Assessment of the Status of Industrial Waste Water Effluent for Selected Industries in Addis Ababa, Ethiopia

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Abstract
Environmental pollution constitutes a great health hazard to human, animals and plants or abiotic and biotic components with local, regional and global implications. Effluents from industries are normally considered as the main environmental pollutants containing organic and inorganic compounds. The Objective of this assessment is to know the Status of the selected industrial waste water effluent in Addis Ababa city. For this assessment parameters like (pH, temperature, suspended solid (SS), chemical oxygen demand (COD), biological oxygen demand (BOD), , SO_4^{2-}, total NO_3^-, total PO_4^{3-}, total NH_3 , Cd, Cr, Pb, total coliform bacteria) have been determined to assess the pollutant status and pollution levels of the selected industrial waste water effluent. The analyses results of bacteriological and physico-chemical characteristics of selected industrial waste water were evaluated with the acceptable standard limits for surface water. As the result reveals Temperature and acidity were not the problem for effluents discharge, but the COD, BOD, suspended solids, total nitrogen, total phosphorus, total ammonia and heavy metal concentration should be controlled to prevent pollution caused by effluent discharge. Generally, the results indicate the effluent of all selected industry were physically, bacteriological, and chemically polluted the surrounding environment.
Keywords: pollutant, parameters, effluent,

INTRODUCTION

Industrialization is considered as the cornerstone of development strategies due to its significant contribution to the economic growth and human welfare, but the increase of industrial activities in the world was intensified environmental pollution and the deterioration of ecosystems, especially, aquatic ecosystem, with the accumulation of organic and inorganic pollutants. In recent years, increasing concern about the effect of toxic metals in the environment has resulted in more strict environmental regulations for industrial applications that discharge metal bearing effluents (Papageorgiou *et. al.*, 2008).

Addis Ababa is one of the city in which industrialization is highly expanded in Ethiopia like other cities in developing world. Since most of industries were established without environmental impact assessment and almost all industries in the city are located in the vicinity of water course, about 90% of these industries are simply discharging their effluent in to the nearby river or sewerage (AAEPA). This disposal method of untreated wastes water in to the nearby river or sewerage could be the major effect for the environment, due to industrial waste water content in toxic substances like heavy metals, pesticides, solvents, and used oils. So, the presence of these pollutants in water bodies, soil, and atmosphere could make the existence of life very difficult, especially the water bodies near to industrial area have been extremely affected from the disposal of industrial waste water which can alter the physical, chemical and biological nature of the receiving water body (Ademoroti, 1996). Know day industrial waste water is the most common source of water pollution and it increases yearly due to the fact that industries are increasing because the cities are getting industrialized. As a result, water bodies which are major receptacles of untreated and partially treated industrial wastes have become highly polluted. The resultant effects of this on public health and the environment are usually great in magnitude when comparing with other sources of pollutants (Kannj and Achi, 2011). The addition of high levels of pollutants in river water systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), toxic metals such as Cd, Cr, Ni and Pb and Fecal coliform (Ademoroti, 1996). The pollution of the environment due to industrial waste water is depends on the activities of the industries, such as its process technology, their concentrations through utility use, contaminants added in the process operation, nature of raw materials and process methodology (Kannj and Achi, 2011). So, one of the most critical environmental problems of Ethiopian country especially, in Addis Ababa is improper management of vast amount of wastes generated by various industrial activities that leads for this assessment study. Almost all industries found in Addis Ababa city do not have proper waste water treatment plant and studies approved that quality of the river waters changed and other environmental aspect that become unfit for some useful purpose. The waste water generated from industries can create significant health problems and a very unpleasant living environment if not treated and disposed safely and appropriately. These industrial wastes can carry various types of contaminants to the river, lake and groundwater. Thus, assessing the status of industrial liquid waste and evaluating their waste management practices is critical for monitoring of the waste producers.

