II and III were evoked. Furthermore, phosphorus and nitrate abundance promote the growth of aquatic plants and algae in water bodies, resulting in eutrophication and algal blooming. The water body is harmed as a result of the decrease in oxygen concentrations that aquatic species require to survive (Perry et al., 2007).

Oil-grease – The measured average oil-grease levels were higher in the site II (590 ± 42.4 mg/l) and site III (102.8 ± 9.05 mg/l) than the recommended threshold of 5 mg/l. by WHO (2008). The presence of oil and grease in domestic and industrial wastewater is of concern to the public because of its deleterious aesthetic effect and its impact on aquatic life.

Regulations and norms have been established that bear monitoring of oil and grease in water and waste water. This test system provides a logical procedure to measure oil and grease in water and waste water. Oil and grease cause ecology damages for submarine organisms, factory, beast, and inversely, mutagenic and carcinogenic for mortal beings. They discharge from different sources to form a subcaste on water face that decreases dissolved oxygen. Oil and grease subcaste reduces natural exertion of treatment process where oil painting film conformation around microbes in suspended matter and water. This leads to drop dissolved oxygen situations in the water. Also oxygen motes are difficulty to be oxidative for microbial on hydrocarbon motes and beget ecology damages to water bodies.

Because of the fact that, there was high pH (basic) at downstream site of the river due to discharge of chemicals like NaOH, KOH, wax and Oil from the factory. This implies that, more of the organic and inorganic pollutants from effluents discharged were in combination rise the amounts of the above physiochemical parameters. Temperature was independent of other physicochemical parameters but it affect them since it was not as such difference in temperature among study sites ($P > 0.05$). The decomposition of organic waste which needs oxygen affects the physical and chemical characteristics of the river. Potassium and oil-grease were strongly correlated with each other than the rest parameters (Table3).

Water quality parameter

Water quality assessment in Ethiopia has substantially involved comparing the attention of water quality parameters to the WHO water quality standard. Based on a number of water quality parameters, the water quality indicator gives a single figure that represents the general state of the water at a specific place and time. The goal of the water quality indicator is to make complex data about water quality understandable and useful to the average person (WHO, 2008). WQI values for Werabo River are 179.5 and 231 for rain and spring seasons, respectively. The high values of WQI have been found in the spring season and a lower value in the rainy season. This is because of the high concentrations of pH, TDS, EC, salinity, phosphate, potassium, nitrates, and oil grease in the Werabo River water. The WQI values for both seasons of Werabo River exceeded the safest limit (i.e., WQI < 50) and are in the category of poor to very poor water quality (Table 4). Over time, the river system experienced the consequences of the wastewater discharge from the soap and detergent company. The system impact of this change can be measured by linking water quality to potential water use (Adimalla & Qian, 2019). In general, water quality indicators incorporate data from multiple water quality parameters into a fine equation that rates the health of a water body with a number (Yogendra & Puttaiah, 2008) (Table 5).

In general, the study's discussed that the mean concentrations of pH, temperature, EC, saltiness, TDS, BOD, phosphate, nitrate, potassium, sodium, and oil and grease varied significantly between the tested locations. The affected point (point II) had high mean values, while point III had lower mean values than point I. Additionally, because the top location had less interference than the two downstream spots, grandly DO was observed there. Dissolved oxygen is essential for the survival of the aerobic organisms present in the water body. In addition, microorganisms like bacteria and fungi use the dissolved oxygen to putrefy the organic material at the bottom of the water, which contributes to the recycling of nutrients. The high values of dissolved oxygen suggest that further photosynthesis is being produced by the shops than microorganism's consumption, while the low values suggest that the oxygen is being consumed briskly than it's produced, negatively affecting fish and invertebrate populations. In fact, their concentration in the impacted points did not fit with standard value designed by EPA (2003) of Ethiopia. For example, the Environmental Protection Agency of Ethiopia (EPA, 2003) set a standard to EC of 1000 μs/ cm for any surface water, although the EC in fresh water ranges from 10 to 1000 μs/ cm (Chapman and Kimaster, 1996).

