IJREH
International journal of Rural Development, Environment and Health Research
ISSN: 2456-8678
Volume - 1 | Issue - 2 | July- August 2017

Study on Physico- Chemical Parameters of Waste Water Effluents from Kombolcha and Debreberhan Industrial Area, Ethiopia

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Abstract—*The physicochemical parameters of wastewater collected from five sampling sites were investigated. These parameters were analyzed by standard methods. The pH of the waste water varied from 4.7 to8.2, while the waste water conductivity ranges from 1205.3 to 7130.17 μScm^{-1}. The maximum total dissolved solid was 8100mg/l.and the maximum biological oxygen demand was 2763.35 mg/l. The chemical oxygen demand of the selected samplesites varied widely (772.56–3105.13 mg/l), the nitrate content was found to be maximum insample W5 (166.00mg/l), and the sulfate content was found to be high in samples W1 andW5 (500and 4875mg/l). The chloride and sulphied contents were maximum atsamplesof W3 and W5 their concentrations were8543.45 and 10.7mg/lrespectively. Thephysicochemicalparameters studied in this work were varied between the samplesand almost all parameters studied were higher compared with the permissible limit prescribed by the United States Environmental Protection Agency and World Health Organization.*

Keywords— Wastewater, Physicochemical, conductivity, Biological oxygen demand, Chemical oxygen demand, TDS,Chloride, Sulphied.

I. INTRODUCTION

The pollutants from the wastewater are harmful to the public health and the environment, and they are toxic to the aquatic organisms as well. The wastewater treatment helps to remove contaminants from water to decrease pollutant load [1]. Water pollution occurs through natural processes in certain cases, but most of the pollutions caused by human activities [2]. The used water of a community is called wastewater or sewage. The waste waters are not treated before being discharged into waterways, which causes serious pollution in the particular environment [3]. There are three major categories of pollutants that cause pollution in water. The first category includes disease-causing agents such as viruses, protozoa, parasitic worms, andbacteria, which enter sewage systems and untreated waste. Because of the abundance of these microbes, wastewater acts as the common source of transmission for diseases such as dysentery, cholera, and typhoid. The second category of water pollutants includes oxygen demanding waste, which includes the biodegradable matter such as plant residues and animal manure, which are added to the water naturally or by human beings. In natural process, this biological waste uses oxygen present in the waste water and thereby results in oxygen depletion. Once all the oxygen has been depleted, bacteria are able to take control of the sewage, by making the water polluted. The third category of water pollutants includes water soluble inorganic pollutants such ascaustics, salts, acids, and toxic metals. Another kind of water pollutants includes ammonium salts, nitrates, phosphates, and so on. The pollutants such as nitrates and phosphates are the important nutrients, andthis favor thegrowth of algae and thereby results in eutrophication [4 -6]. Studies on the water quality were carried out by various researchers on various effluents. Earlier studies revealed that anthropogenic activities strongly affect the water quality. This was a result of cumulative effects not only from upstream development but also from inadequate wastewater treatment facilities [7]. The waste water quality can be measured by analyzing the variations of total suspended solids, total phosphorous, chemical oxygen demand (COD), copper, iron, nickel, nitrogen, lead, zinc, and so on [8-10]. Wastewater is any water that has been adversely affected in quality by anthropogenic influences. It comprises liquid waste discharged by domestic residences, commercial properties, industries, and/or agriculture and can encompass a wide range of potential contaminants and concentrations [11]. The contamination and quality ofirrigation water are of the main concern especially in the regions with limited water resources [12]. Characterization of wastewater andactivated sludge has been used for control and optimization of existing processes and development of new processes. The most possible sources of water, soil, and plant pollutions are sewage sludge and residues of industries and intensive fertilization [13]. The importance of testing a waste characterization in this study is to identify the composition of the waste so actions can be taken to reduce the amount of trash discarded [14]. The waste water discharged from various domestic and industrial sources has been characterized by various researchers [11, 13]. Urban environmental management is one of the important issues as the urbanization trend continues globally. The under-management of municipal wastewater in many southern urban areas is a major challenge. Management of wastewater in metropolitan cities is a very difficult task. The unsafe disposal of wastewater results in water pollution as well as terrestrial pollution. It causes various health problems that are epidemics due to the processing of the contaminated water [15,16]. This wastewater eutrophicates the water bodies, causing the mortality of aquatic biological resources. Hence, the role of treatment plants is in the sustainable use of wastewater as they make the water usable for various purposes [17]. The major objective of the present study was to characterize the wastewater discharged from different industries inkombolcha and Debrebrhantown, Ethiopia. A study of this kind will improve our knowledge on the quality of wastewater being discarded into the environment due to various anthropogenic activities.