The presence of contaminants from industrial contaminant within the water may reduce the yield of crops and the growth of plant and it will harmful to the aquatic living organism too. The contamination of metals is a major environmental problem and especially in the aquatic environment. Some metals are potentially toxic or carcinogenic even at very low concentration and are thus, hazardous to human if they enter the food chain. Metals are usually dissolved into the aquatic system through natural or anthropogenic sources. Metal ions are distributed thoroughly during their transport in different compartments of the aquatic ecosystems, in biotic or abiotic compartment such as fishes, water, sediment, plant. Metals remain in contaminated sediments may accumulate in microorganisms which in return entering into the food chain and eventually affect human wellbeing (Shakeri & Moore, 2010).

The early studies suggested that higher concentration in metals can be carcinogenic and teratogenic (Brien *et al*., 2003; Yadav *et al.,* 2007). It is estimated that approximately one-third of the world's population are using groundwater for drinking purposes, but Pollution of ground water due to industrial effluents is a major issue (Vasanthavigar *et al*., 2011). In developing countries it is estimated that around 80% of all diseases are directly related to poor drinking water quality and unhygienic conditions (Olajire & Imeokparia, 2001; Vasanthavigar *et al*., 2011). Human activities like industrialization are responsible to the groundwater quality and the groundwater contamination and spread of contaminant are amongst the major factor lead to human hazards.

Effect of heavy metal to the environment and human health

Specifically the heavy metals discharged to the environment above the limit can affect the environment and human health. Among these some of them are described below.

High concentrations of Al can cause hazard to brain function such as memory damage and convulsions. In addition, there are studies suggested that Al is linked to the Alzheimer disease (Jordao *et al*., 2002).

Cadmium (Cd) is harmful to both human health and aquatic ecosystems. Cd is carcinogenic, embryotoxic, teratogenic, and mutagenic and may cause hyperglycemia, reduced immunopotency, and anemia, as it interferences with iron metabolism (Rehman & Sohail Anjum, 2010). Furthermore, Cd in the body has been shown to result in kidney and liver damages and deformation of bone structures (Abbas *et al*., 2008).

Chromium Cr (III) is essential nutrient for animal and essential to ensure human and animal lipids' effective metabolism but Cr (VI) is carcinogenic. Cr (VI) is the most toxic form of chromium and having equivalent toxicity to cyanides. It can cause skin ulcer, convulsions, kidney and liver damage. Moreover, it can generate all types of genetic effects in the intact cells and in the mammals in vivo (Khe´rici-Bousnoubra *et al*., 2009). It has also been reported that intensive exposure to Cr compounds may lead to lung cancer in man (Jordao *et al*., 2002). Iron is an essential element in several biochemical and enzymatic processes. It involved the transport of oxygen to cells. However, at high concentration, it can increase the free radicals production, which is responsible for degenerative diseases and ageing (Jordao *et al*., 2002).

Lead could accumulate in kidney, liver, bone, and brain. Chronic intoxication can lead to encephalopathy mainly in children (Jordao *et al*., 2002).

Mercury can cause brain damage, heart, and kidney and lung disease in human. At very low concentration, Hg can permanently damage to the human central nervous system (Rai & Tripathi, 2009). Inorganic and mercury through biological processes, can converted into MeHg. MeHg is organic, toxic, and persistent (Wang *et al*., 2004; Rai & Tripathi, 2007). Furthermore, MeHg can cross the placental barriers and lead to foetal brain damage (Rai & Tripathi, 2009).

Nickel is an essential element to both plant and human, but high exposure to this metal can lead to cancer in organs of the breathing system, cardiovascular and kidney diseases (Jordao *et al.,* 2002).

Zinc is an essential element to human and plant (Jordao *et al*., 2002). Recent studies indicated that Zn is also involved in bone formation. However, elevated intake of Zn can cause muscular pain and intestinal hemorrhage (Honda et al., 1997; Jordao *et al*., 2002).

High concentration of fluoride can cause dental and skeletal fluorosis such as mottling of teeth, deformation of ligaments and bending of spinal cord (Janardhana Raju *et al*., 2009). High concentrations of nitrate cause methemoglobinemia in infants and could cause cancer. In the blood, nitrate convert hemoglobin to meet hemoglobin, where it does not carry oxygen to the body cells, which may lead to death from asphyxiation (Purushotham *et al*., 2011).

High potassium concentration may cause nervous and digestive disorders (Purushotham *et al*., 2011), kidney heart disease, coronary artery disease, hypertension, diabetes, adrenal insufficiency, pre-existing hyperkalaemia. Infants may also experience renal reserve and immature kidney function (WHO, 2009).