The Werabo River's downstream sites exhibited conductivity levels beyond the lowest acceptable limit in comparison to these standards. This is a clear suggestion that the water in the swash wasn't safe both to humans and other domestic creatures. The degradation and mineralization of organic materials at the discharge point (point II) and downstream point III, as well as the backwater discharged from the Woliso detergent factory, is the causes of the elevated conditions of those physicochemical parameters. This has natural relevance since it disrupts the ecosystem's fragile ecological balance, reduces the number of creatures, and causes the sluice's once-depleted biodiversity to disappear (Imoobe & Ohiozebau, 2009). Downstream, the majority of these affected parameters seem to have smoothly returned to their initial state.

According to UNEPA (2019), the high concentration of oil and grease destroys physical goods, such as sheeting animals and shops with oil paint and suffocating them by oxygen reduction; it is poisonous and forms poisonous products; it destroys future and existing food inventories, breeding creatures, and territories; it produces rancid odors; it fouls plages; it clogs water treatment shops; it affects submarine life by reducing both the penetration of light and the oxygen transfer between air and water; it catches fire when ignition sources are present; and it forms products that linger in the terrain for a long time.

Table 4
Demonstrates how the Water Quality Index is used to classify the state of the water.

Quality Class	WQI value	Water Quality Status	References
I	<50	Excellent	Bhaven et al., 2011; Srinivasa and Padaki, 2012; Ramakrishnaiah et al., 2009
II	50–100	Good Water	
III	100–200	Poor water	
IV	200–300	Very poor water	
V	>300	Water unsuitable for drinking	

For the purpose of calculation of WQI for Werabo River, twelve water quality parameters have been selected, which included pH, temperature, DO, TDS, EC, salinity, BOD, PO_4^{3-}, NO_3^-, Na, K, and oil grease. The results of estimated WQI values are summarized in Table 4. The results showed that the WQI values for Werabo River are 179.5 and 231 for rain and spring seasons, respectively.

Table 5
Water Quality Index computation for the initial sample (Rainy Season (a) and spring season (b)).

Parameters	Sn	1/Sn	∑1/Sn	K = 1/∑1/Sn	Wn = K/Sn	Vo	Vn	Vn/Sn	Qn = Vn/Sn*100	WnQn
a. Rain season										
pH	8.5	0.118	0.5733	1.744	0.2052	7	8.17	0.96	96	19.69
DO	6	0.167	0.5733	1.744	0.2906	14.5	2.35	0.39	39	11.3
Temp.	30	0.033	0.5733	1.744	0.0581	0	17.37	0.58	58	3.36
EE	1500	0.0007	0.5733	1.744	0.0012	0	895.53	0.59	59	0.07
TDS	500	0.002	0.5733	1.744	0.0035	0	446.93	0.88	88	0.31
BOD	300	0.003	0.5733	1.744	0.0058	0	19.76	0.066	6.6	0.04
Salinity	600	0.0016	0.5733	1.744	0.0029	0	441.73	0.74	74	0.21
PO_4^{3-}	10	0.1	0.5733	1.744	0.1744	0	11.9	1.19	119	20.75
NO_3^-	20	0.05	0.5733	1.744	0.0872	0	58.3	2.92	292	25.46
Na	200	0.005	0.5733	1.744	0.0087	0	43.83	0.22	22	0.19
K	12	0.083	0.5733	1.744	0.1453	0	76.03	6.34	634	92.12
Oil-grease	100	0.01	0.5733	1.744	0.0174	0	345.6	3.45	345	6.01
Sum		0.5733		∑Wn	1.0003				∑WnQn	179.5
b. Spring season										
pH	8.5	0.118	0.5733	1.744	0.2052	7	9.65	1.14	114	23.39
DO	6	0.167	0.5733	1.744	0.2906	14.5	3.31	0.55	55	15.98
Temp.	30	0.033	0.5733	1.744	0.0581	0	17.16	0.57	57	3.31
EE	1500	0.0007	0.5733	1.744	0.0012	0	1389.4	0.93	93	0.11
TDS	500	0.002	0.5733	1.744	0.0035	0	854.9	1.71	171	0.59
BOD	300	0.003	0.5733	1.744	0.0058	0	23.96	0.079	7.9	0.05
Salinity	600	0.0016	0.5733	1.744	0.0029	0	825.26	1.375	137.5	0.39
PO_4^{3-}	10	0.1	0.5733	1.744	0.1744	0	14.35	1.44	144	25.1
NO_3^-	20	0.05	0.5733	1.744	0.0872	0	140.76	7.038	703.8	61.37
Na	200	0.005	0.5733	1.744	0.0087	0	44.63	0.223	22.3	0.19
K	12	0.083	0.5733	1.744	0.1453	0	77.96	6.49	649	94.3
Oil-grease	100	0.01	0.5733	1.744	0.0174	0	358.13	3.58	358	6.22
Sum		0.573		∑Wn	1.0003				∑WnQn	231

