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Characterization of phsico-chemical of textile industries effluent discharge on environment in Oromia region, Ethiopia

BY

ADDISU TIBEBU KUMSA

PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTERS OF ART IN ENVIRONMENTAL AND SUSTAINABLE DEVELOPMENTS

June, 2020

Addis Ababa, Ethiopia

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PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTERS OF ART IN ENVIRONMENTAL AND SUSTAINABLE DEVELOPMENTS

June, 2020

Addis Ababa, Ethiopia

DECLARATION

This thesis entitled "Characterization the phsico-chemical of textile industries effluent discharge on environment in Oromia region, Ethiopia. " Is the original work and has not been presented for a Masters or any other Degree in Addis Ababa University center of environmental and sustainable development or any other university.

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ABSTRACT

Textile wastewater mixed with various contaminants at different ranges. Therefore, environmental legislation commonly obligates textile factories to treat these effluents before discharge into the water bodies. The effluent treatment plant is designed to remove certain pollutants found in the effluent of textile industry. Therefore this study focuses on the Evaluation of phsico-chemical characteristics of textile industries effluent discharge on environment in Oromia region, Ethiopia. Samples of raw effluent discharged were collected from the outlet after different levels of treatment plants (primary, secondary, and tertiary) and analyzed by standard laboratory methods. The laboratory data were statistically analyzed using simple descriptive statistics and one-way ANOVA. The analyzed data was presented by using tables and graphs compared with World Bank and Ethiopian guidelines standard for textile wastewater. The physicochemical characteristics of the textile wastewater fluctuated depending on the level of the textile treatment plant. The one way ANOVA taste result showed that pH, COD, TSS, S^{-2}*, TP, TN,* TNH_3^-*and Phenols exhibited statically significant differences across sampled textile industries with different levels of environmental treatment plants (ETPs). However, the Post Hoc tests based multiple comparisons revealed that statistically insignificant differences were observed in the case of the concentration of heavy metals (Copper, Lead, and Chromium) in the textile wastewater having different levels of ETP. The analysis revealed that most pollutants such as pH, chemical oxygen demand (COD), total suspended solids (TSS), Sulfide (*S^{-2}*), total phosphorus (TP), total nitrogen (TN), Total Ammonia (*TNH_3^-*), Phenols, Copper (Cu) and Chromium (Cr) form the textile factories that passed the different ETP were found above the permissible limit of World Bank Environmental, Health and Safety Guideline of Textile Manufacturing (EHSGTM) and Ethiopian guidelines standard. Therefore, the textile industries should improve the performance of the wastewater treatment plants to minimize the possible pollution. In this regard, the industries should balance the inlet and outlet to the existing effluent designed capacity level treatment, properly dose treatment chemicals and understand basic concepts of ETP operational process and better to using from preliminary treatment technology up to advanced treatment technology. In addition to this, it is better to recycle wastewater. The relevant government bodies also need to do regular monitoring and enforcement of environmental laws and regulations as per the national standard.*

Keywords: effluent; chemical pollutants; effluent treatment plant; the processing of textiles.

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LIST OF ABBRIVIATIONS

ABHA	American Public Health Association
BOD	Biological Oxygen Dissolved
CMC	Carboxyl Methyl Cellulose
COD	Chemical Oxygen Dissolved
CSA	Central Statics Agency
EC	Environmental Council
EHSGTM	Environmental, Health and Safety Guideline of Textile Manufacturing
EIAP	Environmental Impact Assessment Proclamation
EPA	Environmental Protection Authority
EPCP	Environmental pollution Control Proclamation
EPOEP	Environmental Protection Organs Establishment proclamation
ETIDI	Ethiopian Textile Industry Development
ETP	Effluent Treatment Plant
FDRE	Federal Democratic Republic Of Ethiopia
GTP	Growth Transformation Plan
GV	Guideline Values
Mg/L	Milligram per liter
pH	Hydrogen Ion Concentration
PVA	Polyvinyl Alcohol
REA	Regional Environmental Authority
TDS	Total Dissolved Solids
TSS	Total Suspended Solid
UN	United Nation
WHO	World Health Organization
WWT	Waste Water Treatment
FAAS	Flame Atomic Absorption Spectrometry

1. INTRODUCTION

1.1 Definition of basic terms

Biological Oxygen Demand: The determination of the BOD involves the measurement of the dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter.

Coagulation: is refers to water treatment practitioners and chemists is referred to as an entire process that included the addition of chemicals coagulants.

Chemical Oxygen Demand: The COD of wastewater is, in general, higher than that of the BOD because more compounds can be chemically oxidized than can be biologically oxidized.

Effluent treatment plant (ETP): a processes design for treating industrial waste water for its reuse or safe disposal to the environment.

Effluent: untreated of industrials waste water.

Flocculation: refers to water treatment processes that assemble or combine or "coagulate" small particles which decant out of the water as sediment.

Liquid waste management: A systematic administration of activities that provide for the proper handling, treatment and disposal of liquid waste/wastewater or sewage.

Primary treatment*:* Screening, grit removal, and sedimentation the primary treatment comprises of pretreatment step and sedimentation step.

Secondary /Biological/ treatment: Biological treatment, oxygen supplied to the bacteria is consumed under controlled conditions so that most of the Biological Oxygen Demand is removed in the treatment plant rather than in the water course.

Tertiary wastewater treatment: is to minimize residual chemical oxygen demand load and/or when specific wastewater constituents are not removed by previous treatment stages.

Waste water: is any water that has been adversely affected in quality by anthropogenic influence.

1.2. Background

Industries are often considered as an engine of economic growth by which many countries promote their rapid economic growth. The textile industry is one of the most important subsectors of the manufacturing industry that contributed to the transformation of economies in countries such as China, Bangladesh, India, Vietnam, Turkey, and Nigeria (Alderin, 2014). Textile industries positively affect economic development worldwide. China is the most important exporter of all types of textiles, followed by the European Union, India, and then the USA (Holkar et al., 2016).

Ethiopia's textile industry has been identified as a clue growth industry since 1995. Its performance was lack until the implementation of the GTP II in 2016. Ethiopia has a long history of textile manufacturing industries majorly meant for the local market. In recent years, the sector has undergone rapid growth; with a number of new players, often foreign textile and garment manufacture establishing production facilities with the objective of supplying to external markets. This expansion has both internal and external reasons (Endalkachew, 2013). Ethiopia has locked as an interesting option having a large and cheap workforce. In an effort to diversify agriculture dominated economy, in connection to this, the Ethiopian government has contributed to the growth of the textile and garment industry by prioritizing it as a strategic sector (Alderin, 2014). As a result, the government has set ambitions targets for the industry in its GTP II (the national plan runs from 2016-2020), which aimed to increase annual earnings from 160 million USA dollar in 2007 to One billion USA dollar by 2016 and increase direct foreign investment by 1.6 billion dollars (De Haan and Theuws, 2016).

Textile export of Ethiopia was above 123 million USD in 2015 with an average growth of 51% over the 5 - 6 years, (Business beyond Boundaries, 2018). The number of medium and large size textile factories showed a regular increase that reached 150 and accounts for 6% of the country's total annual export. The Ethiopian textile growth has been annually producing 102 thousand tons of yarns, 207 million meter woven fabrics, 50 million kg of knitted fabric, 63 million of knitted garment and 28 million of a woven garment. It also creates enormous job opportunities, as it employed more than 48,000 workers. Similarly, the export performance of the sector has also shown a tangible increase which on average 50% annual growth rate per annum up to 2014. For example, the country earned USD 111.3 million in 2014 from this sector (ETIDI, 2014).

Despite the contribution of the textile industry for employment creation and economy of the country, the sector is blamed for creating environmental problems. One of the problems associated with textile factories is the unacceptable effluents, especially dyes, which are difficult to be degraded through the natural process (ETIDI, 2014). In any industrialized or industrializing country, textile industries are big consumers of water. As a result, the different processes of textile industries release a considerable amount of wastewater to the environment (Ashfaq and Khatoon, 2014). The process in textile industries begins with the production or harvest of raw fiber (ABA, 2018). Therefore, this is a call for research to understand and know the level of pollution the sector has been creating.

1.3. Statement of the problem

Textile industries are among high consumers of water. As a result of the different processes in textile industries, a considerable amount of polluted water has been released to the environment (Yaseen and Schol, 2018). The different processes in textile industries result in the release of a considerable amount of polluted water as each processing step namely sizing, de-sizing, bleaching, mercerizing, dyeing, and printing use various kinds and the huge amount of processing chemicals.

Oke, (2018) asserted that the textile industry uses high volumes of water throughout its operations from fibers washing stage to bleaching, dyeing, and producing finished products. The analysis showed that, on average, approximately 200 liters' water required to produce a kilogram of textile products. This implies that the production process equally consumes a huge volume of water and also produces a large volume of wastewater. The large volumes of wastewater generated also contain a wide variety and quantity of chemicals, used throughout processing. These can cause damage to the environment, if not properly treated before being discharged into the environment. Of all the steps involved in textiles processing, wet processing creates the very best volume of wastewater.

The aquatic life toxicity of the textile industry effluent differs considerably among production facilities. The sources of aquatic life toxicity can include salt, metals, and metal complexes, organic chemicals, biocides, and toxic anions. Most textile dyes have minimum aquatic life toxicity. On the opposite hand, detergents, emulsifiers, and dispersants are important in almost each textile process and maybe a crucial contributor to effluent aquatic toxicity, biological oxygen demand, and foaming (Assefa and Sahu, 2016).

A study by Assefa and Sahu, (2016) indicated that in Ethiopia the wastewater has been discharged directly into drains that connect the industry to the main drainage network to rivers and streams. The authors emphasized that Mojo, Hawas, and Sebeta Rivers are among such natural drains affected by such a problem where the drains altimetry flow into big rivers and lacks like Awash and lack Hawas. The researchers analyzed the huge volume of untreated textile dye wastewater discharged into the drains adjoining textile printing units. The study also indicated that a number of dyes were used in textile printing industries and these dyes have been released to the natural system without proper treatment.

Therefore the expansion of textile industries might lead to a higher concentration of organic matter, emerging chemical and which, contributed to an increase of fresh and groundwater pollution. Having all the above environmental concerns in relation to wastewater release to the environment from expanding textile industries in the country, no sufficient study has been conducted so far to inform decision-makers and the investors. Therefore, this study aimed at assessing the status of the physiochemical properties of effluents from the textile industries with different treatment plant performance.

1.4. Objectives of the Study

1.4.1. General Objective

The general objective of this study is to characterization the phsico-chemical of waste-water from the textile industries at different level of treatment plants in the Oromia region, Ethiopia.

1.4.2. Specific Objective

- To characterize physico-chemical effluents of textile industry wastewater across different levels of treatment plants.
- To evaluate textile industry wastewater management systems across different levels of treatment plants.
- To evaluate the waste-water parameters of textile industries with national and international limit values across different level of ETP.

1.5. Research Questions

1. How to characterized physicochemical effluents of textile industry wastewater?
2. By what mechanism we evaluate textile industry wastewater management systems?
3. To what extent the textiles factories waste water parameters of study area higher than the national and international standards?

1.6. Significance of the study

The study will contribute to improving the understanding of the factors that affect the environment from textile industries. The research finding will contribute to the sustainable management of factors of environmental pollution in the study area and beyond. The research also helps to increase understanding, formulation, and implements of environmental pollution management strategies. The information generated can represent an important preliminary tool in decision making pertaining to manage environmental pollution from textile industries. This study may have importance in revealing the hidden problems and understanding of the ongoing human activities in the study area, besides defining the status and magnitude of the impact of the sector on the environment.

1.7. Limitation of the study

The research was conducted under the following two major limitations. Not all textile wastewater effluent variables were measured in the same laboratory. Hence, there might be accuracy differences among laboratories where the tests were performed. This might cause a difference in the analysis results. Moreover, due to time and financial limitations, the temporal variability of discharged effluents was not accounted for in sampling.

2. LITERATURE REVIEW

2.1. Textile Manufacturing Process

The textile industry is categorized as the economic activity whose goal is the making of fibers, yarns, fabrics, and clothing and textile goods for different purposes. The sector is one among the oldest and sophisticated which includes many sub-sectors covering the whole making cycle, from raw materials and intermediate products to the assembly of ultimate products (Tafesse et al., 2015). Broadly the textile factory process includes the spinning, knitting, and weaving of natural and man-made fibers, the finishing of textile, and the production of ready-made garments. The most common sectors in the Ethiopian textile industry are cotton fabrics, wool fabrics, man-made fabrics, synthetic fabrics, and blended fabrics (World Bank, 2013).

Spinning is the way that changes raw fiber into yarn or thread (World Bank, 2013). The fibers are prepared and then drawn out and twisted to form the yarn, which is then wound onto a cone. The spinning process is entirely dry, although some yarns may be dyed and finished as an end-user product. The knitting process is almost completely dry, although some oils may be applied during the process for lubrication. These are removed by subsequent processing and enter the waste-water stream (Assefa and Sahu, 2016).

According to the World Bank, (2013), weaving is the common method important to use for producing fabrics. The process is administered on which numerous varieties exist that interlaces lengthwise warp yarns with widthwise ones before weaving; the warp threads are coated with to extend their tensile strength, size, and smoothness. Natural starches are the commonly used sizes, although compounds like polyvinyl alcohol (PVA), alkali-soluble cellulose derivatives, resins, and gelatin glue are used. The sizing compound is dried on the threads and remains a neighborhood of the material until it's removed within the subsequent processes. Other chemicals, such as agents, lubricants, and fillers, are often added to impart additional properties to a fabric (Tafesse et al., 2015).

Sizing: is a wet process that carried out before the weaving process to maximize the smoothness and strength of the yarn, to reduce yarn breakages. De-sizing: with acid or enzymes then removes size from the fabric, so that chemical penetration of the fabric in later stages is not inhibited. Effluents have very high organic concentrations, contributing 40-50% of the total organic load from the preparatory sequences (Karlsson, 2015). Gums and PVA could also be removed by an easy hot wash but starch and its derivatives need to be made soluble by soaking with acids, enzymes, or oxidants before being removed by warm water.

Scouring: is a process to remove unwanted that are found in textiles (e.g. proteins, waxes, fatty, acids, etc.) and acquired (such as size, dirt and oil picked up during processing). This is usually done at more temperatures with sodium hydroxide and produces strongly alkaline effluents with maximum organic loads. They tend to be dark in color and have high concentrations of grease, TDS, and oil. The souring is done with an open width pad roll system. Common scouring agents include wetting agents, detergents, soaps, alkalis, antistatic agents, framers, deformers, and lubricants (IJES, 2015).

Bleaching: a process used to whiten fabrics and yarns using sodium hypochlorite. Many cotton processing factories use sodium hypochlorite as it is cheaper than hydrogen peroxide (Lawrence, 2016). However, this is highly toxic and is now banned in many countries. It also can break right down to form absorbable organo-halogen compounds, which are both toxic and carcinogenic. According to Assefa and Sahu, (2016) bleaching process generates effluents with low organic content, high TDS levels, and strong alkalinity. Once the bleaching is complete, the bleaching agent must be completely removed, either by a thorough washing or using enzymes. Mercerizing: in this step, the cotton yarn or fabric is treated with an alkali (sodium hydroxide) to improve dye uptake, luster, and strength it also removes immature fibers. The process is often administered on dry fabric; wet mercerization reduces the energy consumption, but requires stringent control of the operational parameters, like hydrated oxide concentration. Excess caustic soda is generally recovered for reuse in either the scouring or other mercerization stages. The rinse wastes are alkaline, high in inorganic solids and caustic alkalinity, and low in Biological oxygen demand. With the increasing trend toward cotton-polyester blends, much less mercerizing is being carried out (World Bank, 2013).

The major commonly of dyestuffs used in the textile industry are Acid Dyes (used on wool, silk, and polyamide fibers). They give very bright colors, whose fastness ranges from very poor (allowing colors to run) to very good; Basic Dyes (mainly applied to acrylics and polyesters to produce very bright colors; Direct Dyes (most applied to rayon and cotton); Disperse Dyes (used to cellulose acetate, polyamide and polyester fibers); Reactive Dyes (it produces a range of bright shades, and commonly used for cellulose textile), Sulfur Dyes (Most mainly used for dyeing cotton, rayon, and cotton-synthetic blends and produce strong deep colors in the final fabric), Vat Dyes (this almost full range of shades and are particularly important in the dyeing of cellulose fibers) and Azoic Dyes: produce deep shades of blue, violet, yellow, orange and scarlet (Lawrence, 2016).