Excessive sulphate concentration may lead to laxative effect (Purushotham *et al.,* 2011) and it affects the alimentary canal (WHO, 2004). Because of the above listed effects are visible on the environment and humans are highly on progressive, this assessment is required

METHODS

Study Area and Period

The study was conducted in Addis Ababa city. Addis Ababa is the capital city of African Union and other International Organizations, it is located within the central plateau of Ethiopia, extending between 8^0 55' and 9^0

05' North latitude and 38^0 05' and 39^0 05' East longitude. The total physical land area of the current city administration is 54,000 hectares (540 km^2), out of which about 22,000 hectares has designated for green use (environmental function).

Study Design

Experimental study was carried out in the laboratory of Addis Ababa Environmental protection Authority in Addis Ababa. The experiment was carried out using selected industrial waste water effluent.

Study Variables

Parameters	**Instruments name and methods used for experimental analysis**
pH	Electrometric probe
Temperature	Electrometric probe
Suspended Solids (SS)	Spectro photometric
Cadmium (Cd)	Atomic absorption spectrometric method
Sulfide (S^{-2})	Spectrophotometer method
Lead (Pb)	Atomic absorption spectrometric
Zinc (Zn)	Atomic absorption spectrometric
Total nitrogen (N)	Spectro photometric
Total phosphorous (P)	Spectro photometric
Total ammonia (NH_3)	Spectro photometric
Chemical oxygen demand (COD)	Spectro photometric
Biochemical oxygen demand (BOD)	Winkles methods
Chromium (Cr)	Atomic absorption spectrometric method
Total coliform	Membrane filtration method

The data was taken from AAEPA laboratory and aggregated carefully to figure out Addis Ababa industrial waste water effluent status. The industrial effluent samples were collected from the selected discharge outlet points of industries. Sterile plastic bottle was used, each bottle was labeled in code, HNO_3 (nitric acid) was added to preserve effluent for heavy metal analysis. pH and temperature of wastewater were measured there and brought wastewater sample for the left physico-chemical and bacteriological parameter analysis to the laboratory.

Quality Control

The procedure of the experiments was done consistently through the whole study to minimize the sources of error and all equipment were calibrated. Triplicate analysis of each parameter was done following the standard protocol in order to get satisfactory result. Moreover, the standard set by the country were used for every triplicate analysis of each parameter during all the experiment.

RESULTS AND DISCUSSION

Industrial wastewater management practice

Industries generate effluent with high concentration of pollutants that needs specialized treatment system, but most of the time they release in to the river or open space adjacent to the factory without any kind of treatment, or only have pretreatment system to remove the toxic component and release partially treated effluent to the environment, and mix the sludge part with lime, and press to make filter cake then dispose hazardous solid to Repi disposal site. Some industries have treatment plant but it is not functional it seems not to incur additional cost. The following graphs summarize some of the more recent waste water observations for resent microbiological and physico-chemical characteristics of selected industrial waste water effluent.

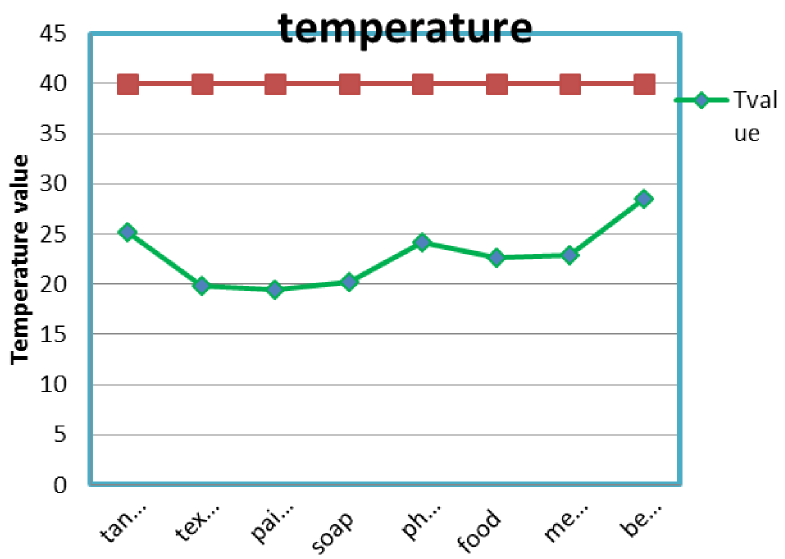

Figure 1: Comparison of the selected industry interims of temperature

As we can see from the above graph all the temperature value of the selected industries was below the provisional standard value set by EPA.