II. MATERIALS AND METHODS

Materials

For the present study, effluent samples were collected from different industries in Ethiopia. The effluent samples were collected from the outlet of the process. The effluent was collected in polythene containers of two litres capacity and were brought to the laboratory with due care and was stored at 20ºC for further analysis. Chemicals used for the analysis of spent liquor were analytical grade reagents. The physical and chemical characteristics of industrial effluents parameters viz. pH, total alkalinity, total acidity, COD, BOD5, total solids (TS), total dissolved (TDS), totalsuspended solids (TSS), chlorides and sulfides were analyzed as per standard procedures [15].

Methods

Determination of pH

The pHis determined by measurement of the electro motive force (emf) of a cell comprising of an indicator electrode (an electrode responsive to hydrogen ions such as glass electrode) immersed in the test solution and a reference electrode (usually a calomel electrode). Contact is achieved by means of a liquid junction, which forms a part of the reference electrode. The emf of this cell is measured with pH meter.

Determination of total alkalinity

The alkalinity of sample can be determined by titrating the sample with sulphuric acid or hydrochloric acid of known value of pH, volume and concentrations. Based on stoichiometry of the reaction and number of moles of sulphuric acid or hydrochloric acid needed to reach the end point, theconcentration of alkalinity in sample is calculated. A known volume of the sample (50 ml) is taken in a beaker and a pH probe was immersed in the sample. HCl or H_2SO_4 acid (0.1N e.g 8.3 ml conc. HCl in 1000 ml distilled water) added drop by drop until the pH of the sample reached 3.7. The volume of the acid added was noted [15].**Calculation**

Alkalinity as mg/l of $CaCO_3$= (50000× N of HCl× ml acid titratedvalue)/volume of sample taken

Determination of chemical oxygen demand (COD)

The chemical oxygen demand of an effluent means the quantity of oxygen, in milligram, required to oxidize or stabilize the oxidizable chemicals present in one litre of effluent under specific condition. 2.5 ml of the sample was taken in tube, 1.5 ml of 0.25 N $K_2Cr_2O_7$(potassium dichromate), spatula of mercuric sulphate $HgSO_4$ and 3.5 ml of COD acid were added and kept in COD reactor for 2hrs at 150ºC. After cooling the sample titrated against FAS (standard ferrous ammonium sulfate 0.1N) and used ferrion as indicator. The end point is reddish brown color. In the blank tube 2.5 ml of distilled water was taken and then follow the same procedure in the sample [15].

Calculation

COD (mg/l) = (blank value-titrated value) ×N of FAS×8000/ volume of sample

8000 = mill equivalent wt. of O_2×1000ml

Determination of biochemical oxygen demand (BOD)

Biochemical oxygen demand (BOD) of an effluent is the milligram of oxygen required to biologically stabilize one liter of that effluent (by bio-degradation of organic compounds with the help of micro-organisms) in 5 days at 20ºC.If the BODvalue of an effluent is high, is high, then that effluent contains too much of bio-degradable organic compounds and so will pollute the receiving water highly.

Procedure

1. Take 5 litres of distilled water, aerated for 3.5 hours, added nutrients 1 ml nutrient for 1 litre aerated distilled water (FeCl, $CaCl_2$, PO_4, $MgSO_4$, domestic water), aeration for 30 minutes.

2. BOD bottle (300 ml), add sample, fill the bottle with aerated water, put the lid (avoid air bubbles), keeping BOD incubator at 20ºC for 5 days, after 5 days take the bottle and add 2 ml $MnSO_4$, 2ml alkaliazide iodide and 2 ml conc. H_2SO_4. Shake the bottle well (yellow colour) take 200 ml sample add starch solution as indicator (purple colour) titrated with 0.025 N sodium thiosulphateend point colour change from purple to colorless. In blank filled the bottle with aerated water without the sample and follow the procedure [15].