Printing: is a process that is used for applying color to a fabric. Unlike dyeing, it is usually only carried on the prepared fabric where it is applied to specific areas to achieve a planned design. The finishing process imparts the final aesthetic, chemical, and mechanical properties to the fabric as per the end-user requirements. Mildew Resistance Using hazardous substances such as mercury, copper, arsenic, and chlorinated phenols (Ghaly et. al., 2014).

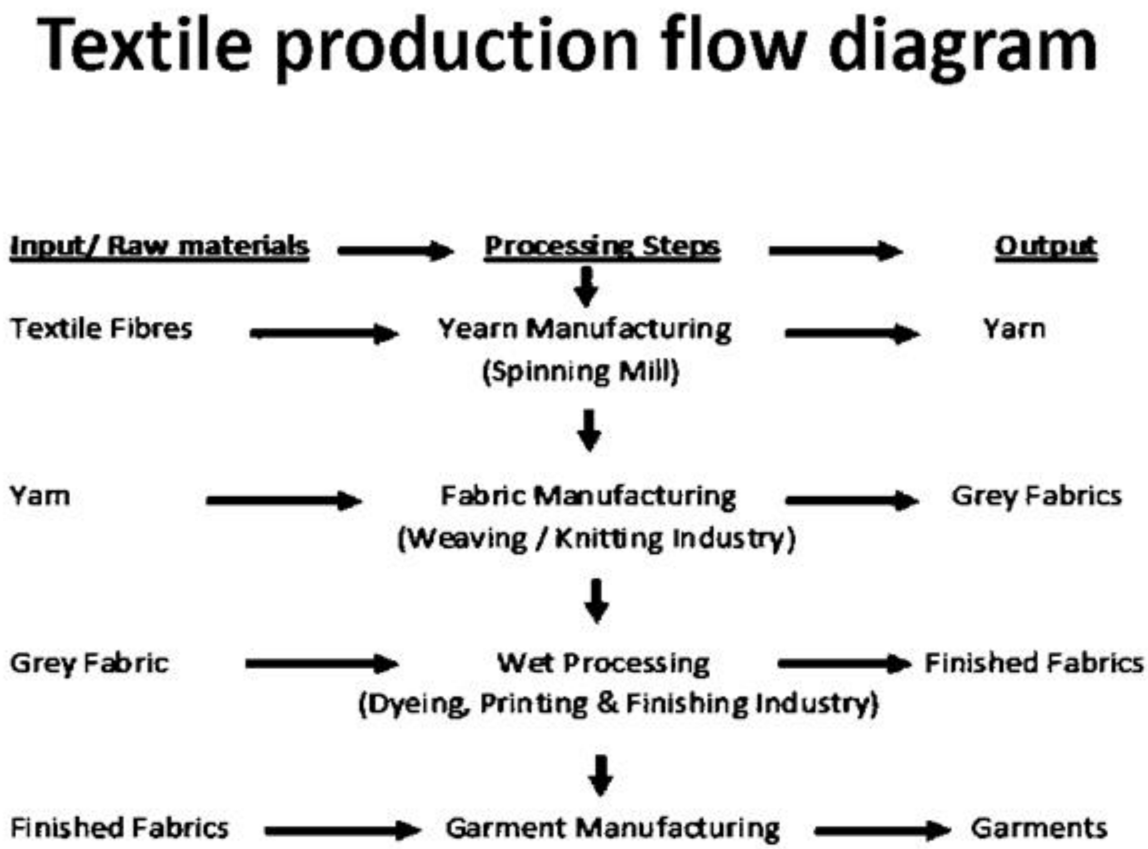


Fig 2.1.Textile production flow diagram (Assefa and Sahu, 2016)

Table 2.1. Effluent characteristics from textile industries

Process	Effluent composition	Nature
Sizing	Starch, waxes, carboxyl methyl cellulose (CMC), Polyvinyl alcohol (PVA), wetting agents.	High in BOD, COD
Desizing	Starch, CMC, PVA, fats, waxes, pectin	High in BOD, COD, dissolved solids (DS)
scouring	Caustic soda, waxes, soda ash, sodium silicate, sodium phosphate.	Dark colour, High in BOD, COD, SS, dissolved solids (DS)
Bleaching	Sodium hypochlorite, Caustic soda, Hydrogen peroxide, acids, surfactants, Caustic silicate, sodium phosphate,	High alkalinity, high SS
Mercerizing	Cotton and wax Sodium hydroxide	High pH and DS, low BOD
Dyeing	Dyestuffs urea, reducing agents, oxidizing agents, Acetic acid, detergents, wetting agents.	Strongly coloured, high BOD, DS, low SS, heavy metals
Printing	Thickeners, cross-linkers, reducing agents, alkali. Pastes, urea, starches, gums, oils, binders, acids,	slightly alkaline, low BOD ,Highly coloured, high BOD
Finishing	In organic salts	High pH

Source: Tadele and Omprakash, 2016

2.2. The impact of Textile waste water on environment

Textile generated wastes and the main environmental pollution associated with the textile industry are typically those associated with a water body that caused by the discharge of untreated effluents which are conducted during different parts of the textile manufacturing process that characterized by the high consumption of resources like water, fuel and a variety of chemicals such as, sulfur, COD, BOD, acetic acid, soaps, nitrates, chromium compounds, and heavy metals such as copper, lead, arsenic, cadmium, mercury, nickel, and cobalt combination makes the wastewater highly toxic with high temperature and pH, which makes it highly, affects environments (Oke, 2015). The colors and oil present in wastewater increases its turbidity and give a bad appearance and smell to the water. This effluent when discharged to freshwater prevents sunlight penetration necessary for the process of photosynthesis for aquatic plants. When agricultural fields are watered with these effluents, the pores of the soil are clogged, which results in the loss of soil productivity. The wastewater, when flown in drains, corrodes and varnishes the sewage pipes, whereas, in rivers, it affects the drinking water quality in hand pumps making the water unfit for human consumption (World Bank, 2013).

Table 2.2. Textile waste water pollutants and its negative effect on environments

Pollutants	Symbol	Main Negative Effects
Total ammonia	NH_3	adverse effects on aquatic life like fish and Pungent odour
Total Nitrogen	TN	Causes excessive plant growth and formulation of algae cause eutrophication and reduction of oxygen
Chrome	Cr	Toxic to aquatic life, human and crops At high temperature oxidizes to chrome VI, which is extremely toxic
Biochemical Oxygen Demand	BOD	BODs indicate the quantity of oxygen may be consumed while biologically decomposition the organic constitute.
Chemical Oxygen demand	COD	COD- is measure of oxygen consumed during chemical oxidation of the constituents of effluents.
Total Dissolved Solids	TDS	Harmful to plants and civil structures, unfit for human, industrial and agricultural use. High salinity cause osmotic pressure (reduced water availability and retarded plant growth. High concentrations of sodium ions in irrigation water affect the soil structure and properties by causing dispersion of clay.
Oil & Grease	O&G	Forms surface films on water and shoreline deposits which lead to environmental degradation and interfere with biological processes
pH	pH	Acidic conditions cause metal corrosion and are toxic to aquatic life. High alkaline conditions are toxic
Suspended Solids	Suspended Solids	Can form deposits and create anaerobic condition (odour) which pose a danger to aquatic life
Sulphide	S^{2-}	Odour nuisance at low levels and fatal in high concentrations Poisonous to aquatic life, depletes dissolved oxygen damages sewerage systems

Source: World Bank, 2013

2.3. Factory Waste Water Treatment

The aim of treatment is to reduce the level of pollutants in the wastewater before reuse or disposal into the environment, the standard of treatment required will be location and use-specific. There are many aerobic, anaerobic and physico-chemical processes that can treat wastewaters to almost any standard of effluent. Treatment strategies range along a continuum from high technology, energy-intensive approaches to low technology, low energy, biologically and ecologically focused approaches (EPA, 2013).

2.4. Conventional effluent treatment technology

According to EPA, (2013) summarizing the main unit processes that make up the conventional effluent treatment plant are intake screening, coagulation/flocculation, sedimentation, filtration, biological treatment and advanced treatment.

2.5. Treatment methods

Treatment methods are grouped into three general categories: The volume and pollution load of sanitary wastewater in comparison with industrial wastewater is insignificant. Very arbitrarily the following are main phases of treatment (EPA, 2013).

2.5.1. Preliminary treatment

In the case of ETPs servicing textile clusters often found in developing countries, it is essential to have pre-treatment units installed in individual textiles (EPA, 2013). Their role is to remove large particles and sand/grit before the effluent is discharged into the collection network.

2.5.2. Primary treatment

Screening, grit removal, and sedimentation the primary treatment balance of the pretreatment step and sedimentation step. The goal is to: To eliminate the coarse material normally present in the raw wastewater that could block pipes, pumps and possibly sewer lines, To mix and balance well different textile streams and thus produce homogenized that can be treated in a consistent manner, To control pH and eliminate toxic substances and avoid shock loads that can negatively affect the rather sensitive biological treatment and to significantly decrease the BOD/COD load and thus simplify the biological treatment phase and reduce its cost (Oke, 2018).

2.5.2.1. Screening

It is the primary treatment stage that does not alter the chemical and bacteriological quality of water. It blocked and removed large particles that are usually installed at the entry of the wastewater treatment plant to avoid mechanical equipment, avoid inhabited with plant operations prevent objectionable floating objects such as rags or rubber from entering the first settling tanks (Lawrence, 2016).

2.5.2.2. Aeration /Equalization

The first stage of aeration is applied for two reasons: homogenization of the effluent (quantity and quality); and sulfide removal by catalytic oxidation and for maximizing oxygen and minimizing carbon dioxide content (World Bank, 2013). As applied to water treatment, aeration may be defined as the process by which a gaseous phase, always air, and water are brought into intimated contact with each other for the purpose of transferring volatile substances which may include oxygen, carbon dioxide, nitrogen, hydrogen sulfide and various unidentified organic compounds responsible for taste (Manikandan et al., 2015).

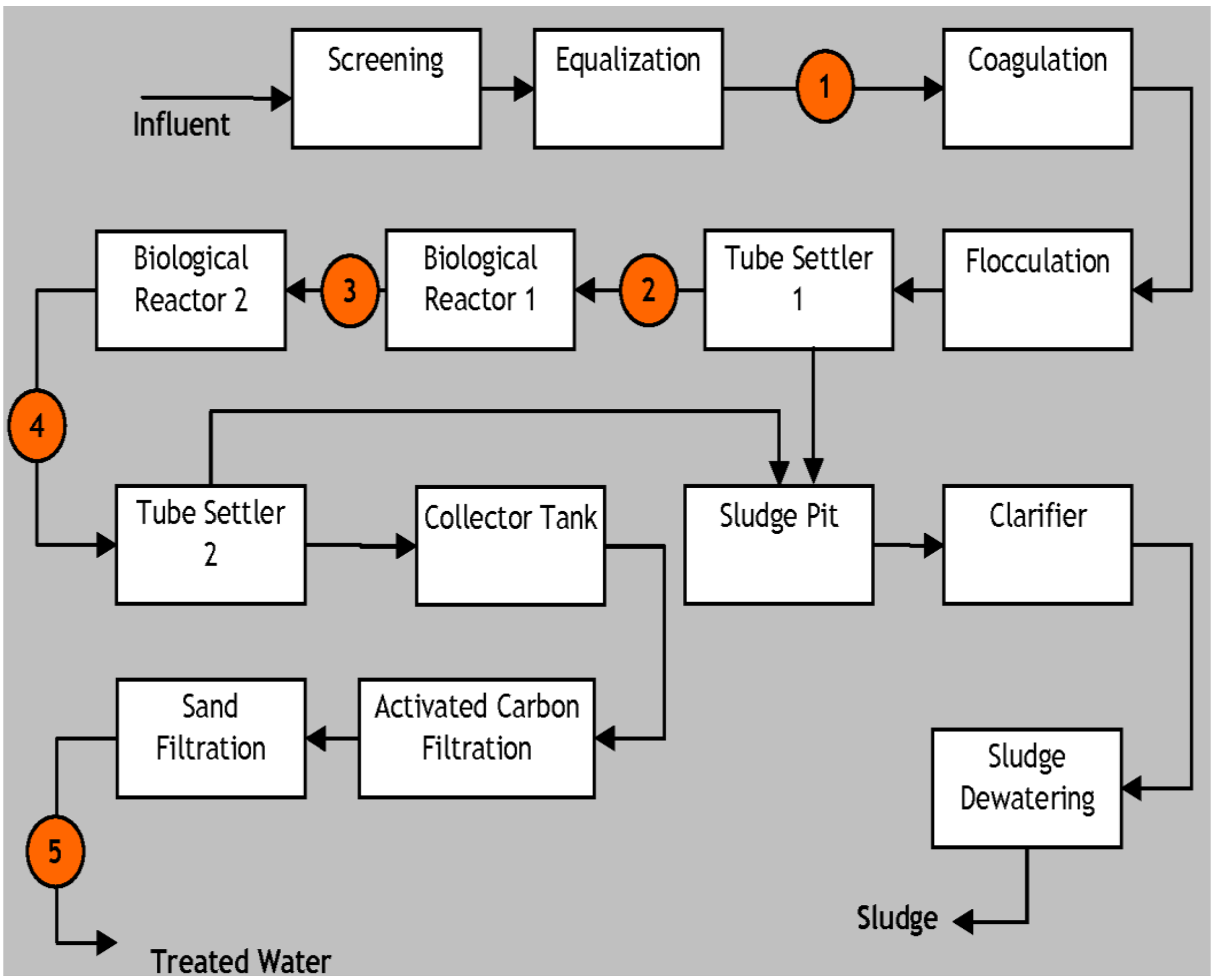
2.5.2.3. Chemical treatment

Coagulation according to water treatment practitioners and chemists is referred to as an entire process that included the addition of chemicals coagulants, (iron or aluminum salts), such as aluminum sulfate- $Al_2(SO_4)_3$, iron sulfate -$FeSO_4$, iron chloride- $FeCl_3$ or polymers to the water and lime: industrial calcium hydroxide $Ca(OH)_2$. These chemicals are called coagulants and have a positive charge. The positive charge of the coagulants neutralizes the negative charge of dissolved and suspended particles in the water. It is a way of reducing the amount of total suspended solids (Tadele and Sahu, 2016).

According to Joshi and Santani, (2012) and Word Bank, (2013) define the word of flocculation refers to water treatment processes that assemble or combine or "coagulate" small particles which decant out of the water as sediment. Settling or sedimentation happened naturally as flocculated particles settle out of the water. Flocculants - are water-soluble organic (anionic) polyelectrolytes that support agglomeration of colloidal and really fine suspended matter thus enhancing the impact of coagulation. So that concentration of COD, BOD, and TSS is reduced through sedimentation.

2.5.2.4. Sedimentation

According to EPA (2013), sedimentation is that the way for smallest things in suspension to dawn out of the suspense liquid during which they're entrained and are available to rest against a protective. This is thanks to their motion through the fluid in response to the forces performing on them: these forces are getting to flow from to gravity, centrifugal acceleration, or electromagnetism. Sedimentation is the termination of the settling process. Settling tanks (sedimentation tanks, sedimentation basins, settling basins, or clarifiers), are used in water treatment to reduce the number of settleable solids suspended in water.



Source: EPA, 2013

Fig2.2. Model of textile effluent treatment plant

2.5.3. Biological treatment

The main goal at the secondary stage is to further minimize the amount of organic (expressed as BOD and COD) and other substances still present in the effluent after the chemical treatment and thereby satisfy the standards/limits for discharge into surface waters (World Bank, 2013). The secondary wastewater treatment duplicates processes that occurred in nature, but under manageable conditions and, especially, at a highly accelerated pace; however, the efficiency of this treatment largely depends on the biodegradability of the polluting substrate, i.e. its inherent capacity to decompose by microorganisms or biological processes (Manikandan et al., 2015).

2.5.4. Advanced treatment

The tertiary or advanced wastewater treatment is to minimize residual chemical oxygen demand load and/or when specific wastewater constituents are not removed by previous treatment stages (Punzi, 2015). In other cases, despite extensive physical-chemical and biological treatment in a well-designed ETP, the quality of the final effluent does not meet the promulgated discharge limits. It includes Sand and activated carbon filter, microfiltration, membrane filtration, disinfection advanced oxidation process, evaporation, and crystallization (EPA, 2013).