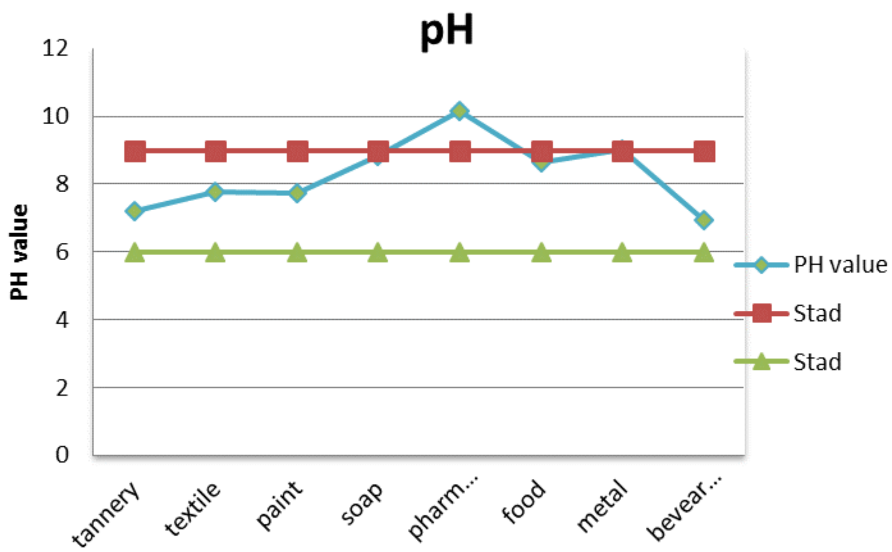

Figure 2: Comparison of the selected industry interims of pH

As we can see from the above graph all the pH value of the selected industries was in the range of the provisional standard value set by EPA except at one point.

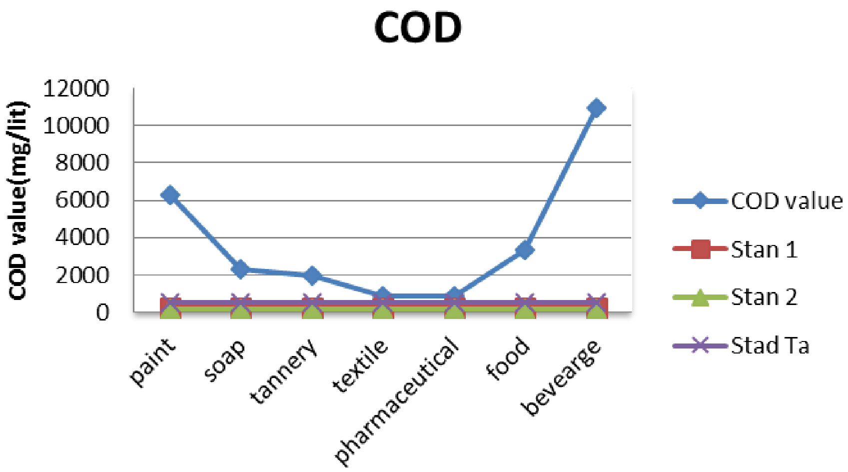

Figure 3: Comparison of the selected industry interims of COD

As we can see from the above graph all the mean COD value of effluent from selected industries were significantly above the maximum permissible limit value. Effluent with high COD (mg/lit) load are released from beverage and followed by paint,food,soap,tannery textile, pharmaceutical industry