Calculation

BOD5= (blank value-titrated value) ×300/volume of sample

Determination of Total solid

The term solid refers to the matter either filtrable or non-filtrable that remains as residue upon evaporation and subsequent drying at a defined temperature. Residue left after the evaporation and subsequent drying in oven at specific temperature 103-105°C o f a known volume of sample are total solids. Total solids include Total suspected solids (TSS) and Total dissolved solids (TDS).

Procedure

Dry weight of empty dish or crucible (initial weight), add 50 ml sample, keep it in water bath until dry, keep it in oven (103 to 105°C) for at least 1 hour, desiccator, take final weight of dish [15].

Calculation

Total solid (mg/l) = (final weight-initial weight) ×1000×1000 / volume of sample

Determination of total dissolved solid

Procedure

Dry weight of empty dish or crucible (initial weight) take sample and filter with What man No.1, add 50 ml filtrate sample, keep it in water bath until dry, keep it in oven (103 to 105ºC) for at least 1 hour, desiccator, take final weight of dish [15].

Calculation

Total dissolved solid (mg/l) = (final weight-initial weight) ×1000×1000 / volume of sample

Determination of total suspended solid

The difference between the total solids and total dissolved solids is suspended solids.

TSS = TS-TDS

Determination of chloride

Chloride is determined in a natural or slightly alkaline solution by titration with standard silver nitrate, using potassium chromate as an indicator. Silver chloride is quantitativelyprecipitated before red silver chromate is formed.

Procedure

Take sample (10 ml to 50 ml), add 2 ml of hydrogen peroxide (H_2O_2), add 2 ml K_2CrO_4 (potassium chromate indicator), titrate with silver nitrate (0.0141N), end point formation of reddish yellow colour (yellow to orange). In blank trial take distilled water instead of sample and follow the same procedure above [15].

Calculation

Chloride (mg/l) =(A-B) ×N. of silver nitrate×35.45×1000/ volume of sample

A = ml titration for sample

B = ml titration for blank

N = normality of $AgNO_3$

Determination of sulfide

The sulfides in the solution are oxidized with and excess of a standard iodine solution and the excess back titrated with a standard thiosulfate solution.

Procedure

Take sample (10ml) in conical flask, add 5 ml zinc acetate (5%), filter through filter paper, take the filter paper and put it in the same conical flask, add 100 ml distilled water. then add 20 ml, iodine solution and 4 ml 6N HCl, add 2 drops of starch as indicator (purple colour will form), titrate against sodium thiosulphate (0.025N), end point the colour change from blue colour to colorless. In the blank test take 100 ml distilled water instead ofsample and follow the same procedure above for the sample [15].

Calculation

Sulfide (mg/l) =<u>(BV-TV) xN. thiox400</u>
VolumofsamplexN. ioden

BV= blank value

TV= titrated value

Table.1: Location of sampling site

Location/site	Sample
Waksu Textile	W1
Kombolcha tannery	W2
Debreberhan tannery	W3
Hayek Tannery	W4
Debreberhan Ethanol	W5

III. RESULTS AND DISCUSSION

The values of the physico-chemical parameters observed in the present study may serve as an indicator of the fertility or pollution level of the study area. The experimental data on physico-chemical properties of wastewater samples collected from different indusial area of Kombolcha and Debreberhanare shown in Figures1–10.

Table.2:Physico Chemical characterization of industrial waste water

Parameter	W1	W2	W3	W4	W5
PH	5.2	6.77	7.66	5.7	4.7
EC	1205.3	4287.8	4156.7	5863.2	7130,17
TDS	1370	4300	4270	6840	8100
BOD	878.2	1267.32	1196.12	2321.01	2765.35
Alkaline	2500	2000	4500	4100	2501.3
COD	772.56	1287.65	1246.03	2461.54	3105.13
Cl^-	3403.2	886.25	8543.45	5388.4	3010.33
S^{2-}	6.3	0.135	0.475	2.235	10.7
Total N	56.25	20.5	40.5	66.5	237.5
SO_4^{2-}	500	250	375	425	4875
SS	700.02	600	1050	1550	6500

Determination of pH

The pH of all five samples was measured immediately after its collection using a pH meter. The pH of the water sample collected from different sites was ranging from 4.7 to 8.2 and the result was shown in table 2.and Figure 1. The pH of the water is known to influence the availability of micronutrients as well as trace metals [20]. It is well known that the pH is an important parameter in evaluating the acid–base balance of water. A pH value of 7 is neutral; a pH less than 7 is acidic, and a pH greater than7 represents base saturation or alkaline. The principal component regulating ion pH in natural waters is the carbonate, which comprises CO_2, H_2CO_3, and HCO_3[21].