2.6. Industrial pollution control

Sustainable development is included in the 1995 Federal Democratic Republic of Ethiopia (FDRE) Constitution, 298 the 1997 EPE, 299 and the three core environmental proclamations, namely the Environmental Protection Organs Establishment Proclamation (EPOEP) No.295/2002; the Environmental Impact Assessment Proclamation (EIAP) No.299/2002; and the Environmental Pollution Control Proclamation (EPCP) No. 300/2002 (Tsegai, 2015).

The Ethiopian government's commitment to separate environment-related laws is a recent issue, that is, in the 1995 Constitution have influenced various conferences related to environment and sustainable development although some argue that it was greatly influenced by donors. However, irrespective of the question of influence, the fact of the matter is that a combined reading of Arts 43, 44, and 92 of the Ethiopian Constitution right to clean and healthy environment as a fundamental right. In Ethiopia, the Environmental Pollution Control Proclamation is the core legislation that deals with pollution control standards at Federal and regional levels. Art.3 (4) and 17 (c) thereof state the need to protect the environment but do not endorse the polluter pays principle in clear terms (EFDRE Constitution, 1989). The Ethiopian Environmental Pollution Control Proclamation (EPCP) defines pollution as any condition which is hazardous or potentially hazardous to human health, safety, or welfare or to living things created by changing any physical, heat, chemical, biological or other property of any a portion of the environment in contravention of any condition, limitation or restriction made under this Proclamation or under any other relevant law.

The main issues related to pollution in Ethiopia are public health, air pollution, pollution of inland waterways, contamination of drinking water, soil contamination, and groundwater contamination.

Waste Water quality parameters based on present-day standards and guides are presented to assist in the establishment of discharged system performance goals for any plant. The nature and form of industrial water standards may vary among countries and regions. There is no single approach that's universally applicable. It is essential within the development and implementation of standards that the present or planned legislation concerning water, health, and the native government is taken under consideration in which the capacity of regulators in the country is assessed. Approaches that will add one country or region won't necessarily transfer to other countries or regions. It is essential that each country review its needs and capacities in developing a regulatory framework (EPCP, 2002). Based on textile effluent discharge to water standards stipulated by the EPCP ranks were assigned for each parameter depending on the respective tested values, as given in Table 2.3.

Table 2.3.Textile Limit Values for Discharges to Water

Parameter	EPA (2002) limit Values mg/L	EHSGTM (world bank, 2007) limit values mg/L
pH	6 – 9	6 – 9
BOD	50	30
Total nitrogen (as N)	40	10
COD (mg O_2/l)	150	160
Total phosphorus (as P)	10	2
Suspended solids	30	50
Total ammonia (as N)	20	10
Oils, fats & grease	20	10
Phenols	1	0.5
Nickel (as Ni)	2	0.5
Cobalt (as Co)	1	0.5
Lead (as Pb)	0.5	0.5
Chromium (as Cr VI)	0.1	0.5
Chromium (as total Cr)	1	0.1
Cadmium (as Cd)	1	0.5
Zinc (as Zn)	5	2
Copper (as Cu)	2	0.5
Sulphide (as S)	2	1

Sources: EPCP Ethiopian standard guidelines, (2002) and World Bank, (2007)

3. MATERIALS AND METHODS

3.1. Study Area

The study was conducted in 4 textile industries located within an 80 km radius from Addis Ababa in the Oromia region, Ethiopia. From these industries one was located in Sebeta town of latitude and longitude of 8°54′40″N 38°37′17″E and an elevation of 2,356 meters, the town had a population of 49,331 (CSA, 2016). The second factory was located in mojo town in central Ethiopia, named after the nearby Modjo River. It is Located in the eastern Shewa Zone of Oromia region, it has a latitude and longitude of 8°39′N 39°5′E with an elevation between 1788 and 1825 meters above sea level. It is the administrative center of Lome woreda. The town had a total population of 21,997 of whom 10,455 were males and 11,542 were females (CSA, 2016). Those of two textile industries are located in Akaki woreda around Dukem town of the Oromia Special Zone Surrounding Finfinne of Oromia region, 37 kilometers southeast of Addis Ababa and 10 kilometers northwest of Bishoftu, this town features latitude and longitude of 08°48′N 38°54′E and an elevation of 1950 meters above water level. Dukem town is situated along with the Addis Ababa to Dire Dawa highway and is a station on the Ethio-Djibouti railway. It is also the situation of a tract covering 40 hectares owned and developed by East African group, Dukem has an estimated total population of 8,704 of whom 4,095 are men and 4,609 are women (CSA, 2016). All factories directly discharged to the river. These textile industries were purposefully selected as they directly discharge effluents to the nearest streams/rivers.

3.2. Study design and sample Size

The experimental study design was used to assess the physicochemical properties of wastewater discharged from the textile industries. The industries somehow have similar methods of effluent treatment technology and cotton-polyester based textile processing units and they are discharging their effluents directly to the environment after passing some treatment. Before the actual sampling design was made so as to collect samples from textile industries, which have different treatment plants, varying from primary to tertiary. As indicated in table 3.1, three samples were collected from each industry after the wastewater passed the last effluent treatment plant/s (ETP). Of the sampled industries, one has primary ETP only, two industries have a secondary level of ETP and the third category other textile industry has up to the tertiary level of ETP. Purposive sampling method was used to determine representative sampling points. Therefore sampling was done from each industry after the wastewater passed the last treatment plant/s in three replications in one week's interval. Sample collected from the same sampling point in three different days were considered as replication so as to minimize error that might occur due to difference in time of discharge. Moreover, in order to reduce sampling error and maximize representatives of the sample, sampling was made at the middle time of the discharge. Samples were collected in 2 liters capacity sample bottles. In total 12 samples were taken from 4 sample sites (textile industries) for physico-chemical analysis. The study was carried out from the beginning of November 2019 to June 2020.

Table 3.1: Sampling design

Textile factory code	Level of Effluent Treatment Plants	Number of Replicates
C_2	Primary treatment plant	3 (R1, R2 ,and R3)
C_1 and C_3	Secondary treatment plant	6 (R1, R2, and R3)
C_4	Tertiary treatment plant	3 (R1, R2, and R3)
Total samples		12

Note: C_2 = textile factory with primary ETP, C_1 and $C3_=$ textile factory with secondary ETP and C_4 = textile factory with tertiary ETP.

Samples were taken by pre-cleaned plastic polyethylene bottles and properly disinfected glass bottles for biological samples. Prior to sampling, all the sampling containers were washed and rinsed thoroughly with the treated distilled water. The collected samples were transported to the laboratory in an icebox for further analyses. Besides sample collection for physio-chemical parameters laboratory analysis, on-site tests mainly pH tests were conducted using a multi-parameter probe.

Samples collected for laboratory analysis were taken in separate bottles of one liter capacity from each sampling point (twelve in total) in triplicate samples were collected. On-site measurements were made three times. Sampling was undertaken according to APHA (2017) procedure. The labeling of each sample was done on the site of sampling. The digested samples were placed in an icebox that contains ice cubes and then transported to laboratories with a maximum of 8 hours after sampling. Maximum care was taken to avoid contamination during and after sampling and transportation.

3.3. Sample Analysis Procedures

3.3.1. Study Variables

The study variables were physical parameter mainly pH, and chemical such as chemical oxygen demand (COD), total suspended solids (TSS), Sulfide (S^{-2}), total phosphorus (TP), total nitrogen (TN), total ammonia (TNH_3^-), Chromium(Cr), Lead (Pb), Copper (Cu), and Phenol.

3.3.2. Samples field level and laboratory analysis

Apparatus used during laboratory and field investigations include Icebox, portable multi-parameter probe (HQ40d Model), Ion chromatography (model Dionex600), Spectrophotometer (model 6405 UV/Vis). The Physico-chemical analysis was also undertaken in the same laboratory, using validated multiple tube fermentation techniques. Sampling bottle, taste tubes, diurnal tubes, knife/spoon, distilled water, incubation machine, Sterilization machine, refrigerator, pipette, burettes and stand, autoclave, petri dish, filter unit, incubator and photo cameras, were used in Physico-chemical textiles wastewater analysis in the laboratory.

All the wastewater samples were analyzed in Addis Ababa Environmental Protection and Green Development Commission (EPGDC) and Ethiopian Environment and Research Institute (EERI) laboratories. The pH value was determined on-site with the help of a portable multi-parameter probe (HQ40d Model). The rest of all physical-chemical parameters were analyzed in EPGDC and EERI laboratories, as per standard methods endorsed by the American Public Health Association (APHA, 2017).

Image3.1. Samples and laboratory analysis

Source: photo taken by the Author, 2019

On-site pH was measured on sampling site using pH meter, The chemical analysis was carried out for Chemical Oxygen Demand (COD)-reactor analyzed digestion method, total suspended solids (TSS) are determined by photometric method, Sulphide (S^{-2}) by -Methylene Blue method, Total Nitrogen (TN)-Persulfate Digestion method, Total Ammonia (TNH_3^-) determined by salicylate method, Total phosphorus (P) -Molybadovandate With Acid Persulfate Digestion method, Phenols- 4-Aminoantipyrime and for heavy metals like Lead (as Pb), Chromium (Cr) and Copper (as Cu) by American Public Health Association (APHA) 3111C- Flame Atomic Absorption Spectrometry (FAAS) method (APHA, 2017).

3.4. Statistical Analysis

The wastewater laboratory analysis and field test data were statistically analyzed using SPSS (version 20); Origin Pro 8 and Microsoft excel (2016) software. The data were also subjected to analysis variance one-way ANOVA to assess the effect and concentrations of textile industries wastewater discharged from different levels of treatment plants on the environments. As the level of physiochemical vary with sample collection from different textile wastewater treatment technologies and treatment plants. The significance of each sample at a 95% confidence level interval was analyzed.

4. RESULTS AND DISCUSSION

4.1. Physicochemical properties of textile industries effluents

4.1.1. Characteristics of physical parameters

The results of the onsite and laboratory tests are presented in Tables 4.1. The results clearly display wide variations in the physical characteristics of the different wastewater at different levels of textile industries treatment plants.

pH

As effluent reaction parameter pH has a considerable impact on the aquatic and terrestrial environment where the waste-water discharged. pH measurements were conducted onsite. Accordingly, the measurement revealed that the average pH values of the wastewater were ranging from 5 to 9. Detail examination of the different replicated samples shows that alkaline (basic) reaction with very high (11) pH value in one case (at C_1), which has a secondary level treatment plant. In converse, acidic wastewater reactions were observed in C_2 and C_3, which have as low as pH values of 4 and 5, respectively (Table 4.1). The average pH values of wastewater from the different industries were acidic for C_2 and C_3, neutral for C_4, and alkaline for C_1. Although sulfuric and hydrochloric acids are used in the textile processing, the use of salts and caustic slurry in other steps gives the pH of the wastewater to have a neutral and alkaline reaction (Vyas, 2013).

Table 4.1: Laboratory analysis results of physical parameters of the wastewaters

Factory code	Level of ETP	Replicates	pH	Total Suspended Solids/TSS (mg/l)
C_2	1	R1	4	182.5
		R2	5	170
		R3	6	163.5
		Mean	**5**	**172**
C_1 and C_3	2	R1	11	87.9
		R2	8	80.1
		R3	8	66
		R1	7	48
		R2	6	78
		R3	5	69
		Mean	**7.5**	**71.5**
C_4	3	R1	6.5	45
		R2	7.5	50
		R3	7	55
		Mean	**7**	**50**

Total suspended solids

The average total suspended solids (TSS) in the textile wastewater of sample textile industries were found in the range of 50 to 172 mg/l. The content of water depends on the quantity of suspended particles directly related to feeders/turbidities of wastewater. An in-depth examination of each replicates revealed that very high (182.5 mg/l) suspended solids were found in one industry (C_2) which only has primary treatment plant to as low as 45 mg/l in industry C_4 having tertiary level treatment plant (Table4.1). From this one can deduce that increase in the number of environmental treatment plan has the role to reduce the level of TSS.

4.1.2. Characteristics of the chemical

Laboratory analysis of the common chemical mainly Sulphides (S^{-2}), Total Nitrogen (TN), Total Ammonia (TNH_3^-), Total phosphorus (TP), Phenols and chemical oxygen demand (COD) measured in the 4 sampled are effluents from textile industries are detailed in subsequent sections and the value presented in Table 4.2 below.

Sulphides

Analysis of the average of sampled textile industries wastewater passed through the different environmental treatment plant ranged from 5.3 to 10.6 mg/l (Table 4.2). Unlike the other Physico-chemical properties of the textile industries effluents, the concentration of sulphides didn't show very wide variation across the different replicates. The measurement showed vary from 11.8 mg/l in the industry (C_2) having a primary treatment plant to 4.4 mg/l in the industry (C_3) that has secondary level wastewater treatment plants. In general, among the sampled textile industries, wastewater collected from one of the industries (C_3), having secondary level treatment showed a relatively lowest concentration of sulphides even lower than the industry (C_4) with tertiary level wastewater treatment plant (Table 4.2).

Table 4.2: Characteristics of the chemical of textile industry

Factory code	Level of ETP	Replicates	Sulphides (mg/l)	Total Nitrogen/ TN (mg/l)	Total Ammonia/ TNH_3^- (mg/l)	Total phosphorus /TP (mg/l)	Phenols (mg/l)	Chemical Oxygen Demand/ COD (mg/l)
C_2	1	R1	11.8	99	95	46	12	855
		R2	10.7	102	100	46	9	780
		R3	9.6	102	99	55	12	765
		Mean	**10.6**	**101**	**98**	**49**	**11**	**800**
C_1	2	R1	10	89	47	35	5	320
		R2	8.3	97	58	34	6	277
		R3	9	102	60	24	4	243
C_3		R1	4.4	83	38	25	6.5	287
		R2	6.5	82	40	26	6	302
		R3	5	78	45	18	5.5	311
		Mean	**7.2**	**88.5**	**48**	**27**	**5.5**	**290**
C_4	3	R1	7	66	26	20	2	23
		R2	7.8	62	36	17	3	21
		R3	8	58	34	26	4	22
		Mean	**7.6**	**62**	**32**	**21**	**3**	**22**

Total nitrogen and total ammonia

Total nitrogen (TN) showed a similar pattern with COD, total suspended solids, and sulphides. The TN contents of wastewater samples collected in different times of sampling don't show as such a concentration difference among the same groups. Accordingly, the average total nitrogen contents of the wastewater extend from 62 mg/l in case of industry (C_4) with tertiary treatment plants to 101 mg/l in case of industry (C_2) having primary level treatment plant only, while other industries (C_1 and C_3) showed TN contents between the two (Table 4.2).

Total ammonia is formed during the microbial degradation of decaying biomass and organic matter in the wastewater. Nitrogenous compounds like proteins are ammonified to release ammonia into the surroundings. This analysis showed that total ammonia (TNH_3^-) in the study area ranged with mean values from 32 mg/l in the wastewater of textile industry (C_4) having tertiary level treatment plant to 98 mg/l in the industry (C_2) installed with primary level treatment plant only (Table 4.2). The replicated samples collected from the same industry didn't show considerable differences among each other. Almost three of samples (replicates) collected from the same industry nearly showed comparable TNH_3^- with each other. This indicated that the similarity of TNH_3^- concentration across the samples of one industry indicated the similarity of released pollutants and the efficiency of the treatment plant to purify or reduce the pollutant.

Phenols and total phosphorus

Like most chemical properties of effluents from the textile industries under consideration, relatively lower phenols concentration was observed in the industry (C_4) with tertiary level treatment plant, which on average value of 3 mg/l. The maximum phenol concentration (12 mg/l) was measured in one sample of effluent from industry (C_2) with the only primary treatment plant. The other data was, the minimum phenol concentration (2 mg/l) was observed in one sample of the industry (C_4) with the tertiary level treatment plant.

Phosphorus is a vital nutrient for all living things but, the introduction of the excessive amount of the element in the form of phosphates in an aquatic environment can cause eutrophication. Therefore, it is important to know the amount of phosphorus released to the environment particularly to the water bodies. The current analysis indicated that the maximum total phosphorus concentration in the effluents was recorded to be 35 mg/l at C_1, 55 mg/l at C_2, 26 mg/l at C_3, and 26 mg/l at C_4. While the minimum TP value were recorded 24mg/l at C_1, 46 mg/l at C_2, 18 mg/l at C_3 and 17 mg/l at C_4, (Table 4.2). The total phosphorus mean values recorded for the study area of textile wastewater ranges from 21mg/l at C_1 to 49 mg/l at C_4 (Table 4.2).

