Future Technology
Open Access Journal
ISSN 2832-0379
February 2023| Volume 02 | Issue 01 | Pages 62-70
Journal homepage: https://fupubco.com/futech
https://doi.org/10.55670/fpll.futech.2.1.5
Future Publishing LLC

Review

Physicochemical properties of wastewater effluents from selected wastewater treatment plants

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ARTICLE INFO

Article history:
Received 25 August 2022
Received in revised form
24 September 2022
Accepted 28 September 2022

Keywords:
Physicochemical, Wastewater, Effluent

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DOI: 10.55670/fpll.futech.2.1.5

ABSTRACT

The majority of garbage that is dumped into the environment is the consequence of industrial activity, and this waste contains toxic and dangerous substances that have properties. Untreated industrial effluents have repeatedly affected the environment and human health. Additionally, the aim of this review is to determine if water treatment conforms to DWAF and USEPA criteria and to evaluate specific wastewater treatment facilities. Additionally, the effluent from companies was assessed after being collected utilizing composite sampling methods. The findings recognized pH, rivers, and industrial activities. This is a warning sign that the water is unsafe, demonstrating that industrial effluents are contributing to a reduction in river water quality. Receiving water near numerous food-processing facilities showed significant reductions after effluent discharge. As a result, when developing mitigation strategies, governments should consider this. Some of these strategies are enforcing the pollution laws that are already in place; setting up treatment facilities; turning industrial waste into biogas; educating the public; starting programs; and passing laws.

1. Introduction

Water is a fundamental resource that ensures the existence of all life on Earth. Water scarcity is a global phenomenon caused by a decrease in the quantity and quality of freshwater resources available to humans and ecosystems [1]. Globally, 2.1 billion people do not have access to safe drinking water, and approximately 4.5 billion do not have access to adequate sanitation [2]. Freshwater scarcity has been a major issue in many African countries, including South Africa, as well as in some developed countries [1, 3, 4]. According to a recent UN prediction, two-thirds of the world's population will face water scarcity by 2025 if immediate action is not taken [3]. However, due to its scarcity and contamination, millions of people have limited access to this essential resource. Similar to how oil spills happen, pesticides used in agricultural areas find their way to food distribution networks through subsurface pathways. As a result, it is our duty to remediate contaminated water and prevent further pollution. If not, we will experience a water shortage. It will ultimately result in the loss of all life. As a result, the proverb

"Half a loaf is better than no bread" is true. Simply put, "anything is better than nothing" is the message. That implies that treating water to save it is preferable to wasting it [5]. The integration of the three factors of environmental, economic, and social sustainability should be considered. Economic sustainability indicates that expenditures should not be incurred in excess of benefits. Environmental sustainability is the practice of preserving the environment for future generations while reducing emissions and protecting natural resources. Social factors play a role in sustainability [6]. The education that creates public awareness is the foundation of the social dimension. In reality, sustainable development can only be realized in a community that feels accountable for it, recognizes the difficulties, and is willing to live with the results of taking the right steps. The primary responsibility of the wastewater treatment system is to safeguard aquatic life. Low-cost wastewater treatment technologies must be used for this policy to be put into action. The efficiency of wastewater treatment is increased, energy consumption is simultaneously decreased (lowering CO_2 emissions), and waste formation is minimized. Additionally, because the neighborhood is subjected to the negative impacts of the wastewater treatment plant's work, awareness of the issue there must be growing as well. The expense of wastewater treatment and the environmental advantages of reducing water pollution should be balanced in order to discover the optimal path toward sustainable regional development [7]. The world's increasing industrialization and global expansion have led to greater awareness of how operations produce waste and contaminate the environment. A small number of enterprises that lack infrastructure for waste treatment and pollution management [8] cause the majority of pollution. In developing countries like Nigeria, the bulk of companies discharge their effluents untreated. These industrial effluents have complex effects on running streams and threaten the environment and water quality [5]. According to studies by [9, 10], and others, the majority of toxic and hazardous compounds discovered in industrial waste and emissions are dangerous to human health [7]. When looking at trace element contamination, it is important to know what kinds of chemical species are found in industrial environments and where they come from [6]. Even while industrialization is inevitable, several terrible ecological and human tragedies that have lasted over the past 40 years indicate the sector's all sizes [11]. Over-exploration followed by recharging, lax law enforcement and poor governance are all on the decline [12]; [13, 14]. Many researchers have studied the physicochemical analysis of industrial effluent. This study investigated the receiving and effluent businesses. In addition, regular open dumping of waste into the environment by these businesses has a detrimental effect on the local population, animals, wetland ecosystems, and vegetable fields. A high concentration of physicochemicals that could affect the ecosystem could result from surface water contamination. This review acknowledges various physicochemical qualities of effluents from important enterprises in order to investigate the characteristics of their operations.