Electrical conductivity

Water conductivity is mainly attributed to the dissolved ions liberated from the decomposed plant matter [22] and input of inorganic and organic wastes [23]. EC values are noted to be different for various samples, ranging from 1205.3-7130.17 µScm^{-1}, and the result was shown in Figure 2. EC depends on the dissolved solids in the discharged water. The EC being the measure of dissolved solid in solution implies that sampleW5 had more dissolved solids than other sample sites. High EC values indicate the presence of high amount of dissolved inorganic substances in ionized form. The fluctuations in EC in any particular location depend on the fluctuation in TDS and salinity [24].

Determination of total dissolved solids

The amount of TDS in this study varies from 1370 to 8100 mg/l, and the result was shown in Figure 3. In the waste water, TDS are composed mainly of bicarbonates, chlorides, carbonates, phosphates, and nitrates of calcium, magnesium, sodium, and potassium; manganese; salt; and other particles [25]. The higher values of TDS may be due to the discharge of waste from effluents from various small-scale industries in these towns. Kataria et al. [26]reported that increase in the value of TDS indicated pollution by extraneous sources.

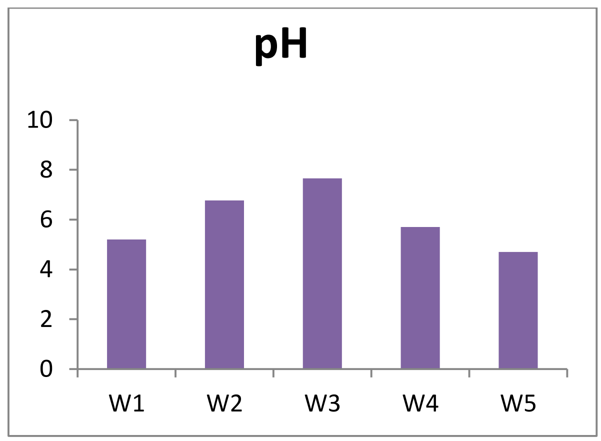

Fig.1: PHof industries wastewater

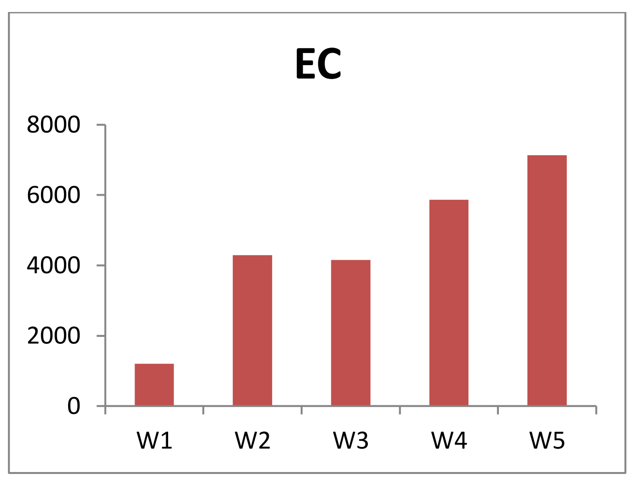

Fig.2 ECof industries waste water

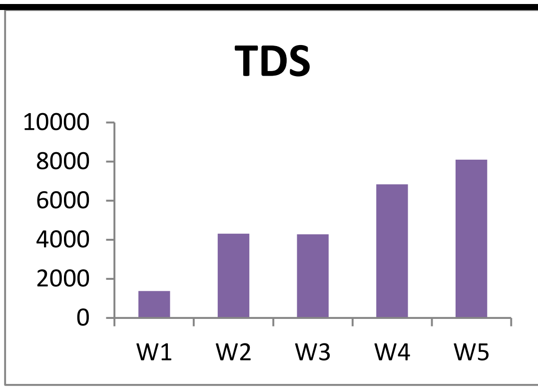

Fig.3 TDS of industries waste water

Determination of Biological oxygen demand

BOD showed the minimum value of 878.2 mg/l and the maximum value of 2765.35 mg/l. The registered BOD value was high in the present study (Fig. 4). BOD increases due to biodegradation of organic materials that exerts oxygen tension in water body [27]. Increases in BOD can be due to heavy discharge of industrial wastewater, animal and crop wastes, and domestic sewage. BOD value has been widely adopted as a measure of pollution in the particular environment. It is one of the most common measures of organic pollutant in water. It indicates the amount of organic matter present in water. Sources of BOD in aquatic environment include leaves and dead plants, woody debris, animals, animal manure, industrial effluents, wastewater treatment plants, feedlots, and food- processing plants and urban storm water runoff [28].