Chemical oxygen demand

Chemical oxygen demand is the combination of both organic and inorganic pollutants, which cause unfavorable conditions for the growth of microorganisms in water bodies (World Bank, 2013). The measure of chemical oxygen demand determines the quantities of organic matter found in the water. The average chemical oxygen demand (COD) of wastewater passed the different treatment plants of the textile industries varying from 22 mg/l at C_4 to 800 mg/l at C_2. The maximum of chemical oxygen demand of textile wastewater was recorded in samples passed through the different treatment plants which showed very wide variation ranging from 855 mg/l at C_2 in one sample to 311 mg/l at C_3 (Table 4.2). In general, one textile industry (C_4) has had very low COD as compared to the other industries where the effluent passed through 3 tertiary treatment plants (ETP) with a very narrow range, i.e., the value varies between 21 and 23 mg/l and the average of 22 mg/l (Table 4.2). From this, it was clear that the level of ETP has a markeable role in the COD level of effluents of the textile industry.

4.1.3. Characteristics of toxic metals

For the characterization of wastewater of textile industries, 4 wastewater samples of different level treatment plant sites were collected and analyzed for toxic metal results of the wastewater as shown in Table 4.3.

Table 4.3: Mean value of toxic metal Parameters analysis laboratory results

Factory code	Level of ETP	Replicates	Lead/ Pb (mg/l)	Copper/Cu (mg/l)	Chromium/Cr (mg/l)
C_2	1	R1	ND	ND	0.69
		R2	ND	0.02	0.69
		R3	ND	0.01	0.96
		Mean		**0.01**	**0.78**
C_1	2	R1	0.001	0.03	0.8
		R2	0.019	0.05	0.07
		R3	0.01	0.01	0.75
C_3		R1	0.009	0.98	0.83
		R2	0.001	1.00	0.81
		R3	0.02	0.99	0.82
		Mean	**0.01**	**0.51**	**0.68**
C_4	3	R1	ND	0.04	0.84
		R2	ND	0.03	0.79
		R3	ND	0.02	0.89
		Mean	**ND**	**0.03**	**0.84**

Note: ND = not detected

As shown in table 4.3, trace amounts of heavy metals mainly lead (Pb), copper (Cu), and chromium (Cr) were detected in some of the effluents collected from the textile industries, while they were not detected in few samples. The concentration of Pb was found minimal ranging from null (not detected) in most cases to 0.02 mg/l in two samples. The average concentration of Cu was varying between 0.01 mg/l in effluents from industry (C_2) with only primary treatment plant to 0.99 mg/l at industry (C_3) with the secondary level treatment plant. As opposed to the three heavy metals, the concentration of Cr was found higher across all samples and industries under consideration with average concentration varying from 0.0.68 mg/l to 0.84 mg/l. The consecration of Cr also doesn't show wide variability even among the different replicates (samples) from the different industries, which ranged between 0.69 and 0.96 mg/l.

From the above discussion, it is clear that the physicochemical characteristics of the textile wastewater in the study area fluctuated very much. The characteristics were found to depend primarily on the level of the textile treatment plant and the kind of discharge released from washing tanks. The concentration of pollutants was high in the textile factories that have a secondary treatment plant next to the primary treatment plant and a decrease in the concentration of pollutants in textile factories that have advanced treatment plants. On the other hand the concentration of toxic heavy metal found for different textile wastewater in the study industries was almost similar. This indicates that the level of treatment plant does not show heavy metal concentration variation in the textile industry effluents.

4.2. Comparison of physicochemical parameters of textile industries effluents across different level of treatment plants

As shown in table 4.4 one-way ANOVA analysis revealed that pH, chemical oxygen demand, total suspended solids, sulfide, total phosphorus, total nitrogen, total ammonia, copper, and phenols exhibited a statically significant difference across sampled textile industries with different level of treatment plants. In contrast, chromium and lead don't show statically significant differences with each other. EPA (2013) indicated that lack of adequate screening, equalization, coagulation, flocculation, filtration, aeration, and sedimentation process of textile wastewater treatment can lead to fluctuations in quantities and quality of effluent in various treatment units (ETP) of textile industries if the treatment unit doesn't perform at the desired level. It also indicated current performance problems are not caused by limitations in size or capability of the existing major unit processes; justifying attempts to optimize existing performance by mitigating other factors such as operational and maintenance. Therefore the level of textile industry treatment plant used can influence the concentration of the common biological, physical, and chemical, bio-physiochemical parameters of effluents (EPA, 2013). This indicated that upgrading the different levels of treatment cannot adjust the concentration of heavy metals found in effluents of textile factories.

Table 4.4: Comparison of the physico-chemical parameters of textile industries effluents across the different treatment plants

Parameters	Comparison	Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	26.250	3	8.750	6.667	.014
	Within Groups	10.500	8	1.313		
	Total	36.750	11			
COD (mg/l)	Between Groups	952449.000	3	317483.000	320.528	.000
	Within Groups	7924.000	8	990.500		
	Total	960373.000	11			
TSS (mg/l)	Between Groups	27260.250	3	9086.750	75.967	.000
	Within Groups	956.920	8	119.615		
	Total	28217.170	11			
S^{-2} (mg/l)	Between Groups	47.483	3	15.828	18.676	.001
	Within Groups	6.780	8	.848		
	Total	54.263	11			
TN (mg/l)	Between Groups	2766.000	3	922.000	53.449	.000
	Within Groups	138.000	8	17.250		
	Total	2904.000	11			
TNH_3^- (mg/l)	Between Groups	7695.000	3	2565.000	105.773	.000
	Within Groups	194.000	8	24.250		
	Total	7889.000	11			
TP (mg/l)	Between Groups	1464.000	3	488.000	18.769	.001
	Within Groups	208.000	8	26.000		
	Total	1672.000	11			
Phenols (mg/l)	Between Groups	104.250	3	34.750	26.476	.000
	Within Groups	10.500	8	1.313		
	Total	114.750	11			
Pb (mg/l)	Between Groups	.000	3	.000	2.326	.151
	Within Groups	.000	8	.000		
	Total	.001	11			
Cu (mg/l)	Between Groups	2.103	3	.701	4006.286	.000
	Within Groups	.001	8	.000		
	Total	2.105	11			
Cr (mg/l)	Between Groups	.174	3	.058	1.199	.370
	Within Groups	.386	8	.048		
	Total	.560	11			

The ANOVA (post-hoc analysis) is used to compare the means of the physio-chemical parameters across different industries having different levels of effluent treatment plants. It compares all possible pairs of means based on a standardized range distribution. The result of

Tukey test of the one-way ANOVA comparisons for the physiochemical properties (mainly pH, COD, TSS, S^{-2}, TP, TN, TNH_3^- and phenols) and heavy metals (mainly Pb, Cu, and Cr) of the sampled textile factories effluents passed through different ETP levels are presented in Table 4.5 to Table 4.7.

The **pH** value of the industry having primary level environmental treatment plant (ETP) do have slightly statistically significant (at P=0.012) difference as compared to the factory with secondary level ETP, but no difference with the factory having tertiary level ETP (Table 4.5). Similarly, the level of ETP doesn't have a significant effect on the pH value between industries having secondary and tertiary level ETP. This indicates that the level of the industries ETP does not bring a vivid difference in the pH of the effluents. Therefore, uses of different chemicals that change the pH to neutral status, for example, use the application of salts to neutralize acidic effluents and the vas-a-vis.

The **total suspended solids** content of effluents industry having primary level treatment plant (ETP) have highly statistically significantly (at P=0.000) higher than factories with secondary and tertiary level ETP (Table 4.5). However, wastewater from the industry with secondary level ETP doesn't have a statistically significant difference in TSS content as compared to the industry with tertiary ETP. Therefore, the performance of secondary and tertiary treatment was almost equal to treat and minimize the amount of TSS found in textile wastewater.

Table 4.5: The physical parameters of effluents across different level of treatment plants

Dependent Variable	(I) Textile factories ETP	(J) Textile factories ETP	Mean Difference (I-J)	Std. Error	Sig.
pH	ETP primary	ETP secondary	-4.00000	.93541	$.012^{*}$
		ETP tertiary	-2.00000	.93541	$.717^{ns}$
	ETP secondary	ETP tertiary	2.00000	.93541	$.220^{ns}$
TSS (mg/l)	ETP Primary	ETP secondary	94.00000	8.92991	$.000^{**}$
		ETP tertiary	122.00000	8.92991	$.000^{**}$
	ETP secondary	ETP tertiary	28.00000	8.92991	$.055^{ns}$

Note: Comparison applied Tukey test, Post Hoc Tests multiple comparisons where
** indicate that the mean difference is significant at $P \leq 0.001$
* indicate that the mean difference is significant at $0.001 < P \leq 0.05$ and.
^{ns} indicate that the mean difference is significant if P>0.05

Our analysis revealed that $\mathbf{S^{-2}}$ of effluents from the different textile industry with various level of environmental treatment plant don't have strong difference. The laboratory analysis indicated slight statistical difference (at P=0.014) in the concentration of S^{-2} in the wastewater between industry with primary and tertiary level ETP (Table 4.5). While, the concentration of S^{-2} in effluent from industry with primary and secondary as well as secondary and tertiary ETP do not have significant difference. This indicates that level of the industries ETP do not have considerable role to bring vivid difference on the effluents S^{-2} content. Therefore, the performance of secondary and tertiary treatment was almost equal to treat and minimizing the amount of S^{-2} concentration that found in textile waste water of the study area.

Post Hoc Tests based multiple comparisons showed that **TN** concentration in wastewater of the textile industry having tertiary level treatment plant have statistically significantly low (at P=0.000) as than industry with primary and secondary level ETP. But no statistical differences in TN content of effluents between industries with primary and secondary level ETP (Table 4.6). This show that textile industry having tertiary level ETP performs best to significantly reduce the TN of the effluents.

Table 4.6: The chemical parameters of effluents across different level of treatment plant

Dependent Variable by mg/L	(I) Textile factories ETP	(J) Textile factories ETP	Mean Difference (I-J)	Std. Error	Sig.
S^{-2}	ETP Primary	ETP secondary	1.60000	.75166	.223^{ns}
		ETP tertiary	3.10000	.75166	.014*
	ETP secondary	ETP tertiary	1.50000	.75166	.266^{ns}
TN	ETP Primary	ETP secondary	5.00000	3.39116	.493^{ns}
		ETP tertiary	39.00000	3.39116	.000**
	ETP secondary	ETP tertiary	34.00000	3.39116	.000**
TNH_3^-	ETP Primary	ETP secondary	43.00000	4.02078	.000**
		ETP tertiary	66.00000	4.02078	.000**
	ETP secondary	ETP tertiary	23.00000	4.02078	.002*
TP	ETP Primary	ETP secondary	18.00000	4.16333	.011*
		ETP tertiary	28.00000	4.16333	.001**
	ETP secondary	ETP tertiary	10.00000	4.16333	.154^{ns}
Phenols	ETP Primary	ETP secondary	6.00000	.93541	.001**
		ETP tertiary	8.00000	.93541	.000**
	ETP secondary	ETP tertiary	2.00000	.93541	.220^{ns}
COD	ETP Primary	ETP secondary	520.00000	25.69695	.000**
		ETP tertiary	778.00000	25.69695	.000**
	ETP secondary	ETP tertiary	258.00000	25.69695	.000**

Note: Comparison applied Tukey test, Post Hoc Tests multiple comparisons where
** indicate that the mean difference is significant at $P \leq 0.001$
* indicate that the mean difference is significant at $0.001 < P \leq 0.05$ and.
^{ns} indicate that the mean difference is significant if $P > 0.05$

Our analysis revealed that S^{-2} of effluents from the different textile industries with various levels of environmental treatment plants don't have a strong difference. The laboratory analysis indicated a slight statistical difference (at P=0.014) in the concentration of S^{-2} in the wastewater between industry with primary and tertiary level ETP (Table 4.6). While the concentration of S^{-2} in the effluent from the industry with primary and secondary as well as secondary and tertiary ETP does not have a significant difference. This indicates that the level of the industries ETP does not have a considerable role to bring a vivid difference in the effluent S^{-2} content. Therefore, the performance of secondary and tertiary treatment was almost equal to treat and minimize the amount of S^{-2} concentration found in the textile wastewater of the study area.

Unlike TN, the level of ETP brought a significant difference in the concentration of TNH_3^- with an increase in the level of ETP. Post Hoc Tests based multiple comparisons revealed that the industry having primary level treatment plant statistically significantly (at P=0.000) high TNH3- content as compared to the factory that uses secondary and tertiary level ETP (Table 4.6). However, the content of TNH_3^- in the wastewater of a factory with secondary and tertiary level ETP was not as high. The analysis showed that TNH_3^- of the effluent from the industry with tertiary level ETP in somehow low (P = .002). Therefore, the role of ETP in reducing the concentration of TNH_3^- the textile industry effluent was not found strong enough with an increase in the level of ETP after the secondary level.

Post Hoc tests based on multiple comparisons of the total phosphorus content of wastewater from the textile industry with different levels of treatment plant showed some difference (Table 4.6). Accordingly, effluent from the industry with primary level treatment plant has significantly higher (at P=0.001) TP content than the industry with tertiary level ETP. However, TP content of wastewater that passed through secondary level ETP somehow lower than the primary levels, as the Post Hoc test comparisons of the TP concentration in the wastewater from primary and secondary ETP showed slightly statistically significant (P = 0.001) difference. On the other hand, the concentration of TP in effluents passed through secondary and tertiary level environmental treatment plants doesn't show a statistically significant difference. From this, it can be deduced that secondary level ETP could be sufficient to purify the phosphorus content provided that the ultimate discharge body (water or terrestrial) has a good absorbing capacity and the TP concentration from the industry with secondary ETP is within the Ethiopian government and global allowable limit.

The Post Hoc tests based multiple comparisons showed that the Phenol content of the wastewater from the textile industry fitted with higher-level ETP was remarkably low. The laboratory result showed that effluent from primary level environmental has significantly (at $P \leq 0.001$) higher concentration of phenols as compared to those with secondary and tertiary levels (Table 4.6). However, the concentration of Phenols in effluents from industry passed through secondary and tertiary ETP doesn't have a significant difference. In fact, the mean Phenol content of the wastewater passed through tertiary ETP is low (3 mg/l) compared to the concentration in the effluent from secondary ETP (5.5 mg/l). Like indicated above in the case of TP content of effluents passed through secondary and tertiary ETP, secondary level ETP could be sufficient to dilute the Phenols concentration as long as the end discharge body (water or terrestrial) have sufficient absorbing capacity without possible damage to the environment in long run and the concentration from the industry having secondary ETP is within the allowable limit of the Ethiopian government and global standard.

The effluent from the industry having primary level treatment plant (ETP) showed statistically significantly (at $P=0.000$) higher COD level as compared to the factory with secondary and tertiary level ETP (Table 4.6). Similarly, the COD of effluent from the industry with a secondary level of ETP also showed statistically significantly ($P=0.000$) higher level as compared to the factory-installed with tertiary level ETP. This indicates that the level of the industries ETP brings a vivid impact on the COD of the effluents. Therefore, tertiary ETP has high performance than primary ETP and secondary ETP to reduce the level of COD. Similarly, the industry with secondary level ETP has better performance than the industry with only primary level ETP in terms of chemical oxygen demand of effluents. These clearly show that the ETP level determines the level amount of COD, i.e., the industry with higher ETP level have better oxygen level and hence lesser impact on the aquatic environment.

As discussed in the earlier section, lead contents of effluents from the sampled textile industries were very low. The concentration of lead in the wastewater from the industry having primary level treatment plants does not show the statistically significant difference as compared to the factory use secondary and tertiary level ETP (Table 4.7). Generally, Post Hoc tests based on multiple comparisons revealed that the industry's ETP level doesn’t have a significant difference in the Pb content of effluents. This indicates that the level of the industries ETP does not have a role in managing Pb, rather the chemicals used in the textile industry possibly have a very limited amount of this heavy metal.