2. Discussion

2.1 Three main Characteristics of Wastewater

1. Physical Characteristics of Wastewater

A. Color: Fresh sewage is normally brown and yellowish in color but, over time, becomes black in color.

B. Odor: Wastewater that includes sewage typically develops a strong odor.

C. Temperature: Due to more biological activity, wastewater will have a higher temperature.

D. Turbidity: Due to suspended solids in wastewater, wastewater will have higher turbidity or cloudiness.

2. Chemical Characteristics of Wastewater

A. Chemical Oxygen Demand (COD): COD is a measure of organic materials in wastewater in terms of the oxygen required to oxidize the organic materials.

B. Total Organic Carbon (TOC): TOC is a measure of carbon within organic materials.

C. Nitrogen: Organic nitrogen is the amount of nitrogen present in organic compounds.

D. Phosphorous: Organic phosphorous (in protein) and inorganic phosphorous (phosphates, PO_4)

E. Chlorides (Cl^-), Sulfates (SO_{4-2}), Heavy metals, Mercury (Hg), Arsenic (As), Lead (Pb), Zinc (Zn), Cadmium (Cd), Copper (Cu), Nickel (Ni), Chromium (Cr), Silver (Ag)

3. Biological Characteristics of Wastewater

A. Biochemical Oxygen Demand (BOD): BOD is the amount of oxygen needed to stabilize organic matter using microorganisms.

B. Nitrogenous Oxygen Demand (NOD): NOD is the amount of oxygen needed to convert organic and ammonia nitrogen into nitrates by nitrifying bacteria.

C. Microbial life in wastewater: Wastewater contains the following microbes:

D. Bacteria, Protozoa, Fungi, Viruses, Algae, Rotifers, Nematodes

2.2 Electrical conductivity (EC)

With the exception of the manufacturing of wine and alcoholic beverages, Arbamich textile, and Mahiber textile, the EC ranged from 1200 to 1870 s/cm (Table 1 in Appendix I). All other industries had values over the advised tolerable limit [15]. The highest concentration of EC was seen in the local agriculture and tannery businesses (Table 1 in Appendix I).

2.3 Analyzing the physicochemical characteristics of industrial wastes (2019)

2.3.1. pH and temperature

Table 2 in Appendix I displays the outcomes of the physicochemical parameters study of the factory wastes during the field survey (2019). In the tannery during the dry season, the alcohols and liquors during both seasons, and in the alcohols and liquors factory, the pH varied between 4.5 and 4.7 log units (Table 2 in Appendix I). The tannery and wine and liquor plants' low pH readings show how acidic the region's discharged effluents are. Additionally, the recorded pH levels were higher than the 6.5–8.5 log unit range suggested by [15]. The tannery and the wine and liquor industries, in particular, became aware of the low pH concentration value.

2.3.2. Electrical conductivity, EC

With the exception of the upper stream (Table 2 of FDRE EPA 2003), all sample locations had EC values that were higher than the allowed limit. Here, the EC value ranged from 2389 to 10450 s/cm. For instance, the tannery had an EC value of 10,470.05 s/cm at 25°C during the dry season. The industries with the highest EC concentration values in 2019 were tannery (10470 mg/L in wet and 10450 mg/L in dry), textile (5710 mg/L in wet), and brewery in both dry (5423 mg/L) and wet (5450 mg/L) (Table 2 in Appendix I).

2.3.3. BOD and COD

The BOD readings, which ranged from 20 to 460 mg/L, were higher than the WHO-allowable limit of 6 mg/L (Table 2 in Appendix I). COD and BOD had the highest physicochemical concentration values in the region. In both the dry and wet seasons, elevated COD concentration levels were observed in the tannery, wine, and liquor industries. The wine, booze, and tanning industries had the highest BOD content levels. Table 2 shows that the following physical and chemical properties often got worse in this order: pH, temperature, TN, ammonia, COD, and BOD.