Determination of Chemical oxygen demand

COD showed the minimum value of 772.56 mg/l and the maximum value of 3105.3 mg/l (Fig. 5). All organic compounds with few exceptions can be oxidized by theaction of strong oxidizing agents under acidic condition. The COD determination is a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong chemical oxidant. While determining COD, oxygen demand value is useful in specifying toxic condition and presence of biologically resistant substances. The COD and BOD values are a measure of the relative oxygen - depletion Dissolve oxygen. The DO content of the wastewater collected from different sources decreases with increase COD and BOD. BOD directly influences the amount of DO in rivers and streams. The greater the BOD and COD the more rapidly oxygen is depleted in the waste water. This means that less oxygen is available to higher forms of aquatic life. The effect of a waste contaminant. Both have been widely adopted as a measure of pollution effect. COD is also one of the most common measures of pollutant organic material in water. COD is similar in function to BOD, in which both measure the amount of organic compounds in water [28].

Determination of Nitrate

The nitrate content of wastewater samples varies from 11.00 to 166.00mg/l, and the result was shown in Figure 6. Nitrate content is an important parameter to estimate organic pollution in a particular environment, and it represents the highest oxidized form of nitrogen. Nitrate is one of the very common contaminants in ground water and surface water. Nitrate occurs naturally in source water as a result of decaying plants. However, there are other manmade sources of nitrate that can increase its presence in source waters to dangerous levels. Agricultural sources of nitrates include livestock waste matter and chemical fertilizers. The presence of nitrates in the water samples is suggestive of some bacterial action and bacterial growth [29].