The concentration of Copper in wastewater from the textile industry was low even if it was somehow higher than Pb. Post Hoc tests based on multiple comparisons verified that the Cu content of the sampled textile industries effluents passed through the three levels of ETP doesn’t show statistically significant differences among each other (Table 4.7). Like Pb, the level of ETP doesn’t have a significant effect on managing the Cu content of the effluents. Therefore, the low level of Cu in the effluents might be strongly related to the chemicals used in the textile industry, which might contain a low concentration of heavy metals so as to reduce environmental impact. It is well known that industries have corporate and legal responsibility to safeguard the environment and humanity. Thus, they are obliged to avoid the use or properly managing toxic substances like heavy metals in the production process.

Table 4.7: toxic metals in effluents across different level of treatment plant

Dependent Variable	(I) Textile factories ETP	(J) Textile factories ETP	Mean Difference (I-J)	Std. Error	Sig.
Pb (mg/l)	ETP primary	ETP secondary	-.01000	.00535	.312^{ns}
		ETP tertiary	.00000	.00535	1.00^{ns}
	ETP secondary	ETP tertiary	.01000	.00535	.312^{ns}
Cu (mg/l)	ETP Primary	ETP secondary	-.02000	.01080	.319^{ns}
		ETP tertiary	-.02000	.01080	.319^{ns}
	ETP secondary	ETP tertiary	.00000	.01080	1.00^{ns}
Cr (mg/l)	ETP Primary	ETP secondary	.24000	.17944	.567^{ns}
		ETP tertiary	-.06000	.17944	.986^{ns}
	ETP secondary	ETP tertiary	-.30000	.17944	.396^{ns}

Note: Comparison applied Tukey test, where
** indicate that the mean difference is significant at $P \leq 0.001$
* indicate that the mean difference is significant at $0.001 < P \leq 0.05$ and.
^{ns} indicate that the mean difference is significant if $P > 0.05$

The concentration of Copper in wastewater from the textile industry was low even if it was somehow higher than Pb. Post Hoc tests based on multiple comparisons verified that the Cu content of the sampled textile industries effluents passed through the three levels of ETP doesn’t

show statistically significant differences among each other (Table 4.7). Like Pb, the level of ETP doesn't have a significant effect on managing the Cu content of the effluents. Therefore, the low level of Cu in the effluents might be strongly related to the chemicals used in the textile industry, which might contain a low concentration of heavy metals so as to reduce environmental impact. It is well known that industries have corporate and legal responsibility to safeguard the environment and humanity. Thus, they are obliged to avoid the use or properly managing toxic substances like heavy metals in the production process

The chromium content of effluents from the textile industries fitted with different levels of ETP was found relatively higher than the other heavy metals. The Cr concentration in the wastewater passed through the three ETP doesn't show a significant difference among each other (Table 4.7) and followed the irregular patterns (Table 4.3). The mean Cr amount was found low in effluents from the industry having secondary ETP than the industry having primary and tertiary ETP. Therefore, ETP either doesn't have a role to purify Cr of the textile industry wastewater or the three ETP levels have the equal performance of cleaning the element from the effluents.

From the above discussion, it is clear that to evaluate textile wastewater at a different level of treatment plant by using Tukey test of the one-way ANOVA at study area was indicated that the value of COD, TSS, TNH_3^- and Phenols wastewater from the industry having primary level treatment plant have highly statistically significant ($P \leq 0.001$) difference as compared to the factory having secondary level ETP. Similarly, the concentration of COD, TSS, TN, TNH_3^- and Phenols in effluents from the industry having primary ETP have highly statistically significantly ($P \leq 0.001$) different as compared to the factory that uses tertiary ETP. The analysis revealed a slight difference in the pH value between effluent from the industry with primary and secondary ETP ($P = 0.012$) as well as the S^{-2} content difference between effluents from primary and tertiary ETP (P = 0,014). In converse, the statistically insignificant differences observed in the value of pH, TSS, S^{-2}, and TP between effluents from industries having secondary and tertiary ETP. Generally, the concentration of most physical and chemical parameters in the effluents from industrial wastes decreased with an increase of ETP level, although the rate of decrease shows variability across the different parameters. Thus in most cases, the performance of secondary and tertiary effluent treatment plants was not as strong (statistically) enough compared to primary level ETP. Therefore, if factories have constraints they can go at least up to tertiary level ETP as long as the values of physical and chemical parameters are within allowable limit of EPA and/or World Bank standard.

However, the Post Hoc tests based multiple comparisons revealed that statistically insignificant differences were observed in the case of the concentration of heavy metals (TP, Cu, Pb, and Cr) in the textile wastewater having different levels of ETP. There are different arguments about the level of conventional effluent treatment plant were discussed below. But the result of this study didn't show each level of the treatment plant in the study area has a performance problem issue that compere with the mentioned arguments. According to Tadele Assefa and Omprakash (2016), the primary method of wastewater treatment avoid 80-90% of the total suspended solids, 40-70% of BOD, 30-60% of the COD and 80-90% of the bacteria can be removed. However, in simple sedimentation, only 50-70% of the total suspended at full performance.

The secondary treatment (biological) process removes dissolved matter in a way similar to the self-depuration but in a further and more performed than primary treatment methods. The removal efficiency depends upon the ratio between organic load and the biomass present in the oxidation tank, its temperature, and oxygen concentration (Tadele Assefa and Omprakash, 2016).

According to Oke (2018), Primary treatment also known as chemical treatment (Coagulation and flocculation) process is one of the most used methods to treat wastewater, especially active on the suspended matter, colloidal type of very small size, their electrical charge gives repulsion and prevents their aggregation. Dossing in water electrolytic products such as ferric sulfate, aluminum sulfate or ferric chloride, giving hydrolyzable metallic ions or organic hydrolyzable polymers (polyelectrolyte) can remove the surface electrical charges of the colloids. The metallic hydroxides and the organic polymers, besides giving the coagulation, can help the particle aggregation into flocs, thereby increasing the sedimentation at the end divided suspended solids and colloidal particles can't be efficiently removed by simple sedimentation by gravity. In such cases, mechanical flocculation or chemical coagulation is used. In mechanical flocculation, the textile wastewater is skilled a tank under gentle stirring; the finely divided suspended solids join together into larger particles and settle out. The degree of clarification obtained also depends on the quantity and quality of chemicals used (Punzi, 2015).

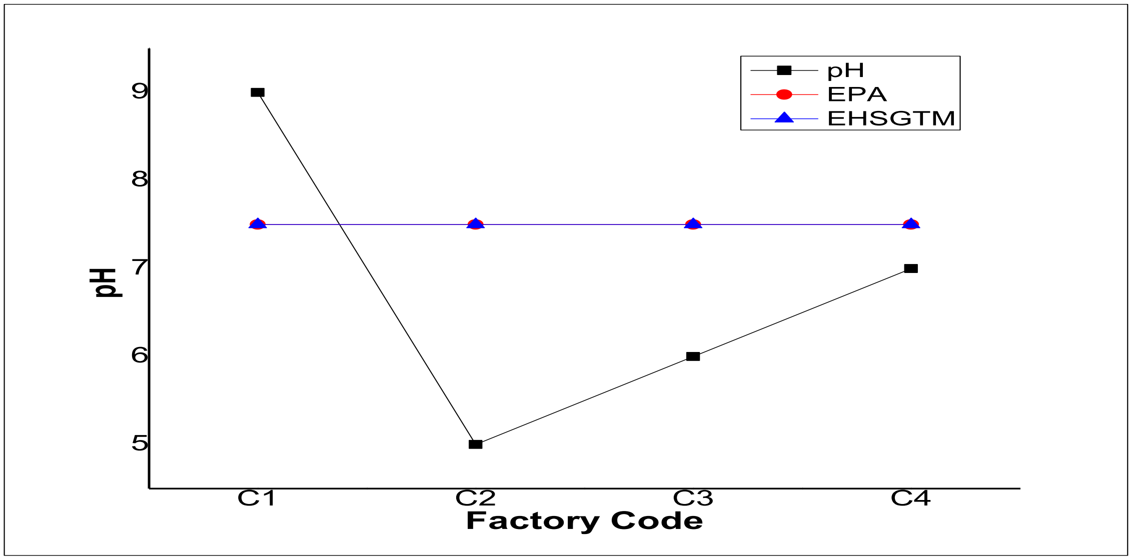
4.3. Evaluate the waste-water parameters of textile industries of study areas with national and international limit values across different level of ETP

The spatial variations of the physical and chemical analysis results are discussed in detail. The result is compared with World Bank of the Environmental, Health, and Safety Guideline of Textile Manufacturing (EHSGTM) and Environment forest and climate change Commission (EFCCC) guidelines to evaluate the textile limit values for discharges to water. The detailed discussion and results of four textile industries effluent wastewater from the treatment plants are given under.

4.3.1. Physical parameters

pH

As shown in figure 4.1, the mean pH of the textile wastewater was found in a wide range varying from 6.5 to 9.0. The minimum 5 pH is found in C_2 the wastewater and while the maximum of 9 pH is found in C_1 and C_3 the wastewater from four industries. Thus the wastewater of the textile industry is neutral to alkaline because in most of the steps caustic and other detergents of alkali nature are used in large quantities. This result show when compared with EPA and EHSGTM only at C_2 show above the allowable limit of the standard, thus it needs a solution. In the textile processing unit's pH is very much an important factor. It is regulated at various steps for better results. pH is a useful biotic factor that serves as an indicator of pollution. The more narration in the pH value of wastewater can influence the rate of biological reaction and survival of various bacteria in the treatment process (Oke, 2018). The pH is also important in the dyeing step as the solubility of the dyes depends on pH and also changes with cloth processing type. Although sulfuric and hydrochloric acid is used in the coloring textile process, the use of other salt and caustic slurry in other steps resulted in the neutral nature of the discharged effluents from the system (Vyas, 2013).

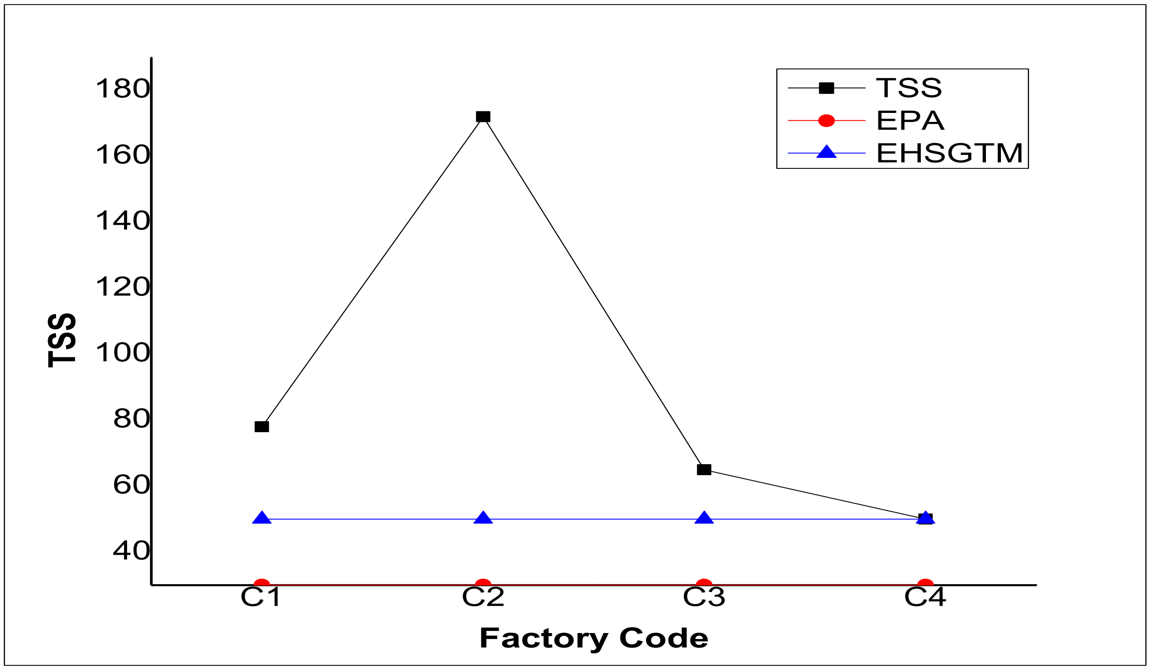


Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.1.Variation textile waste water of pH in study area.

Total Suspended Solid (TSS)

The average total suspended solids of the textile industries were found to vary from 50 to 172 mg/L from industry C_4 and C_2 respectively. The minimum total dissolved solid was recorded from the wastewater of industry C4 while the maximum recorded from industry C_2 (Figure 4.2). This depends on the type of cloth processes and total production. The wastewater contains suspended solids in high quantity thanks to which the wastewater becomes viscous. The suspended solids are due to non-dissolved solid particles removed from the cloth. Sometimes, the chemicals used also get precipitated due to a change in pH, which increases the suspended particles. However, the average suspended particles of all four industries were 91.25 mg/L. our analysis revealed that the TSS in the wastewater of almost all sampled industries that passed different ETP were found to be higher than EPA (2002) and World Bank (2007) standard, thus there should be a solution to bring the level to the allowable limit. The total suspended solids can form deposits and create anaerobic conditions (odour) which pose a danger to aquatic life (World Bank, 2013).



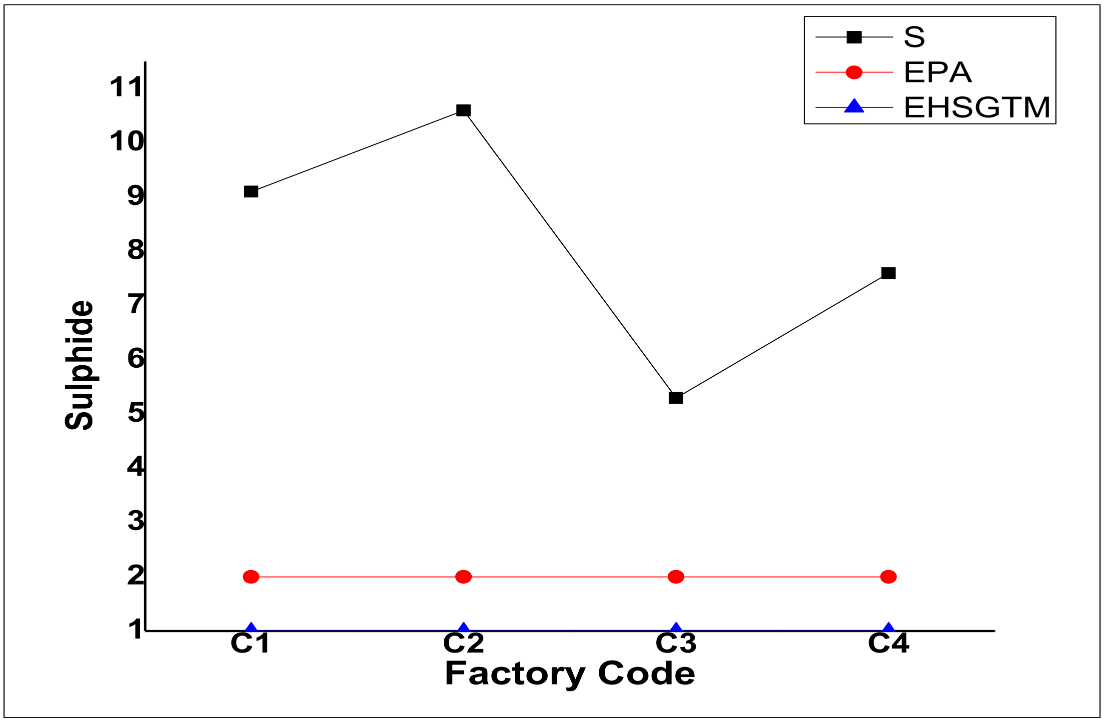
Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP..

Figure 4.2.Variation textile waste water of TSS in study area.

4.3.2. Chemical parameters

Sulphide (S)

The study result shows that the average concentration of sulphide varied from 5.3 to 10.6 mg/L in the four industries. Maximum sulphide concentrations were recorded in effluents from industry as similar primary and secondary ETP (Figure 4.3). Generally, sulphide concentration of effluents from the industries with all level of ETP was very high as compared to EPA (2 mg/l) and World Bank (1mg/l) standard. Therefore, the government and respective industries should tack appropriate measure to care for the disposal of sulphide to the environment. According to world bank (2013) indicated that sulphide wastewater of all industries could be determined due to highly coloured wastewater, the odour nuisance at low levels and fatal in high concentrations Poisonous to aquatic life, depletes dissolved oxygen damages sewerage systems.