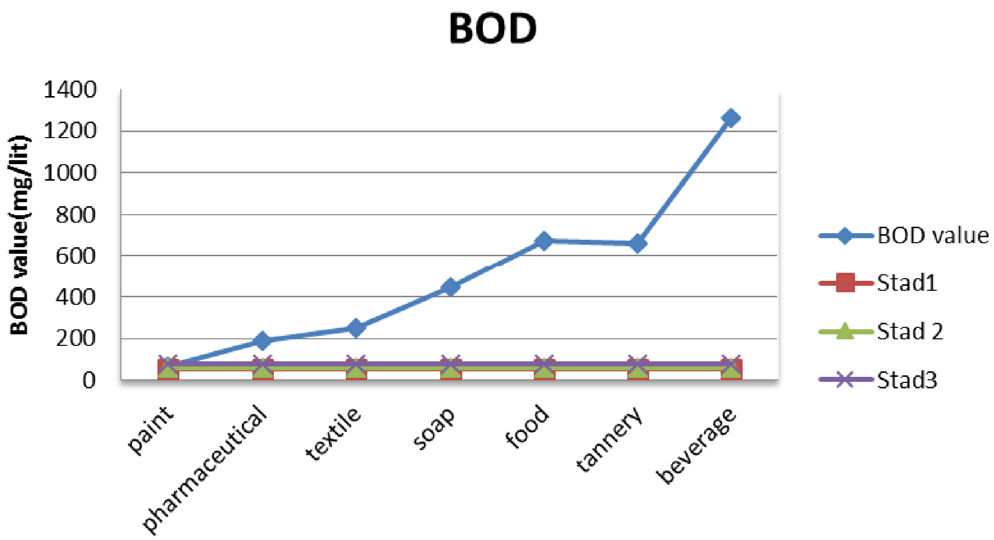

Figure 4: Comparison of the selected industry interims of BOD

As we can see from the above graph all the mean BOD value of the selected industries were significantly above the maximum permissible value. Effluent with high BOD load are released from beverage industry and followed by food, tannery, soap ,textile pharmaceutical industry and paint factory. This is similar with the above COD value.

When an excess of organic matter enters the water body organic matter increases in water, the number of decomposers will increase. These decomposers grow rapidly and use a much amount of oxygen during their growth that leads to a depletion of oxygen as the decomposition process occurs a lack of oxygen can kill aquatic organisms. As the aquatic organisms die, they are broken down by decomposers which lead to further depletion of the oxygen level.

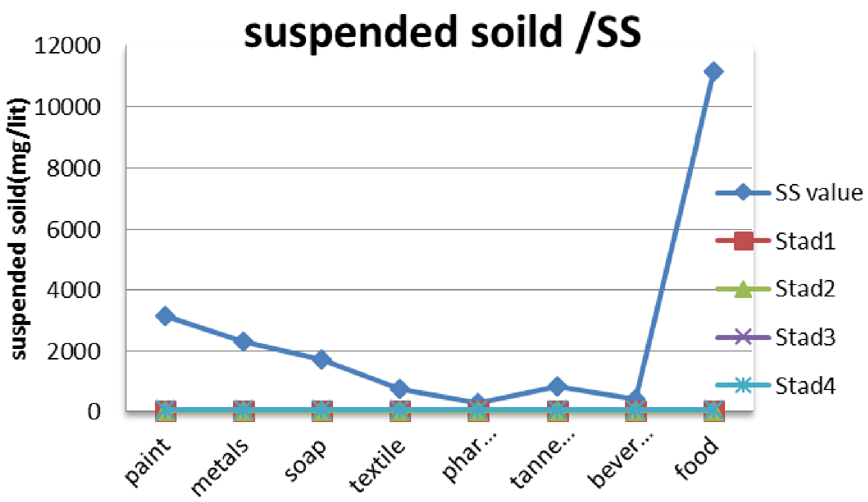

Figure 5: Comparison of the selected industry interims of SS

The mean SS value of effluent was significantly above the maximum permissible value. High suspended solid concentration can block light from reaching submerged vegetation and it causes less oxygen to be released into the water. It also cause an increase in surface water temperature absorb heat from sun light, this can cause dissolved oxygen level to fall