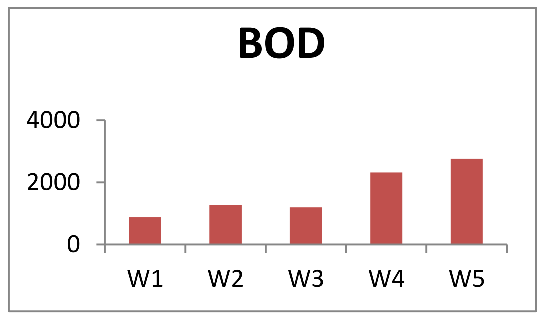

Fig.4: BOD of industries wastewater

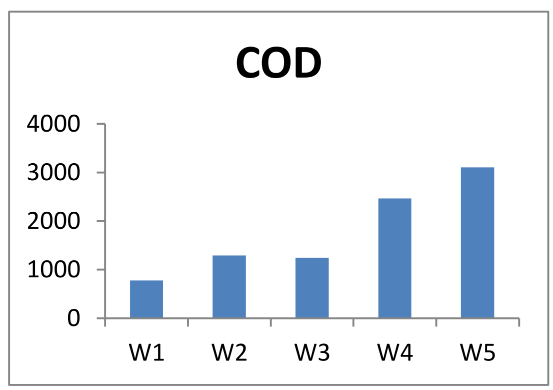

Fig.5: COD of industries waste water

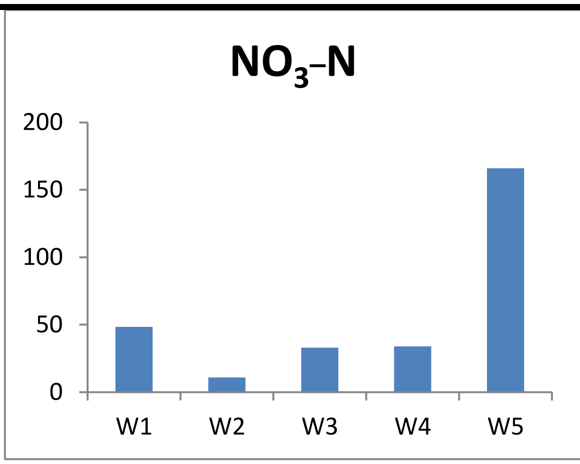

Fig.6: Nitrogen in Nitrate of industries waste

Determination of Sulfate

The sulfate content of wastewater varies from 600to 6500mg/l, and the result was shown in Figure 7. Sulfates are considered toxic to plants or animals at beyond normal concentrations. Sulfates are formed due to the decomposition of various sulfur- containing substances present in water bodies. The sulfate ions ($SO4^{-2}$) occur naturally in most water supplies and hence are also present in wastewater. In human beings, small concentrations cause a temporary laxative effect [30]. Sulfate occurs naturally in water as a result of leaching from gypsum and other common minerals [31].

Determination of Chloride

Thechloride content of wastewater samples varies from 886.25 to 8543.45mg/l and the result was shown in table 2. Figure 9.And the levels exceed the permissible chloride level of 1000 mg/L of effluent discharge into inland surface waters. The chloride content in water sample gives an idea of the salinity of water sample.

Determination of Sulfide

Sulfides are particularly objectionable because hydrogensulfide will be liberated if they are exposed to a low pHenvironmental, and if they aredischarged into stream containing iron, black precipitates will be formed. Sulfides may be toxic to stream organisms or to organisms employed inbiological treatment systems. The results of present study revealed that sulfide level from industrial wastes were given in Table 1 and figure 10. W1, W3, W4and W5 exceeds the permissible sulfide level of 2 mg/ L. of effluent discharge into inland surface waters [32].

Determination of Alkalinity

Alkalinity of water is its acid neutralizing capacity. It is the sum of all the bases. The alkalinity of natural water is due to the salt of carbonates, bicarbonates, borates silicates and phosphates along with hydroxyl ions in the Free State. However, the major portion of the alkalinity is due to hydroxides, carbonates and bicarbonates. The results of present study revealed thatalkalinity level from each industrial wastes are given in Table 1 and figure 11.

Determination of Total Suspended Solids (TSS)

The results of present study revealed that TSS level from different industrial processes are given in Fig. 6 and it exceeds the permissible TSS level of (20-200) mg/ l. These suspended impurities cause turbidity in the receiving streams. The composition of solids present in industrial effluent mainly depends upon the nature and quality of raw material processed in the industries. High level of total suspended solids present in the industrial effluent could be attributed to their accumulation during the processing of finished proses. Presence of total suspended solids in water leads to turbidity resulting in poor photosynthetic activity in the aquatic system [33] and clogging of gills and respiratory surfaces of fishes [34].