Note: WQI < 50 denotes excellent water, 50–100 denotes equitable water, 100–200 denotes poor water, 200–300 indicates very poor water, and >300 indicates unfit for human consumption. WQI value.

The quality of the river water downstream of a soap factory effluent discharge point has significantly declined, according to this study. Electrical conductivity (EC), total dissolved solids (TDS), salinity, biochemical oxygen demand (BOD), phosphate, nitrate, sodium, potassium, and oil and grease are all higher downstream than at the upstream control site. Dissolved oxygen (DO) levels notably decreased, suggesting a decline in water quality and possible ecological stress.

The most significant increases were seen in BOD (from 8.05 to 33.5 mg/L), phosphate (from 1.41 to 20.5 mg/L), and oil and grease (from 11.6 to 590 mg/L), all of which are directly related to the processes used to make soap. Risks of eutrophication are also indicated by the increase in temperature and pH as well as by excessive nutrient loads, particularly phosphate and nitrate.

This study has particular significance because it focuses on an understudied topic: the environmental effects of soap industry effluents on stream ecosystems. The study provides important insights into the contribution of the soap industry to freshwater pollution by examining the distinct pollutant profile typical of soap production. The results validate the necessity of regulatory supervision and focused wastewater treatment.

For clarify and compare the result obtained from phyisco-chemical parameters, similar studies from indoor and outdoor source were obtained.

Level of perceived impact of water pollution on human health

According to the respondents, peoples in the area uses the contaminated stream for the sake of drinking cattle's (79.8 %), bathing (19.4 %), and 29.86 % could be used for irrigation purpose rather than drinking. From this, majority of cattle's were died due to water contamination. Farmers near to factory were used the stream for irrigation purpose. Most of the time, they cultivated cabbage, salad, tomato, onion, potato, carrot, Red beet and green pepper which is indirectly affect the health human.

The researcher find out that, 49.3 % the respondents were poor feeling or perception on the condition of the impact of water pollution on human health and aquatic ecology. Perhaps, 29.2 % and 12.5 % of the respondents have fair and good perception of waste water that affect health and ecology of the stream while the rest 9.03 % were better feeling on the entire impact. As the response from respondents indicates that, out of water borne diseases, 35 % of dysentery related was highest in the area. Cholera, Typhoid, Respiratory infection and others accounts 12 %, 22 %, 26 % and 5 % respectively (Fig. 3).

Almost 95.2 % of the respondents agreed that the factory emits wastewater without any per-treatment to nearby Werabo River. According to the respondents, too much trash, toxic chemicals, sediments and other waste were discharged to the river. The local communities

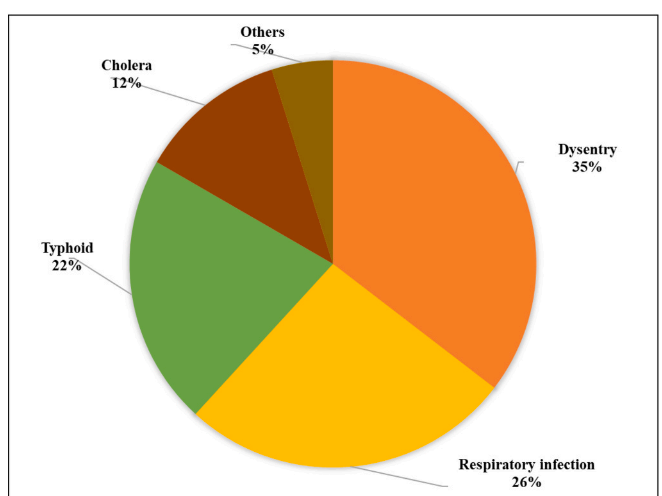

Fig. 3. Showing common infectious diseases in the study area.

induce to re-evoke the impact of waste water through community participation, avoidance of using water for domestic/agricultural purpose, convincing with owners to reduce the amount of discharge.