2.4 The physiochemical properties of the arriving waters and effluents

Tables 3 and 4 in Appendix I display the physiochemical characteristics of the incoming waters and effluents from each of the evaluated food-processing industries. The obtained pH range falls within the 5–9 range recommended by FEPA [2], with the exception of solids. Sectors varied noticeably. Industrial effluents from oil processing had a significantly higher level of dissolved oxygen. After effluent discharge, receiving water near several food-processing facilities exhibited notable drops in discharge, COD rose thresholds, or according to FEPA [2]. The effluents from the following oil processing companies had the highest BOD concentrations: Best Oils (149.00 mg/l), Sword Sweet (142.00 mg/l), EFCO (161.00 mg/l), and Premier Agro Oil (180.00 mg/l). All of the industries' obtained BOD and COD values (30 and 40 mg/l, respectively) were much higher than the recommended guidelines by FEPA [2]. As stated by UKEPA (1993), the wastewater from food processing industries contains a variety of organic contaminants in addition to some lost products. The permitted COD for effluents from these sectors is 150 mg/l. These substances combine with part of the oxygen that has been dissolved in the water during the oxidation process. Therefore, consumption reliable sign presence says the chlorinated and extracted organic halides that can be absorbed have caused toxicological concerns in the past. Following the effluents' discharge into the receiving water, the BOD tests revealed that a significant amount of oxygen (mg/l) was needed to oxidize these products. Readings were typically greater because COD measures the oxygen consumption of both biodegradable and non-biodegradable pollutants. If the numbers were high, it could mean that a lot of the product went into the waste stream.

2.5 Methodical approach and a resolution to the issue

A methodical approach to wastewater repair is essential for the best and most efficient chemical and water-intensive businesses, with an emphasis on water recycling and reuse along with the healing of priceless chemical substances. This necessitates a simple description of the wastewater as well as information on the concentrations and types of contaminants present. A systematic approach to wastewater repair with a targeted emphasis on water recycling and reuse combined with the healing of priceless chemical compounds is extremely important, especially for highly specialized chemical and water-intensive businesses. In addition to the data volumes and versions inside the pollutant concentrations or degrees, this also comprises the fundamental wastewater properties. A schematic flowchart of the important factors that influence the choice of the right era is shown in Figure 1. Given the information that is now available on the procedure and effluent, it is critical to describe the annoyance and needs. The next stage is to list every technically possible method for handling the waste. If healing is important, it is required to define and rank the specific healing strategies. It is essential that you comprehend how these strategies interact with one another in order to increase the overall effluent treatment operation's performance. This assessment identifies the technology for primary, secondary, and tertiary (if required) treatment; a techno-economic feasibility study is then required. At this time, it is also important to consider procedural integration options. Because these changes affect the whole treatment plan, the process of choosing the right strategies or medications must be done repeatedly until the best and most technologically possible option is found.