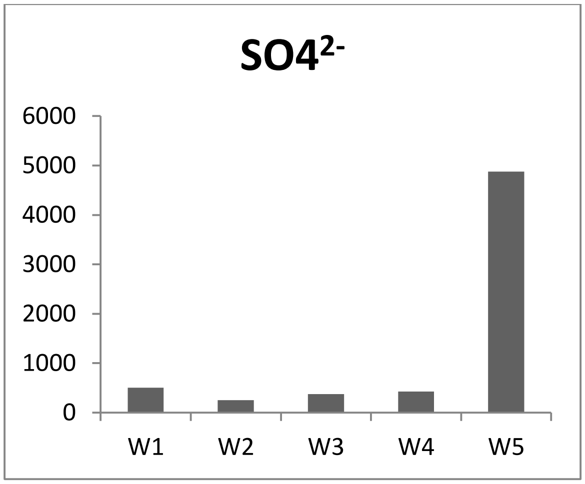

Fig.7.Sulphateof industries wastewater

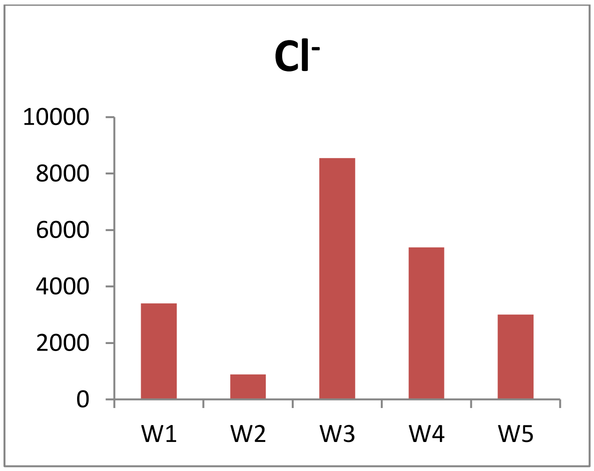

Fig.9: Chloride of industries wastewater

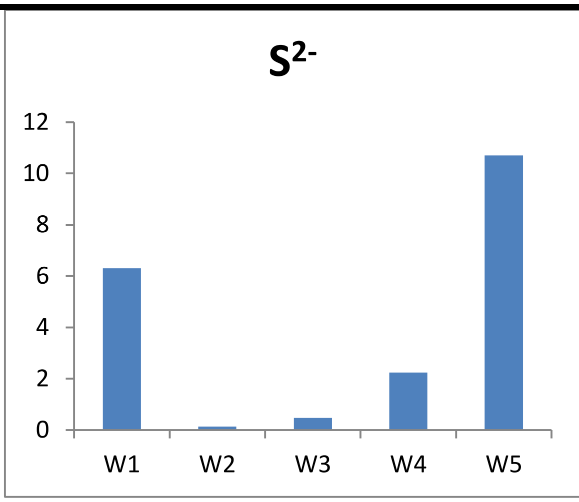

Fig.10: Sulphied of industries waste water

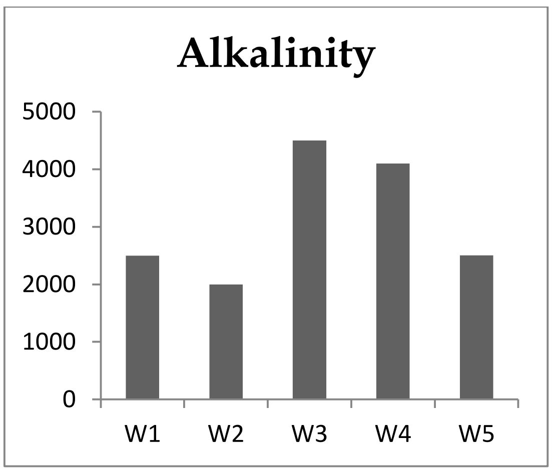

Fig.11: Alkalinity of industries wastewater

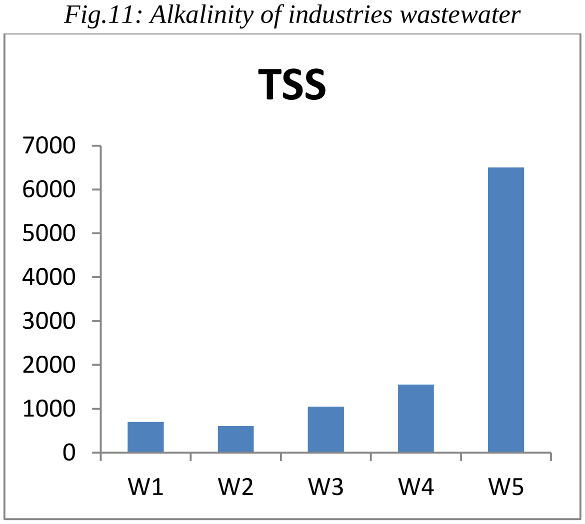

Fig.8: Total suspended solidof industries wastewater

IV. CONCLUSION

From the result of physico-chemical analysis of industrial effluents, it has been concluded that PH, EC, TDS, Chlorides, Sulphate, sulphied, Nitrate,alkalinity, TSS, BOD and, COD are very high in concentration compared to the standards prescribed by WHO and EPA. Such effluent should not be discharged in to the nearby water body or soil without treatment. They are unfit for irrigation. The high level pollution of the industrial effluents cause's environmental problems which will affect plant, animal and human life [31].

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