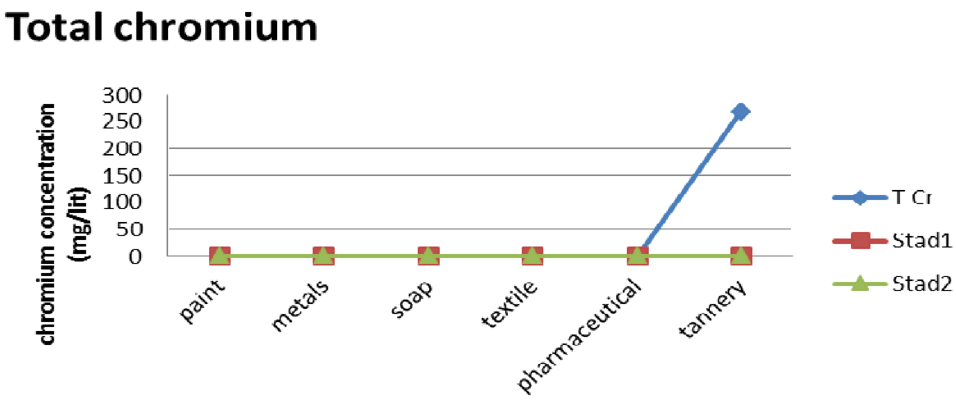

Figure 6: Comparison of the selected industry interims of Total chromium

The mean total chromium concentration of effluent was significantly above the maximum permissible value. Chromium often accumulates in aquatic life. Low-level of chromium exposure can irritate the skin and cause ulceration. Long term exposure can cause kidney and liver damage, and damage too circulatory and nerve tissue.

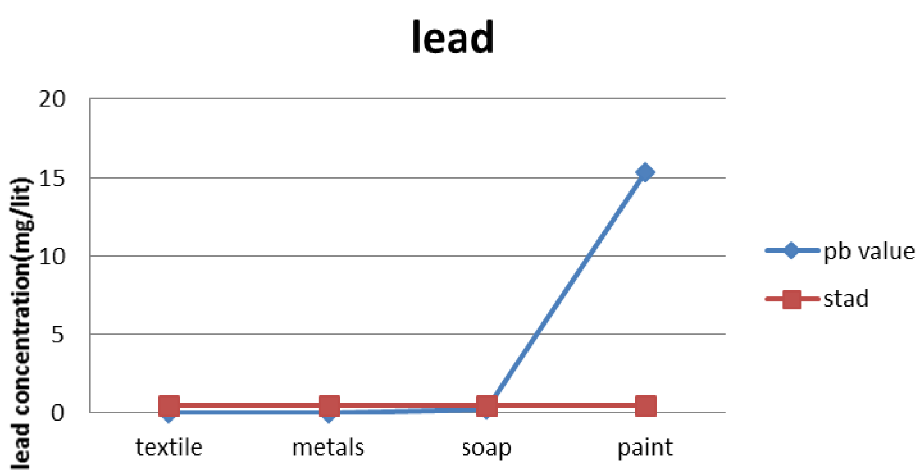

Figure 7: Comparison of the selected industry interims of Lead

The mean lead concentration of effluent was above the maximum permissible limit. Lead is a toxic element that accumulates in the skeletal structures. It accumulate in the aquatic environment and thence in fish. High levels exposure of lead result in toxic biochemical effects in humans which in turn cause problems in the synthesis of hemoglobin, kidneys gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system.

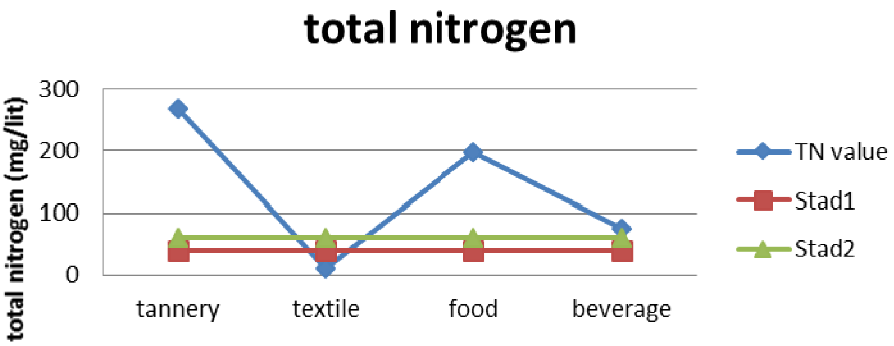

Figure 8: Comparison of the selected industry interims of Total nitrogen

The mean value of effluent was above the maximum permissible limit value. High levels of total nitrogen cause an over growth of plants and algae. As the plants and algae die, they become organic material in the water. The enormous decay of this plant matter in turn lowers oxygen level.