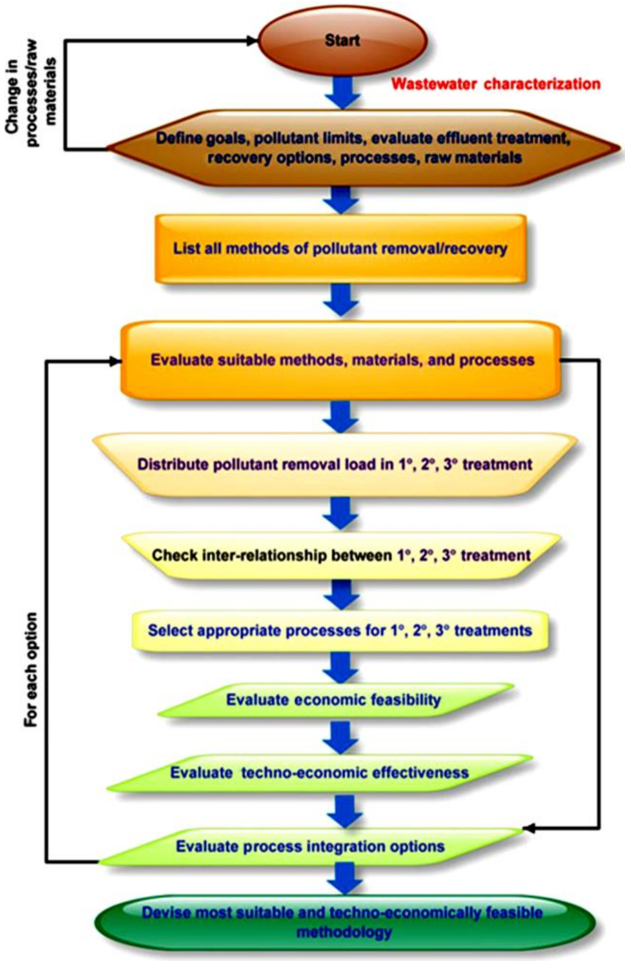

Figure 1. The decision-making process for treating industrial wastewater

2.6 Factors on which the design of sewage treatment plant depends

2.6.1 Plant Location

The location of the plant has to be a certain distance from residential areas. The direction of prevailing winds to reduce the effect of fumes. A treatment plant should be built far enough away from sources of drinking water, groundwater wells, and surface water intakes to keep them from being contaminated.

2.6.2 Flood Protection

The plant should not be constructed on a site susceptible to flooding. Investigations should be done to check flood susceptibility. To ensure protection from any future flood event, sufficient safeguards need to be installed for the electronic, mechanical, and physical components of the plant.

Flood plain regulations of provincial, federal, and municipal agencies should be followed.

2.6.3 Technology Selection

There are three main types of sewage water treatment processes: mechanical, chemical, and biological. Some processes are better suited for larger volumes, while others are for smaller volumes. Depending upon the requirements, a selection of plants is made.

2.6.4 Determination of Capacity

A survey has to be conducted to calculate the capacity of a region. This gives an idea of the average daily flow, minimal daily flow, and peak hour flow of the wastewater generated in a day. For a sewage treatment plant to work at its optimal capacity, effluent should be within a certain range. If a plant is running on volume less than capacity, then it will not work properly. Similarly, if a plant is overloaded, it will be just as ineffective. Capacity should be determined with future expansion in mind so that it can be increased without causing major disruptions in plant operations.

2.6.5 Ensuring Supporting Infrastructure

A thorough treatment facility requires a full supporting infrastructure, including sewage pipes for bringing in and discharging effluent as well as power. The plant's performance is hampered by frequent electrical failures, which reduces its effectiveness. Alternatives must be found, particularly for electricity sources.

2.6.6 Calculate Revenues

Many sewage treatment plants fail due to a lack of planning and revenues. For a sustainable installation, there has to be a revenue source. By taking into account labor, electricity, and other operating costs, revenue should be planned. STPs also need to be taken care of regularly. For example, screens need to be replaced on a regular basis so that they can do their job.

2.6.7 Discharge Management

The leftovers after the wastewater has been treated are very toxic in nature and must be disposed of in a responsible manner. There are certain rules regarding disposal that should be followed.

2.6.8 Manpower Training

Trainees are required for the proper functioning of STP and for regular maintenance of the plant.

2.7 Design of wastewater treatment plant for the removal of metals ions from the tannery industry

Water from tanning operations pollutes our environment severely. One of the main sources of pollution in our environment is the tannery industry. The process of turning raw animal skin into leather is called tanning. The trash or pollutants from animal skins or hides, as well as chemicals and other harmful substances, are found in the effluent from tanning industries. The majority of the harmful metal ions found in tannery wastewater, including cadmium, cobalt, lead, nickel, chromium, etc., are harmful to our environment because of tannery wastewater. This method of tanning makes our environment have more organic matter, chromium salts in the water, etc. Wastewater treatment facilities must be built in order to remove metal ions from tannery enterprises. To do that, we must take steps to preserve our aquatic life. They are;

Step 1: Flotation technique

Adsorption method Metal ions in wastewater can be removed by an ion exchange method. Chemical precipitation treatments of wastewater, electrochemical reduction, reverse osmosis method, industrial electroplating of wastewater, etc. Effective treatment of wastewater is essential since it carries many types of risks, including life-threatening human pathogens. Talk about the different steps and methods that are used at the wastewater treatment plant today. Explain how these steps and methods remove contaminants and biological risks from wastewater so that it can be safely released. The first two phases, referred to as screening and pumping; involve removing oil, plastics, rags, and wood fragments from the entering wastewater using screening equipment. Before the waste is dumped in a landfill, it is cleaned and compressed. The grit removal phase is where the screened wastewater is pumped afterward.