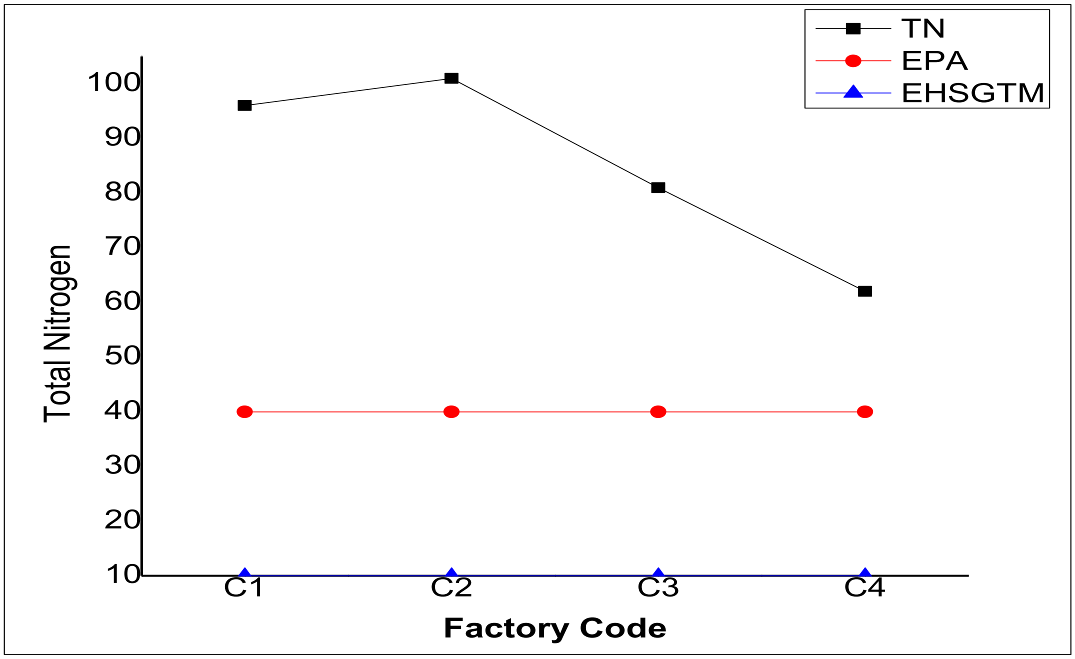


Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.3.Variation textile waste water of Sulphide in study area.

Total Nitrogen (N)

The average amount of total nitrogen in the wastewater of all sampled industries was found more than national (40 mg/L) and international (10 mg/L) standards. Its concentration fluctuates from 62 to 101 mg/L minimum total nitrogen concentration was measured in wastewater from industry C_4 and the maximum was in industry C_2 (Figure 4.4). The source of total nitrogen in the wastewater is the impurities present in the chemicals used in various processes. As the concentration of TN in the wastewater from the textile industries passed through all levels of ETP are beyond the allowable limit, there should be appropriate remedial action to safeguard the environment. Total nitrogen causes excessive plant growth and formulation of algae that result in eutrophication and reduction of oxygen (Khalid and Mahin, 2014). The total nitrogen also increases due to the dyes used (World Bank, 2013).

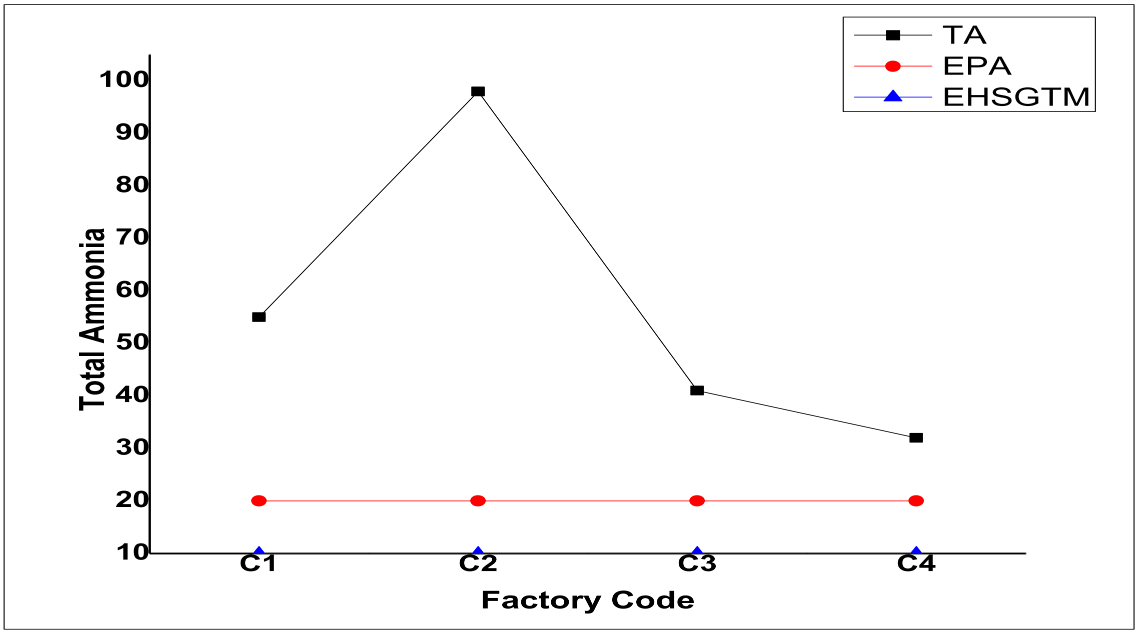


Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.4 Variation textile waste water of Total Nitrogen in study area.

Total ammonia (TNH_3^-)

Total ammonia in the wastewater of all industries was more than 20 mg/L (EPA standard). The current measurement revealed that the average TNH_3- concentration varying from 32 to 98 mg/l. Minimum TNH_3- content was found in wastewater from industry (C_4) with tertiary ETP, while the maximum contains was in the industry (C_2) having primary ETP. The source of total ammonia in the wastewaters is mainly from impurities present in the chemicals used in various processes (Figure 4.5). As indicated above the TNH_3- contents of the effluents passed through the different levels of ETP were very much higher than EPA and EHSGTM standard, thus there should be the well-designed solution to unlock such severe problem which potentially impacts the environment. The high level of total ammonia might be due to the dyes used and pungent odour, which have adverse effects on aquatic life like fish (Husain et al., 2013).

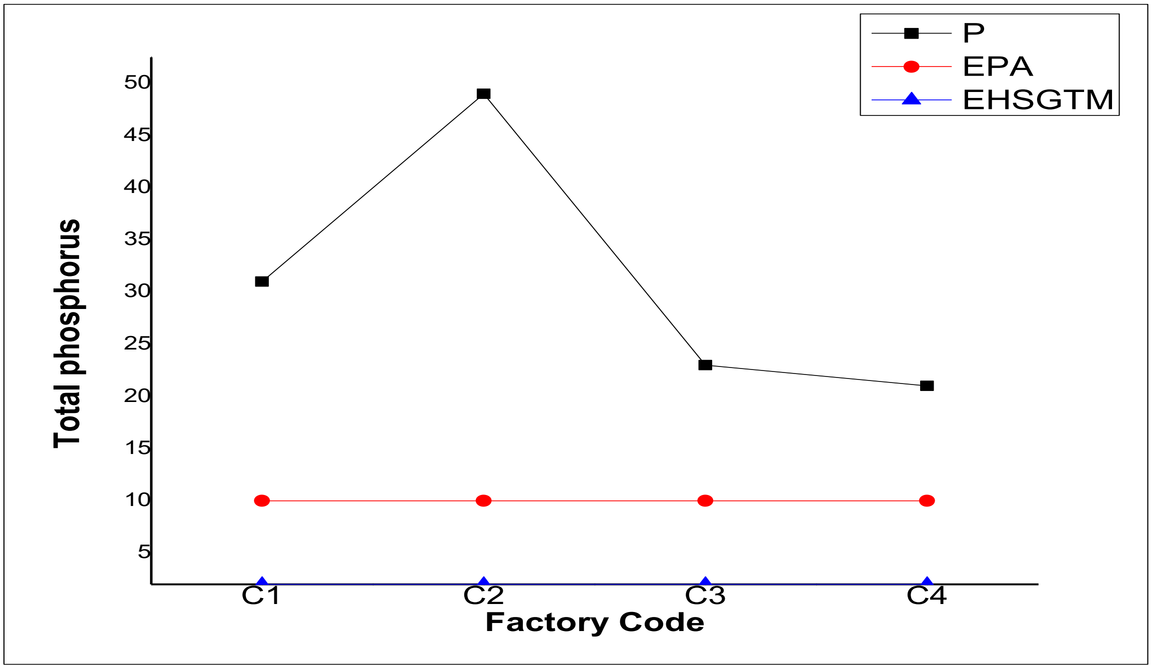


Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.5.Variation textile waste water of Total ammonia in study area.

Total phosphorus (TP)

Total phosphorus in the wastewater of all industries was more than EPA (10 mg/L) and EHSGTM (2 mg/l). The average concentration of TP in the wastewater of the sampled textile industry was ranging from 21 to 49 mg/L. The minimum total phosphorus contamination was measured in the effluent of industry (C_4) tertiary ETP, while the maximum average amount was in the factory (C_2) having primary ETP (Figure 4.6). Regardless of this difference in the TP content of the effluents from industries with different ETP, the level of the TP was much higher than the allowable limit of EPA and EHSGTM standards, which calls for appropriate action before severely impact on the environment. The source of total phosphorus of textile industries wastewaters is mainly from impurities present in the chemicals used in various processes and from dyes used.

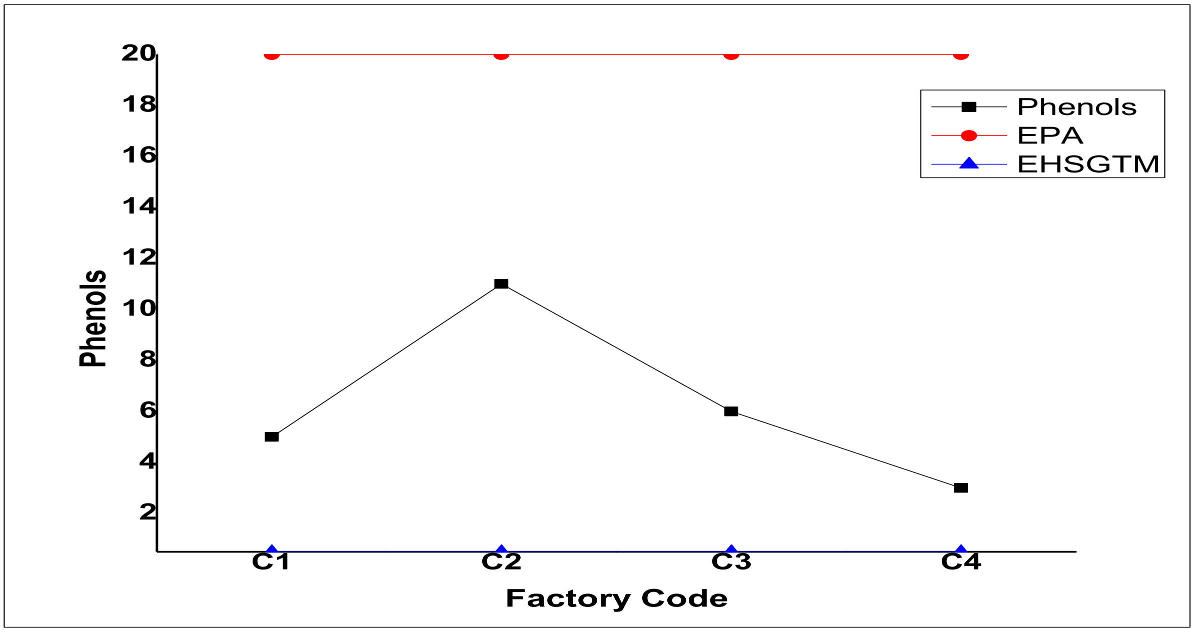


Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.6.Variation textile waste water of total phosphorus in study area.

Phenols

The average Phenols content of wastewater from the textile industry were ranging between 3 and 11 mg/L. The analysis showed that minimum Phenols concentration was measured in effluents from industry (C_4) with tertiary ETP, while the maximum was in wastewater from industry (C_2) primary ETP (Figure 4.7). Although the content of phenols in effluents from the industry with tertiary ETP was statistically significantly lower than the industry with primary ETP, the content is much higher than the national (1 mg/L) and EHSGTM (0.5 mg/L). The sources of Phenols in this range may be from chemical impurities present in the chemical used in various processes of the industry.

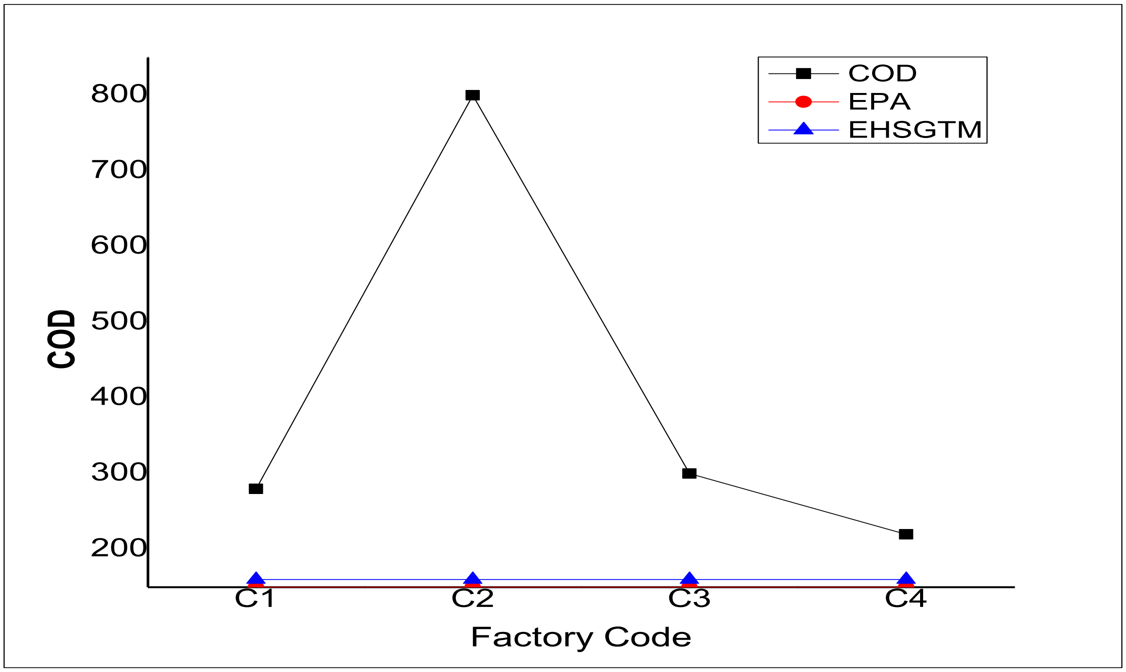


Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.7.Variation textile waste water of phenol in study area.

Chemical Oxygen Demand (COD)

In this analysis, the average chemical oxygen demand of the sampled textile industries wastewater ranged between 22 and 800 mg/L. The minimum and maximum chemical oxygen demand concentrations were recorded in waste-water from industry C_4 and C_2, respectively (Figure 4.8). It is not higher than that of Biological oxygen demand values. The COD of effluents from the industry with primary and secondary ETP is very high compared to EPA (2002) and World Bank (2007) standard, while wastewater that passed tertiary level ETP is below both standards. The higher chemical oxygen demand of the wastewater is due to the presence of ox-disable compounds, which are used in various steps of the process. Higher chemical oxygen demand might be due to impurities present in the chemicals used in various processes of the textile industry. Chemical oxygen demand measures of oxygen consumed during chemical oxidation of the constituents of effluents. The measure of chemical oxygen demand determines the quantities of organic matter found in wastewater. This makes chemical oxygen demand to be useful indicator of organic pollution in surface water (World Bank, 2013). In conjunction with the biological oxygen demand test, the chemical oxygen demand test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances (Husain et al., 2013).