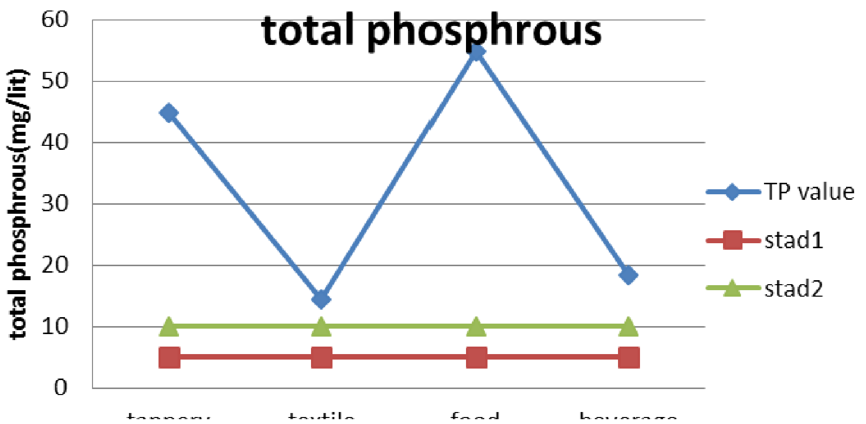

Figure 9: Comparison of the selected industry interims of Total phosphors

The mean phosphorus concentration of effluent was above the maximum permissible limit value. High levels of total phosphorus cause an over growth of plants and algae. As the plants and algae die, they become organic material in the water. The enormous decay of this plant matter in turn lowers oxygen level.

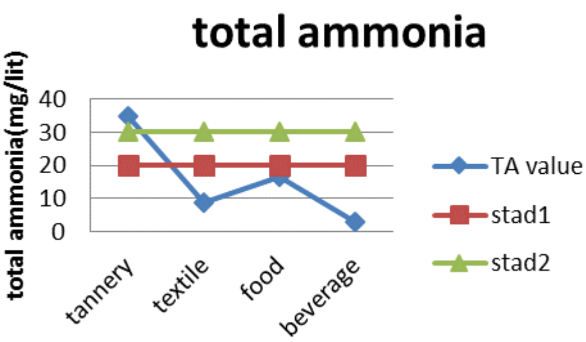

Figure 10: Comparison of the selected industry interims of Total ammonia

Tannery industry effluent had high total ammonia concentration than food ,textile and beverage industry. High levels of total ammonia cause an over growth of plants and algae. As the plants and algae die, they become organic material in the water. The enormous decay of this plant matter in turn lowers oxygen level.

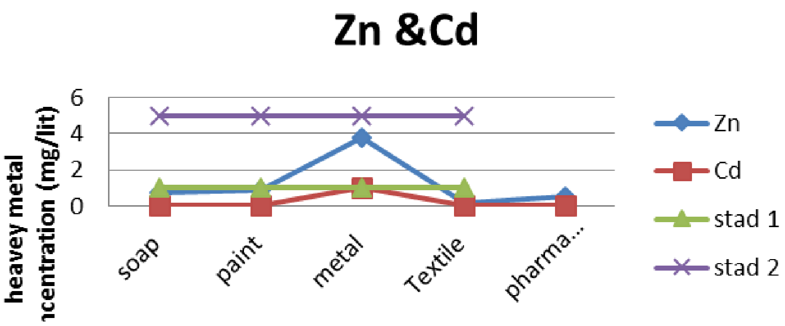

Figure 11: Comparison of the selected industry interims of Zn and Cd

Effluent released from metal factory had Zn concentration signifcantlly above the maximum permissible limit. But the value of Cd is in the range of the satandard. Both Cadmium and zink is biopersistent, It accumulates in plant cell and highly toxic effects for all animals if it is above the consentration recommended.