In general, the key informants (KI) and experts from Woliso Town Environmental protection office depicted the following key points.

1. Impact on the environment and humans: There is a negative impact of waste from the factory, which adversely affects the physical characteristics of water, like changing the color, smell (fouling) of water, PH, etc. The smoke released to the atmosphere is also another challenge to the health of community, which results in respiratory infections. The other risk that sometimes occurred was the burning (explosive) of some parts of the factory due to excessive heating, which damaged the property of the factory and resulted in frustration for the community.
2. Socioeconomic: Positively, the owners take part in the community services by donating money and soap for the community as far as possible, planting trees, providing economic support for the town in the developmental projects, and reducing the work less youth by employing them in the factory.
3. The Role of owner to mitigate the problem: As far as they are concerned, they have to carry out the most advanced treatment strategies since they used primary treatment for their engagement. Furthermore, after treatment, it is better to reuse the water for other purposes.

Finally, all participants argued that the federal, state, and local governments are expected to implement laws, principles, and regulations amended for EIA. Regular supervision, control, and environmental auditing are the main duties of environmental expertise to minimize the problems encountered.

Conclusions and outlooks

Globally, industrial activities are endangering biological life and the water ecology. According to this study, the receiving water and nearby towns were significantly impacted by the wastewater released by soap and detergent factories. The effects of trash on the ecosystem and people were outweighed by all data tabulated from physicochemical parameters, WQI, and interviews. Even if the soap industry contributes to the nation's economic growth, it also has a detrimental effect on the water quality, local residents' health, and aquatic life. Nearly every number in the physicochemical parameters exceeded both national and international standards. The study's findings demonstrated that the river water downstream has been tainted by the soap and detergent factory's wastewater.

This study explores a topic that hasn't gotten much concentrated attention: the precise effects of soap factory wastewater on river water quality. This study looks at the distinct chemical components of soap effluents, like phosphates and surfactants, and their effects on the ecosystem of the river, in contrast to general studies on industrial pollution. The study offers fresh perspectives on the effects of soap industry discharges on aquatic life and water quality by fusing field sampling and laboratory analysis. It also offers useful suggestions for better wastewater management.

The results of this research showed that the Werabo River's water quality has declined. The deterioration of the Werabo River ecosystem as a result of receiving wastewater has also been conveyed by the water quality index. The effluents from the Woliso Soap and Detergent plant have probably caused biological systems to be harmed by this situation, which may ultimately limit the water ecosystem's ability to offer its ecosystem goods and services to the local population. The information gathered from the local community and expert interviews best illustrates how the discharge of effluents into the river had a detrimental impact on the water's quality as well as the socioeconomic and health conditions of the community. The polluted water used for washing clothes, drinking cattle's and irrigation at the downstream site.

The study demonstrated that for the Werabo River's health and efficient use, regulatory agencies must pay attention to the effluents released from the factory. This process aids in identifying, addressing, and reducing environmental risks. All of these conditions are maintained through the use of best management practices or wastewater treatment techniques, such as wastewater treatment (pond system), vegetation buffer preparation, wastewater recycling, and appropriate wastewater disposal. Therefore, regardless of the irrigated water and its potential effects on the ecosystem and human health, environmental agencies and researchers have a strong case to do additional research. We can maintain the safety of both people and the environment by conducting environmental audits and assessments, which benefits the local community.

Consent for publication

The authors have agreed to submit and approved the manuscript for submission.

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CRediT authorship contribution statement

Abiy Gezahegn: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Lemessa B. Merga:** Writing – original draft, Formal analysis. **Siraj Mammo:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be available on reasonable request.

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