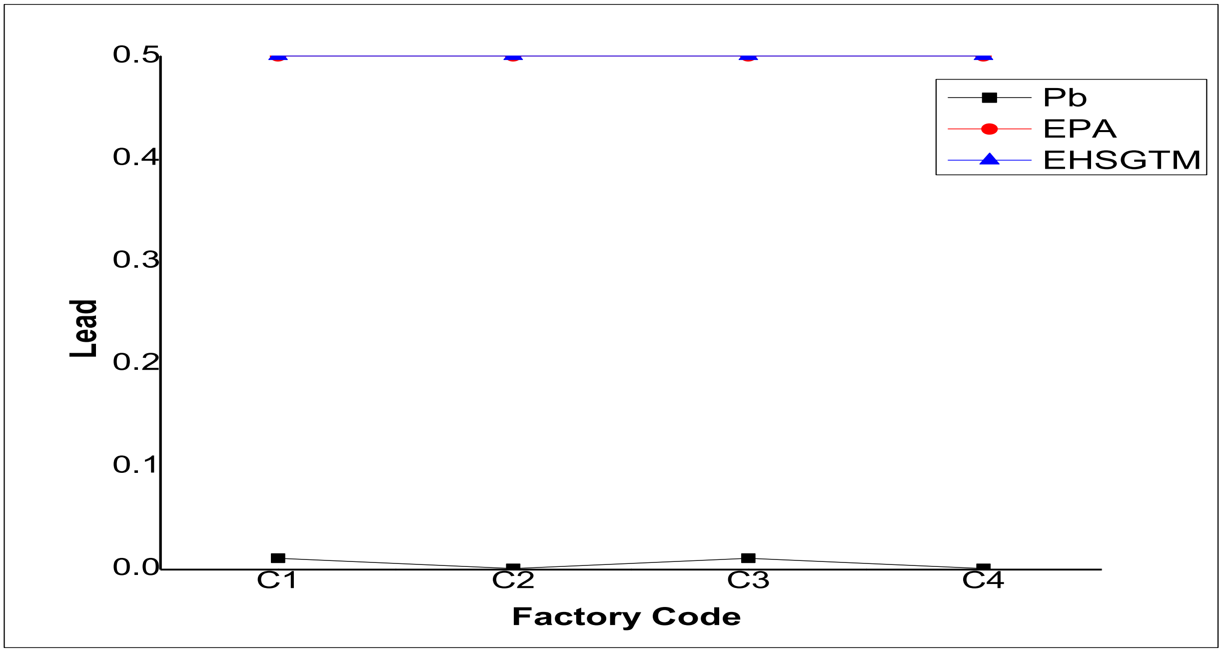
Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.8.Variation textile waste water Chemical Oxygen of demand in study area.

4.3.3. Toxic heavy metal parameters

Lead (Pb)

The current analysis revealed that the concentration of Pb in the wastewater of sampled industries with various ETP was below the allowable limit of EPA (5 mg/L) and EHSGTM (2 mg/L) which was found between 0 and 0.1 mg/L. Therefore, industries need to be encouraged to maintain the concentration of Pb in the wastewater so as to protect the environment from such pollutants. Lead is found in soil, water, and air because of different functions such as burning fossil fuel, mining and manufacturing batteries, ammunition, and metal products (Khalid and Mahin, 2014). Children are particularly sensitive to Pb because of their high metabolism activates and rapid rate of growth, which has serious effects on the nervous system. Acute exposure to Pb may cause proximal renal tubular damage, where long term exposure may also cause kidney damage. It also causes lung and stomach cancer (World Bank, 2013).

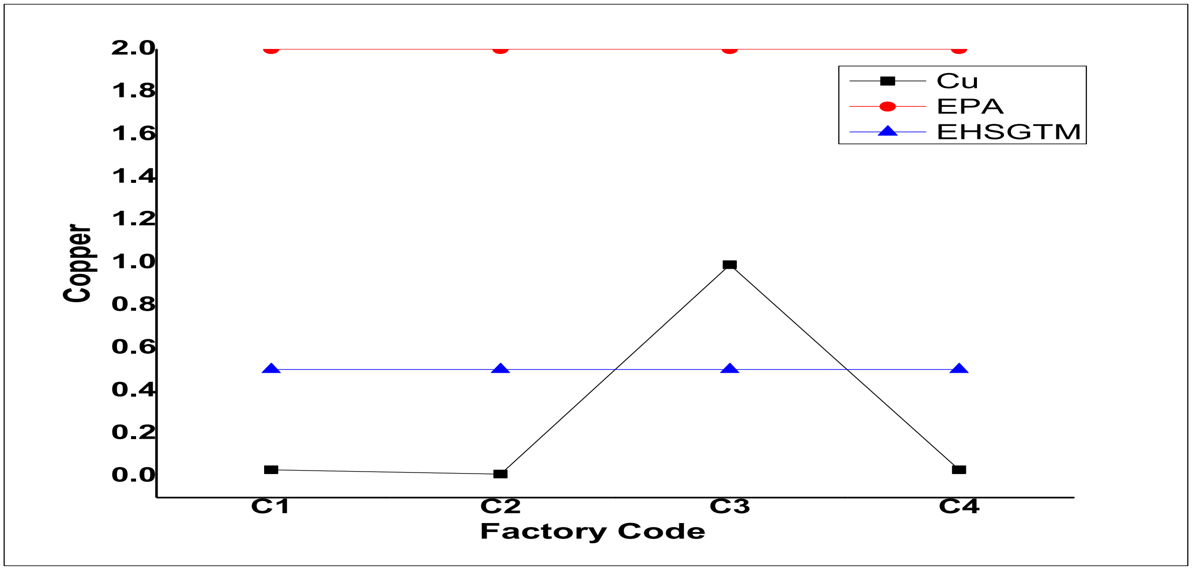


Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.9.Variation textile waste water of lead in study area.

Copper (Cu)

The content of Copper in the wastewaters of four industries varied from 0.01 to 0.99 mg/L. Some (3) samples from one industry (C_3) with secondary level ETP showed slightly higher Cu content (up to 1 mg/L) above EHSGTM (0.5 mg/L) but all samples contain lower than the national (2 mg/L) standard (Figure 4.10). A very small concentration in fie industries may be related to a low level of impurities present in chemicals used. The higher concentration of (0.98 to 1 mg/L) in one industry might be from copper complex dyes other chemicals used in the processing. Presence of higher Cu concentration in some samples as compared to EHSGTM standard tells that the factory needs to tack percussion so as to regulate the amount of Cu released to the environment.

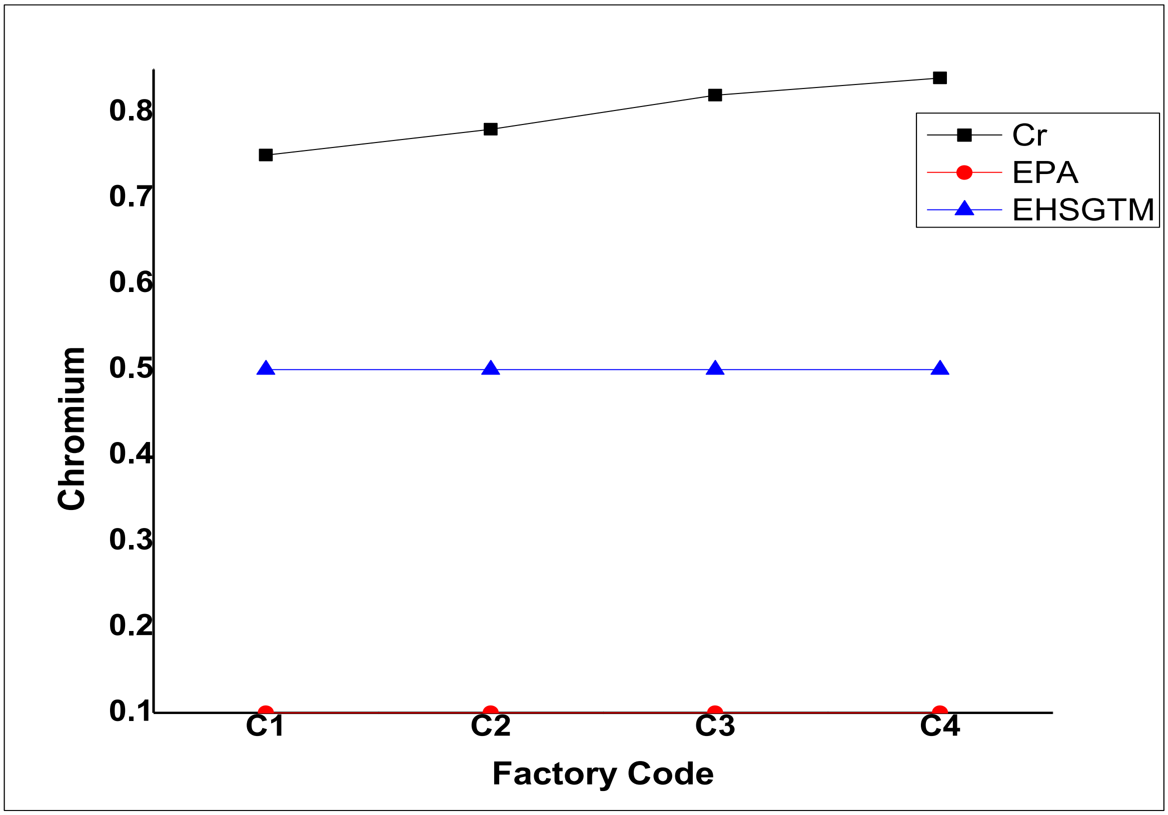


Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.10.Variation textile waste water of copper in study area.

Chromium (Cr)

The current measurement showed that the average Cr content of wastewater ranges between 0.68 to 0.84 mg/L with nearly a similar amount among all samples except one case (0.07 mg/L). The Cr concentration of the effluents is much higher than EHSGTM (0.1 mg/L) standard but lower than EPA (1 mg/L) standard (Figure 4.11). The chromium concentration of wastewater passed the different ETP was found above the EHSGTM standard could be from the complex dye used in the textile manufacturing processes, which might potentially impurities present in chemicals used in various steps of cloth-making processes. Therefore, industries and governments need to pay attention to continue maintaining the Cr release from the waste-water below EPA allowable limit and if possible near to EHSGTM standard. Chromium usually has roles in metal alloys such as stainless steel; and pigments for paints, paper, cement, and other materials. It is also used in electroplating (protective coatings on metal) and processing leather and wood (Khalid and Mahin, 2014). Chromium can be toxic to human, aquatic life and crops at high temperatures that oxidize to chrome VI. It also causes damage to the liver, kidney, and nerve tissue (World Bank, 2013). Ingestion of high amounts of chromium causes gastrointestinal effects in humans and animals, including abdominal pain, vomiting, and hemorrhage (Husain et al., 2013). Chromium pollution is a common problem in the textile industry. Chromium complex dyes and salts are used in textile dyeing.



Note: definition of Abbreviations C_2- Textile factory with primary ETP, C_1 and C_3- Textile factory with secondary ETP, and C_4- Textile Factory with tertiary ETP.

Figure 4.11.Variation of chromium content in textile industry of study area.

From the above discussion, the laboratory result shows that; the concentration of pollutants includes pH, COD, TSS, S^{-2}, TP, TN, TNH_3^-, Phenols, Cu and Cr for each level of textile factories ETP were found above the permissible limit of World Bank Environmental, Health and Safety Guideline of Textile Manufacturing (EHSGTM) standard and Ethiopian guidelines standard except pH for C_1. But the values of COD and TSS for the C_4 Textile factory were found to be below the permissible limit of the World Bank and Ethiopian guidelines standard. Similarly, the value of Pb was found below the permissible limit for each level of textile factories ETP. Due to the poor liquid waste management of textile factories at study area the toxic substances were highly released and it can be one source of environmental pollution and needs a solution.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The goal of the study was to characterization the phsico-chemical of textile industries effluent discharge on environment in Oromia region, Ethiopia. The study analyzed and assessed various physical and chemical textile waste-water parameters.

The physio-chemical characteristics of pollutants were high in the textile factories that have a secondary treatment plant next to the primary treatment plants and a decrease in the concentration of pollutants in textile factories that have advanced treatment plants. On the other hand, the concentration of toxic heavy metals in the textile industries wastewater that passed the different environmental treatment plants (ETP) were similar and above the permissible level.

One-way ANOVA analysis revealed that pH, COD, TSS, S^{-2}, TP, TN, TNH_3^-, and phenols exhibited statically significant differences across sampled textile industries with different levels of treatment plants. In contrast, the concentrations of heavy metals (copper, chromium, and lead) in the effluents of textile factories don't show significant differences across the different ETPs.

Tukey test of the one-way ANOVA indicated that the concentration of COD, TSS, TNH_3^- and Phenols wastewater from the industry having primary level treatment plant have statistically significantly higher as compared to the factory having secondary level ETP. Similarly, concentrations of COD, TSS, TN, TNH_3^- and Phenols in effluents from the industry having primary ETP have statistically significantly higher than the factory with tertiary ETP. The analysis revealed a slight difference in the pH value between effluent from the industry with primary and secondary ETP. Similarly, the content S^{-2} in effluents from the industries with primary and tertiary ETP has a slight difference. Statistically, insignificant differences were observed in the value of pH, TSS, S^{-2}, and TP between effluents from industries having secondary and tertiary ETP. Generally, the concentration of most physical and chemical parameters in the effluents from industrial wastes decreased with an increase of ETP level, although the rate of decrease shows variability across the different parameters. Thus, in most cases performance of secondary and tertiary effluent treatment plants was not as strong (statistically) enough. However, the Post Hoc tests based multiple comparisons revealed that statistically insignificant differences were observed in the case of the concentration of heavy metals (Cu, Pb, and Cr) in the textile wastewater having different levels of ETP.

The COD, TSS, S^{-2}, TP, TN, TNH_3^-, Phenols, Cu and Cr concentration of textile industry pollutants includes for each level of textile factories ETP were found above the permissible limit of World Bank Environmental, Health and Safety Guideline of Textile Manufacturing (EHSGTM) standard and Ethiopian guidelines standard except pH for textile factory with tertiary ETP. But the values of COD and TSS for textile factories with tertiary ETP were found below the permissible limit of the World Bank and Ethiopian guidelines standard. Similarly, the value of Pb was found below the permissible limit for each level of textile factories ETP.

The major problems practices by textile industries with Effluent Treatment Plants are due to the poor liquid waste management of textile factories in the study area, highly toxic substances have been released to the environment, which results in environmental pollution, thus there should be appropriate corrective measures both by the industries and relevant government bodies.

5.2. Recommendation

This research helped to put some recommendations that will be of great preliminary tool to tackling the major problems identified in this study. The most important ones are the following.

- To improve the performance capacity of textile wastewater effluent treatment plants (ETP) so as properly and effectively treat the effluents. The ETP facilities should balance the water at the inlet and outlet of the existing effluent treatment plants by applying appropriate design. The chemicals need to be treated at the required level with a good understanding of the basic concepts of the ETP operational process. In addition to this, industries should apply from preliminary up to advanced treatment technologies as appropriate.
- Improve textile wastewater management efficiency like reducing wastewater generated from the system through isolating the wastewater produced using appropriate ETP process, then reuse than releasing this water after first use to the environment so as to reduce the possible cumulative effect on the environment.
- Cleaner productions system must be applied for effective and efficient use of resources and to minimize a load of environmental pollutants from effluents of textile industries.
- The various levels (local and national) of Environment, Forest and Climate Change Commission should do regular monitoring on compliance of the textile industries as environmental laws and regulations and implement enforcement of the results.
- Textile waste-water management problems should be issue to a public agenda that could facilitate critical stakeholder concern to safeguard community wellbeing and maximize their satisfaction. Therefore, textile manufacturing companies' should support the surrounding society in safeguarding the environment
- To improve the integrated wastewater management system of ETPs servicing textile clusters government must support the installation of the common treatment plants at the national level which provides to reduce effluent treatment cost, better collective treatment, and reduce the land cost for small-scale industrial facilities that can't afford individual treatment plants.
- The government must support the establishment of an internationally accredited or acceptable laboratory to test treated water quality and assist the textile industries.

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ANNEXS

***Annex1*: Sampling Textile waste water from outlet of effluent treatment plant.**

I. Clean the textile wastewater

II. Remove from the wastewater any attachment that may cause splashing. Open the tap Turn on the outlet effluent at maximum flow and let the water run for 1-2 minutes. In this case, the outlet effluent will not be sterilized in order to obtain results which way will provide information on the quality of the wastewater as consumed.

III. Open the sterilized bottle and take out a bottle and punctiliously unscrew the cap or pull out the stopper.

IV. Fill the bottle

V. While carrying the cap and protective cover face downwards (to prevent the entry of dust, which may polluted the sample), immediately hold the bottle under the water jet, and fill Stopper or cap the bottle.

VI. Place the stopper within the bottle or screw on the cap and fix the brown paper protective covering in situ with the string.