Step 2: Eliminating the Grit

In this stage, sand and gravel, and other heavy but fine materials are removed from the effluent. A landfill is also used to dispose of this garbage.

Step 3: Initial Settlement

The material is removed using huge circular tanks known as clarifiers; it will settle, albeit more slowly than in stage two. While the wastewater departs from the top of the tank, the settled material, often referred to as primary sludge, is forced out of the bottom. Grease and other floatable waste are scraped off the top and transferred to digesters with the settled waste. At this time, chemicals are also used to remove phosphorus.

Step 4: Aeration/Activated Sludge

In this step, the majority of the wastewater treatment is completed. Through biological breakdown, the pollutants are transformed into cell tissue, water, and nitrogen after being ingested by microbes. Since it takes years for lakes and rivers to decompose, there is a lot of biological activity in this step that is comparable to what occurs there.

Step 5: Following Settlement

The treated wastewater is now over 90% treated at this stage thanks to big circular tanks called secondary clarifiers, which enable it to separate from the biological waste in the aeration tanks. Step 5 involves continuously pumping the biology (activated sludge) out of the bottom of the clarifiers and back into the aeration tanks.

Step 6: Filtration

By filtering the cleaned effluent through a polyester medium with a 10-micron mesh size, this procedure polishes it. The material that collects on the disc filters' surfaces is routinely backwashed and sent back to the plant's head for processing.

Step 7: Disinfection

UV disinfection is used to make sure that the treated wastewater is almost bacteria-free after the filtration stage. We return to compliance with our discharge permit when the ultraviolet treatment eliminates any remaining microorganisms.

Step 8: Oxygen Absorption

To raise the dissolved oxygen content to the acceptable level, the treated water may need to be aerated. The treated water is then released into the Oconomowoc River via the effluent outfall after being processed. The tight guidelines of the DNR must be followed when water is discharged into a river. Reduction in pollution is maintained at 98% or above.

3. Conclusion

This study looked into the physicochemical characteristics of industrial effluents that indicate localized environmental pollution. The area's water quality was compared to the international standard while determining the concentration of physicochemical properties. The levels of BOD, COD, and TSS were higher than the WHO-recommended guidelines, indicating local water contamination. The effluents from all the industries evaluated between 2016 and 2019 showed a similar pattern. The effluents from alcoholic beverages, distilled spirits, and tannery facilities in 2017 had PH concentration values that were higher than allowed. In all industries during 2019, with the exception of stream, the level of physicochemicals including temperature, BOD, COD, EC, TSS, TN, and TP showed statistical significance. This review has demonstrated that the effluent discharge from the deemed food industry has a considerable impact on receiving water and soil quality. For improved removal of phosphorus, phosphates, acids, metals, and other compounds from wastewater, more current separation technology may be used. Eventually, "intelligent" or "smart" substances will be able to identify and produce harmful pollutants or precious values, improving, deterring, or destroying those chemical substances in an efficient and environmentally friendly way. So, in the future, we may have better technology and ideas for processing effluent in a way that is good for the environment and for recycling and reusing water. Studies that are more extensive are needed to fully comprehend the behavior of the physiochemical characteristics of wastewater effluent from selected wastewater treatment plants. In addition, you should learn how plants work so that you can compare or evaluate them in the future. It is vital to emphasize that there is currently very little knowledge about created studies. Pay close attention to any possible production of hazardous or pharmacologically active compounds during the course of treatment. Research must also be done on the presence, disposition, and removal of human metabolites in UWTPs and how quickly these substances degrade in aquatic environments.

Ethical issue

The authors are aware of and comply with best practices in publication ethics, specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The authors adhere to publication requirements that the submitted work is original and has not been published elsewhere.

Data availability statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflict of interest

The authors declare no potential conflict of interest.