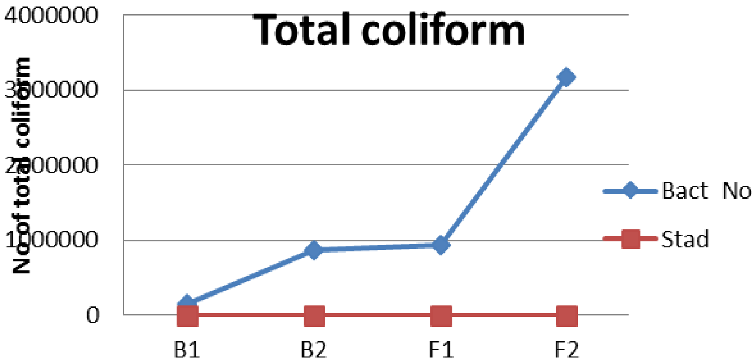

Figure 12: Total coliform comparison only for Addis Ababa Abattoir and edible oil and beverage industry

Effluent from Addis Ababa Abattoir had high total coliform bacteria than edible oil and beverage industry. Coliform bacteria may not cause disease, but can be indicators of pathogenic organisms that cause diseases**.**

CONCLUSION

In general, the experimental result indicated that temperature values of effluent from all industrial subsectors were blowing the provisional standard values. The pH value of all effluent except from pharmaceutical industry was within the provisional standard value. All mean value of COD, BOD and suspended solid concentration of effluent were significantly above the maximum permissible limit value in all sectors. Tannery effluent had significantly high total chromium concentration than paint, soap industries and the maximum permissible limit value. The total nitrogen concentration in the effluent taken from tanneries, beverage and food industries were above the maximum permissible limit. The lead concentration in the effluent from paint factory was above the maximum permissible limit value. Textile, metals, soap industries had effluent with lower lead concentration and below the provisional standard limit value. But, it does not means that these industries always discharge below the limit of provisional standard. Effluent with high phosphorus concentration effluent are released from food and followed by tannery, beverage and textile factory, and the mean values of total phosphorous concentration of all subsectors were above the maximum permissible limit value.

- The total ammonia concentration of effluent from tannery exceeds the maximum permissible limit value.
- Food, beverage and textile factory effluent had low total ammonia concentration .The lowest total ammonia concentration does not means that these industries always discharge below the limit of provisional standard.
- Effluent with high total coliform Bactria extremely above the maximum permissible limit is released from food and beverage industries.

Temperature and acidity were not a problem for effluents discharge. But the COD, BOD, suspended solids, total nitrogen, total phosphorus, total ammonia and heavy metal concentration should be controlled to prevent pollution caused by effluent discharge.

RECOMMENDATION

Based on the results it is recommended that:

AAEPA play its role on the industrial effluent environmental pollution reduction by

- Approval of industrial effluent standards and industry pollution control regulations.

- Establishing a regular monitoring program for industries, evaluating functions of wastewater treatment plant.
- Implementing the existing regulation or enforcing the existing law.
- Providing continuous environmental audit training to industries and preparing workshops, awareness raising programs (Helps for self-audit).
- Require industries to submit report that indicate pollution control plans and measures and examine the report by regular inspection.
- Encourage industries uses technologies free from pollution.
- Discus with polluters (announce their effluent status) on the reduction of effluent pollutant load.

It is recommended for industries to reduce their effluent pollutant load by:

- Establishing environmental unit
- Improving production process to reduce the amount and hazard nature of waste and segregate different types of waste at the source.
- Introducing total management system of material to reduce the excess use of material and to know the amount of effluent discharge from production process.
- Treating effluent by the combination of production process with onsite wastewater treatment and recycling system this helps to reduce the amount and pollutant load of effluent.
- Many factories have their Owen laboratories, with a little commitment in time and money it is possible to carry out a tests on the effluent to check whether it conforms to discharge standards or not and submit laboratory report to AA EPA.
- Wastewater from washing section can be reduced by introducing counter current washing system or reusing the wastewater for washing.
- Effluent from Addis Ababa Abattoirs has organic nature and it may a possible source of CH_4 for biogas production and doing this will help not only to prevent the waste from being an environment hazard but also it will serve as a potential source of energy.

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