***Annex2*: Procedures in the laboratory, According to the American Public Health Association**.

1. Electrometric Determination of pH value

I. Wash the electrodes carefully with distilled water.

II. Add the electrodes into the sample of water (whose pH is to be determined) and wait up to at least one minute for steady reading.

III. The reading is observed after the indicated value becomes constant

2. Molybadovandate with acid per sulfate digestion method determination of total phosphorous value

I. Samples were filtered through 0.45 m membrane filters

II. Then 35 mL of the sample was placed in 50 mL volumetric flask

III. 10 mL of vanadate molybdate reagent was added and diluted to the mark with distilled water.

IV. After that, a blank solution was prepared by replacing 35 mL of the sample with distilled water.

V. After 10 min the absorbance of the sample versus a blank was measured at a wavelength of 470 nm (nanometer) and reading is observed after the indicated value.

3. Digestion method for the determination the chemical oxygen demand value

I. The COD reactor was preheated at 150°C.

II. 2mL of the sample was taken and added to avail which contains chemicals and closed tightly.

III. A blank was prepared with deionized water in another vial. The two vials were gently mixed and placed in the reactor for two hours.

IV. Then the vials were taken from the reactor and cooled.

V. The vial with deionized water was inserted into a colorimeter and set to zero reading.

VI. Then the vial with the sample was placed in the colorimeter and the reading was taken in mg/L.

4. 4-Aminoantipyrime for the determination of the phenol value

I. 500 mL sample was placed into a beaker with the Lower pH to approximately added 5 mL CuSO solution and transferred to the distillation apparatus.

II. Then boiled ceases of 50 mL added to warm distilled water and resumed distillation until 500 mL were collected.

III. The sampled prepared filled in to diluted 100 mL and 2 mL of buffer solution

IV. Then added to 2.0 mL amino antipyrine solution, 2.0 mL potassium ferricyanide solution, and then mixed together.

V. After 15 minutes read absorbance at 510 nm and reading is observed after the indicated value

5. Methylene Blue method for the determination of the sulfide value

I. Prepared deionized water sampled of 10 mL for spectrophotometers and 25 mL for colorimeters.

II. Then slightly mixed the sampled to prevented sulfide loss. Added Sulfide Reagent to sampled cell and used 0.5 mL for spectrophotometers and 1.0 mL for colorimeters were Added Sulfide Reagent cell and closed the sample.

III. Then the sampled was mixed and the pink color was developed initially.

IV. When sulfide is present, the solution becomes blue Start to take read.

6. **Determined by salicylate method for the determination of the total ammonia value**

I. Prepared samples of Hypochlorite Solution 1L was Mixed with 50 mL of sodium hypochlorite (6%) solution into 700 mL of deionized water, and

II. Then Salicylate 1 L and 100 g with sodium salicylate were added to 700mL of water and stirred untilled dissolved.

III. Then Probe Wash Solution was added to 800mL of deionized water or dilute with 1 L.

IV. Then Mixed and stored in a polyethylene bottle to detected ammonia in wastewater and reading was observed after the indicated value

7. **Per sulfate Digestion method for the determination of the total nitrogen value**

I. Placed the amount of the required sample in the sample tube used a graduated cylinder (those samples contained suspended particles) or volumetric pipettes then added a portion of 10 ml of sulfuric acid (98%)

II. Prepared additional blanks, only chemicals and deionized water without sample Suspend the sample carefully by gently swirled the tube Connect the Scrubber B-414 to the Speed Digester K-436 or K-439 to absorbed the acid fumes created during digestion.

III. Inserted the rack contained the sampled into the preheated unit .where the liquid inside the samples tube was not clear and blue-green, digest for an additional 30 min to cool down to the ambient temperature.

IV. Then the samples were placed in the cooling position, it took approx. 30 min to cool them down, when those were left in the heated chamber, it took at least 60 min.

V. Where a sample tends to foam added a small amount of stearic acid to prevented foam. And finally, samples have a high organic matrix, added an additional 1 to 5 ml of sulfuric acid to the samples and blanks. Reading is observed after the indicated value

8. **Photometric method for the determination of the total suspended solid value**

I. A prepared clean piece of paper layout filter pads for number used a Sharpie permanent ultra-fine or very fine point black marker, sequentially number outside edge of each pad with a unique label.

II. Then pads were labeled, placed in a Pyrex dish, and dry overnight in a 105° C oven.

III. When ready to weigh, remove pads from oven and placed into a desiccator to cool to room temperature and checked calibration.

IV. When ready to sample, place pad numbered side down onto filtered apparatus.

V. When ready to analyzed, placed opened pouch with the sample in 105° C drying oven overnight Repeat steps and reading is observed after the indicated value.

9. Flame Atomic Absorption Spectrometry method for the determination of the heavy metal (chromium, copper and lead)

I. To determination the heavy metals concentrations all collected samples were prepared.

II. In this respect, the digestion of water samples with (HNO_3 67%: HCl 37% = 3:1) was achieved. Acid mixture (HNO_3 67%: H2SO_4 98%: HCl 37%: HF 40% = 2:1:1:1) for wastewater samples digestion was used.

III. Atomic Absorption Spectrometry (AAS) was a very common and reliable technique for detected metals and metalloids in environmental samples. The total metal content of water samples was performed by Flame Atomic Absorption Spectrometry (FAAS).

IV. Reading is observed after the indicated value.

Annex 3: **Mean value of chemical Parameters analysis laboratory results.**

Sample code	Textile factory code	Level of ETP	Triplicated	pH	COD	TSS	SULPHIDE	T. N	T. A	T .P	PHENOL	Pb	Cu
C1	**C1**	2	R1	11	320	87.9	10	89	47	35	5	0.001	0.03
			R2	8	277	80.1	8.3	97	58	34	6	0.019	0.05
			R3	8	243	66	9	102	60	24	4	0.01	0.01
			Mean	9	280	78	9.1	96	55	31	5	0.01	0.03
C2	**C2**	1	R1	4	855	182.5	11.8	99	95	46	12	0	0
			R2	5	780	170	10.7	102	100	46	9	0	0.02
			R3	6	765	163.5	9.6	102	99	55	12	0	0.01
			Mean	5	800	172	10.6	101	98	49	11	0	0.01
C3	**C3**	2	R1	7	287	48	4.4	83	38	25	6.5	0.009	0.98
			R2	6	302	78	6.5	82	40	26	6	0.001	1
			R3	5	311	69	5	78	45	18	5.5	0.02	0.99
			Mean	6	300	65	5.3	81	41	23	6	0.01	0.99
C4	**C4**	3	R1	6.5	23	45	7	66	26	20	2	0	0.04
			R2	7.5	21	50	7.8	62	36	17	3	0	0.03
			R3	7	22	55	8	58	34	26	4	0	0.02
			Mean	7	22	50	7.6	62	32	21	3	0	0.03

Source: laboratory result by the author, 2020

Annex 4: **The manufacture and finishing of textiles limit values for discharges to water.**

Parameter	**Limit Values mg/L**
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	50
Total nitrogen (as N)	40
COD (mg O_2/l)	150
Total phosphorus (as P)	10
Suspended solids	30
Total ammonia (as N)	20
Oils, fats & grease	20
Phenols	1
Mercury (as Hg)	0.001
Nickel (as Ni)	2
Cobalt (as Co)	1
Lead (as Pb)	0.5
Antimony (as Sb)	2
Tin (as Sn)	5
Chromium (as Cr VI)	0.1
Arsenic (as As)	0.25
Cadmium (as Cd)	1
Zinc (as Zn)	5
Copper (as Cu)	2
Mineral oils (Interceptors)	20
Benzene, toluene & xylene (combined)	1
Mineral oils (Biological Treatment)	5
Organ chlorine pesticides (as Cl)	0.03
Mothproofing agents (as Cl)	0.003
Organ phosphorus pesticides (as P)	0.003
Absorbable organic halogen compounds (AOX)	5
Sulphide (as S)	2

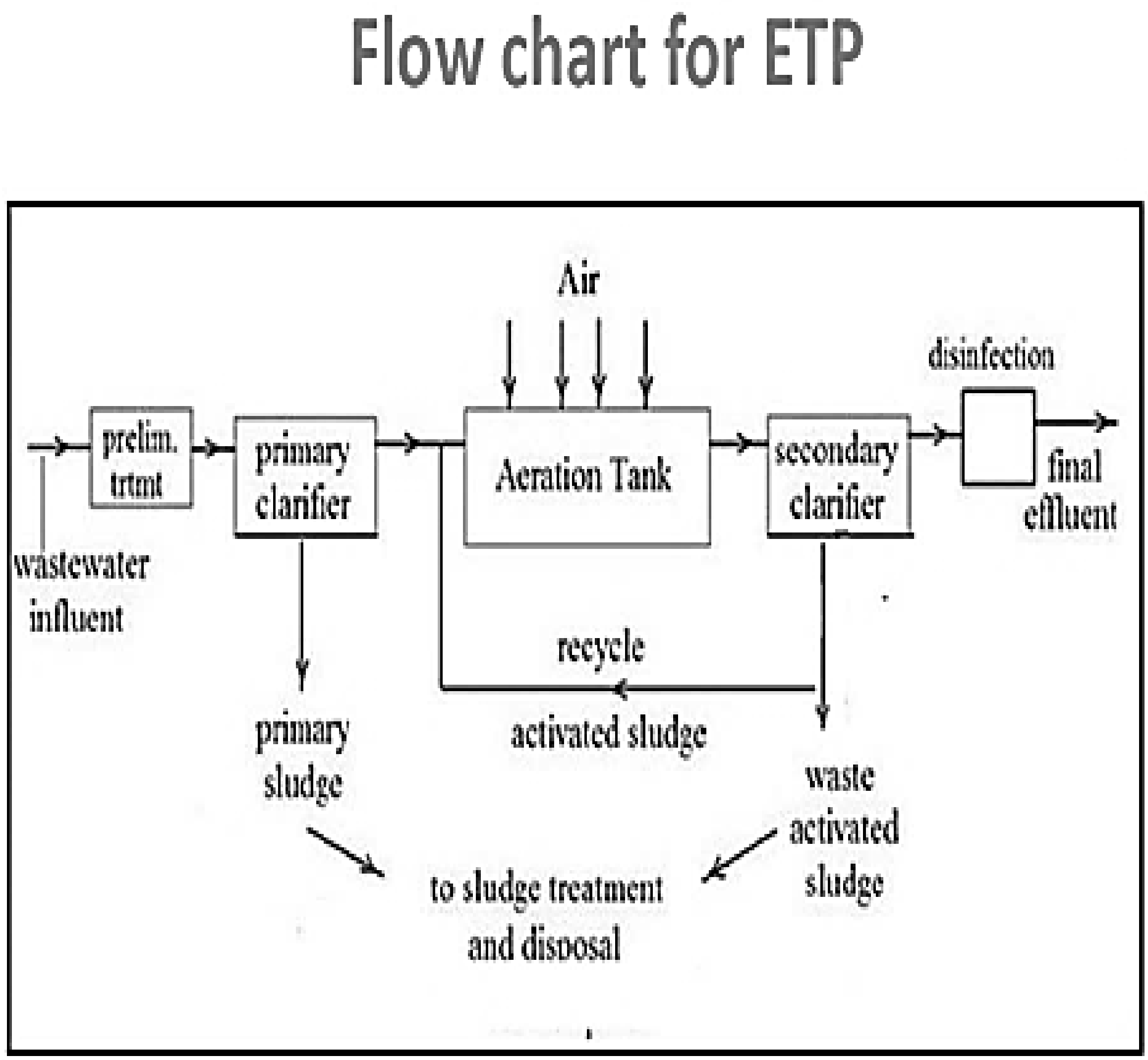
Sources: EPCP Ethiopian standard guidelines, 2002

***Annex 5*: Environmental, Health and Safety Guideline of Textile Manufacturing**

Parameter	**EHSGTM limit values mg/L**
Temperature	40 °C
pH	6 – 9
BOD	30
Total nitrogen (as N)	10
COD (mg O_2/l)	160
Total phosphorus (as P)	2
Suspended solids	50
Total ammonia (as N)	10
Oils, fats & grease	10
Phenols	0.5
Nickel (as Ni)	0.5
Cobalt (as Co)	0.5
Lead (as Pb)	0.5
Chromium (as Cr VI)	0.5
Chromium (as total Cr)	0.1
Cadmium (as Cd)	0.5
Zinc (as Zn)	2
Copper (as Cu)	0.5
Sulphide (as S)	1

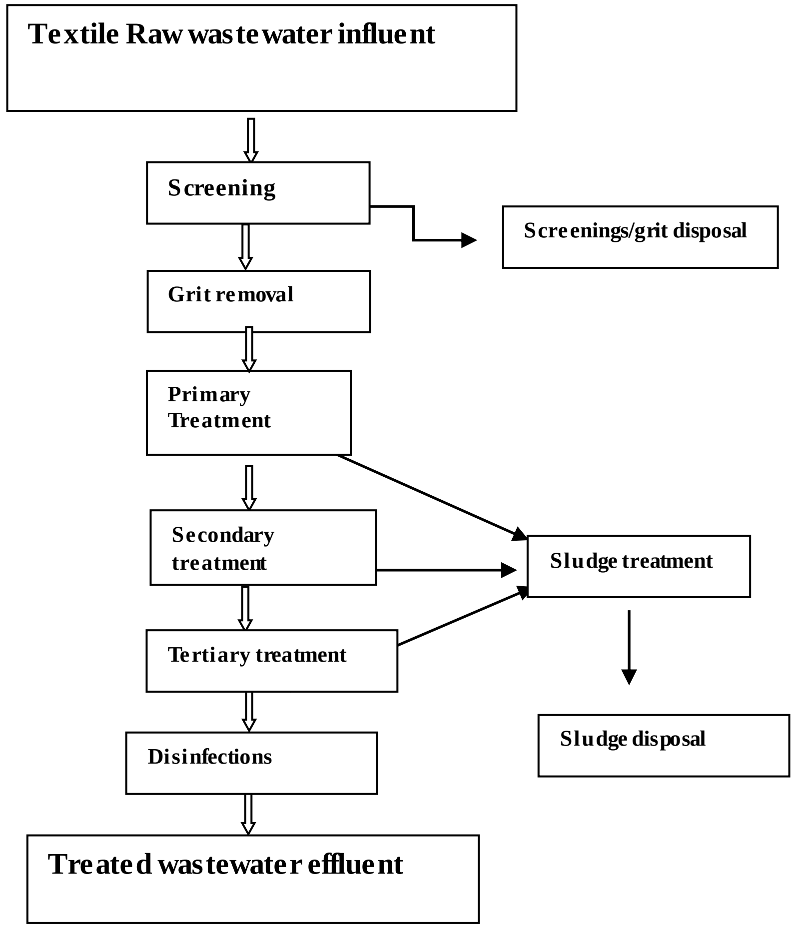
Sources: Environmental, Health and Safety Guideline of Textile Manufacturing of World Bank, 2007

***Annex 6*: Schematic flow diagram of ETP**



Sources: EPA, 2013

Annex 7: **Schematic overview of a textile wastewater treatment system**



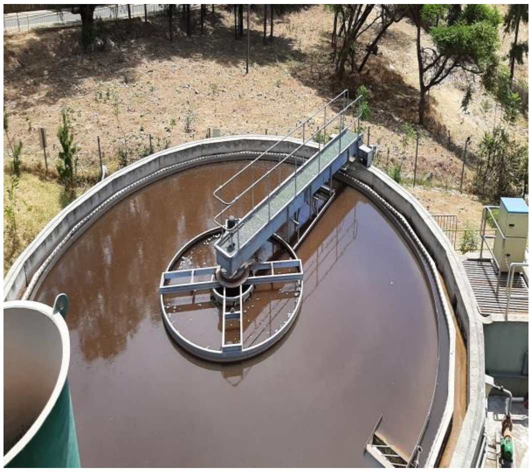
Sources: world Bank, 2013

Annex 8: **Photos**

I. Sample of primary treatement and secondary treatement plants

A **A**

B **B**



Note: A =for primary ETP and B for secondary ETP

Source: photo taken by the author, 2020

II. Sample of secondary and tertiary treatment plant

A B

Note: A =for secondary ETP and B for tertiary ETP

Source: photo taken by the author, 2020

III. Sample of discharged effluent

Source: photo taken by the author, 2020

IV. Laboratory set up

Source: photo taken by the author, 2020