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Appendix I

Table 1. Industry-specific physicochemical parameter analysis (2016–2018)

Year	Industries	Temperature °C	EC, μs/cm	pH	BOD, mg/L	COD, mg/L	TSS, mg/L	Ammonia, mg/L	TN, mg/L	TP, mg/L
2016	Arbamich Textile S.C	37.2	887	8.59	37.2	115.75	15	ND	4.33	2.18
	Mahavier Textile Plc	32	920	6.95	144	44.16	25	12.89	24	12
	Jiadong Textile plc	29	1210	7.03	89.62	714	23.33	2.83	ND	1.04
2017	Meta Abo Brewery S.c	23	1320	8.3	240	90	ND	1.71	17.32	5.47
	Balezaf Alcohol and Liquors	28	876	4	4880	14928	860	17.8	151.41	11.1
	Sabata Agroindustry	25	1560	6.46	300	711.2	770	10.48	18.72	3.63
	Hafede Tannery	31	1780	4.7	1024	2517.33	135	49.79	565.08	4.1
	Ayka Addis Textile and Investment Group	34	1320	6.5	42.24	157.92	10	0.53	13.64	2.4
2018	Ayka Addis Textile and Investment Group	21	1200	7.31	173.64	352.8	290	39.06	58.59	1.91

NB: ND means not detected.

Table 2. Results of physicochemical characteristics of industrial effluents (2019)

Seasons	Sampling sites	Temperature, °C	EC, µs/cm	pH	BOD, mg/L	COD, mg/L	TSS, mg/L	Ammonia, mg/L	TN, mg/L	TP, mg/L
Wet	Ayka Addis Textile	30	5700	7.8	35	33	41.3	28	34	0.5
	Meta Abo Brewery	18	5400	4.5	270	150	132.3	68	83	11.5
	Alcohol and Liquors	25	2389	4.5	ND	2380	143.3	60	70	2.2
	Hafde Tannery	21	10450	7.5	460	4970	621.5	670	810	30.2
	Agro-industry	30.1	5489	7.7	45	37	34.2	28	23	0.4
	Upper stream	22	603	7.4	20	24	21.3	10	13	0.0001
	Upper stream	22	603	7.4	20	24	21.3	10	13	0.0001
Dry	Ayka Addis Textile	30.8	5710	7.9	38	58	44	4.5	33	0.0001
	Meta Abo Brewery	23.8	5450	8.6	148	271	148	30.5	250	11.6
	Alcohol and Liquors	26	2390	4.7	ND	2900	228	2	25	1.4
	Hafde Tannery	21.9	10470	4.95	464	5450	725	51	460	3.1
	Agro-industry	30.7	5490	7.7	46	55	47	6	36	0.0001
	Upper stream	22.5	604	7.5	22	27	34	3.5	10	0.0001
	Downstream	29	5410	7	256	1025	248	2	38	1.4
Range	Ayka Addis Textile	30–30.8	5700–5710	7.8–7.9	35–38	33–38	41.3–44	4.5–28	33–34	0.5–0.0001
	Meta Abo Brewery	18–23.8	5400–5450	4.5–8.6	148–270	150–271	132.3–148	30.5–68	83–250	11.5–11.6
	Alcohol and Liquors	25–26	2389–2390	4.5–4.7	ND	2380–2900	143.3–228	2–60	25–70	1.4–2.2

	Hafde Tannery	21–21.9	10450–10470	4.95–7.5	460–464	4970–5450	621.5–725	51–670	460–810	3.1–30.2
	Agro-industry	30.1–30.7	5489–5490	7.7	45–46	37–55	34.2–47	6–28	23–36	0.4–0.0001
	Upper stream	22–22.5	603–604	7.4–7.5	20–22	24–27	21.3–34	3.5–10	10–13	0.0001
	Downstream	28–29	5360–5410	6.5–7	253–256	310–1025	176.3–248	2–240	38–290	1.4
Mean	Ayka Addis Textile	30.4	5705.0	7.85	36.5	35.5	42.65	16.25	33.5	0.25
	Meta Abo Brewery	20.9	5425.0	6.55	209	210.5	140.15	49.25	166.5	11.55
	Alcohol and Liquors	25.5	2389.5	4.6	ND	2640	185.65	31	47.5	1.8
	Hafde Tannery	21.45	10460.0	6.23	462	5210	673.25	360.5	635	16.65
	Agro-industry	30.4	5489.5	7.7	45.5	46	40.6	17	29.5	0.20
	Upper stream	22.25	603.5	7.45	21	25.5	27.65	6.75	11.5	0.0001
	Downstream	28.5	5385	6.75	254.5	667.5	132.15	121	164	1.4

Table 3. The average physicochemical characteristics of receiving waters and effluents from the beverage industries

Industry	Location	pH	Electrical Conductivity	Hardness	Turbidity	Dissolved Solids	Total Solids	Dissolved Oxygen	BOD	COD
FAN Milk	Effluent	10.20 ±0.29	14.00 ± 0.40	100.00 ± 2.89	152.00 ± 4.39	1600.00 ± 46.19	3400.00 ± 98.15	17.41 ± 0.50	95.00 ± 2.74	136.00 ± 3.93
	RW (Upper)	8.60 ± 0.25	29.13 ± 0.84	61.00 ± 1.76	6.29 ± 0.18	300.00 ± 8.66	800.00 ± 23.09	7.80 ± 0.23	53.00 ± 1.53	125.00 ± 3.61
	RW (Lower)	7.30 ± 0.21	7.25 ± 0.21	53.00 ± 1.53	7.29 ± 0.21	250.00 ± 7.22	950.00 ± 27.42	9.60 ± 0.28	37.69 ± 1.09	84.00 ± 2.42
NBL	Effluent	6.50 ± 0.19	1.70 ± 0.05	50.00 ± 1.44	ND	300.00 ± 8.66	1000.00 ± 28.87	13.00 ± 0.38	72.00 ± 2.08	63.00 ± 1.82
	RW (Upper)	7.90 ± 0.23	10.37 ± 0.30	92.00 ± 2.66	54.70 ± 1.58	850.00 ± 24.54	3100.00 ± 89.49	5.60 ± 0.16	110.50 ± 3.19	62.55 ± 1.81
	RW (Lower)	7.60 ± 0.22	1.67 ± 0.05	70.00 ± 2.02	55.70 ± 1.61	450.00 ± 12.99	2400.00 ± 69.28	5.00 ± 0.14	130.00 ± 3.75	80.00 ± 2.31

Values are means of triplicate readings ± SEM RW: Receiving water

Table 4. The average physicochemical characteristics of incoming waters and effluents from various oil processing plants

Industry	Location	pH	Electrical Conductivity	Hardness	Turbidity	Dissolved Solids	Total Solids	Dissolved Oxygen	BOD	COD
Best Oils Ltd	Effluent	6.70 ± 0.19	2.10 ± 0.06	65.00 ± 1.88	2.65 ± 0.08	400.00 ± 11.55	1200.00 ± 34.64	31.62 ± 0.91	149.00 ± 4.30	172.50 ± 4.98
	RW (Upper)	7.30 ± 0.21	24.00 ± 0.69	70.00 ± 2.02	202.00 ± 5.83	350.00 ± 10.10	1100.00 ± 31.75	4.52 ± 0.13	56.80 ± 1.64	130.00 ± 3.75
	RW (Lower)	7.20 ± 0.21	13.10 ± 0.38	50.00 ± 1.44	203.00 ± 5.86	350.00 ± 10.10	1400.00 ± 40.41	5.60 ± 0.16	32.25 ± 0.93	78.34 ± 2.26
Premier Agro Oils	Effluent	5.50 ± 0.16	17.00 ± 0.49	55.00 ± 1.59	96.40 ± 2.78	800.00 ± 23.09	2200.00 ± 63.51	24.00 ± 0.69	180.00 ± 5.20	130.00 ± 3.75
	RW (Upper)	9.50 ± 0.27	15.75 ± 0.45	160.00 ± 4.62	33.20 ± 0.96	550.00 ± 15.88	1600.00 ± 46.19	7.11 ± 0.21	95.00 ± 2.74	25.10 ± 0.72
	RW (Lower)	9.30 ± 0.27	4.86 ± 0.14	182.00 ± 5.25	34.20 ± 0.99	450.00 ± 12.99	1850.00 ± 53.40	7.00 ± 0.20	76.26 ± 2.20	32.00 ± 0.92

Values are means of triplicate readings ± SEM RW: Receiving water