Physico-Chemical Analysis of Effluents from Tannery Industry in Ethiopia

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Abstract: Tannery industries are one of the most highly pollution intensive sector in developing countries like Africa. This is because of most of the industries don't apply the appropriated wastewater treatment plant and waste management practices. This study examines the status of the waste water effluent discharge of tannery industries. Samples are collected from 8 tanneries and their Physico- chemical parameters like PH, COD, BOD, TSS, Sulfides, Chlorides, phenol, Phosphate and Ammonia are analyzed in laboratory. The observed ranges of the values are ranged between 265 -3687.5 mg/l for TSS, 20.6 – 215 mg/l for phosphate, 63.75 – 684 mg/l for ammonia, 1424 -5950 mg/L for COD, 580 -2000 mg/L for BOD, 1425 -3885 mg/L for chloride, and 1.161 – 194 mg/l for Sulfide and 2.1 – 21.45 mg/l for Phenol. All except two industries are met the PH standard limit value ranged between are 6-9. The two industries are ranged between 9-11 PH values. Hence, the finding of this study shows that the effluent discharge values of all the industries are extremely higher than the Ethiopian tannery effluent discharge limit value. Discharging of these chemicals without any additional treatment is worse for the environment.

Key words: Tannery, waste water, pollution, Physico-chemical, Ethiopia

1. Introduction

Like other developing nations, Ethiopia, particularly urban centers of the country, which are the centers of industrial expansion, are experiencing socio-economic and environmental problems resulting from industrial pollution. Leather industries, both tanning and manufacturing of leather products, are among the various industries which are causing such environmental and social impacts. In Ethiopia, 90% of the industries are releasing their effluents in to water bodies, streams and land without any treatment mechanisms and are the primary cause of water pollution [8]. Among these industries, tanneries and leather processing industries are the major contributors for river pollution by discharging their effluent without appropriate treatment [4]. In Ethiopia, the annual volume of liquid waste discharge from the 15 tanneries based on their annual production capacities is estimated to vary between 2,000,000 and 2,500,000 cubic meters [5] and in most developing countries tannery effluents are discharged directly into sewers or water bodies without treatment [9]. Because of the tremendous volume of water and chemicals used, waste generation and the disposal of waste forms part of everyday lives which is more for industries especially tanneries. The annual estimated pollution load of the Ethiopian tanneries are presented in table (1). From table (1) it can understand that the total estimated BOD_5 equals that generated by a town of 200000 - 230000 people [1].

Table 1: Estimated pollution load of the Ethiopian tanneries [1].

Pollutant	Total load (ton/year)
BOD_5	4600-5000
COD	11000-13750
SS	8000 - 10000
Chloride	9000 - 11000
Sulfide	240 -300
Trivalent Chromium	200 - 250
TKN	800 -1200
TDS	17000 - 21000

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River systems are the primary means for disposal of waste, especially the tannery effluents. Tanneries are generally pollution-intensive industrial complexes generating large volumes and high concentration of liquid and solid wastes. These wastes have historically been discharged in to the rivers, land fill waste sites and to the air with little if any purification [2]. The discard of these wastes causes serious problems because untreated effluents of tannery have high chemical oxygen demand (COD), biological oxygen demand (BOD) and high quantities of salts like chromium, sulfide and chloride, which are highly alkaline [6].

The river near by the tanneries can be said highly polluted rivers since they are serving as recipient of effluent from the factories. The effect of this scenario is expressed by different indicators. The Akaki – Kaliti, Mojo and the tributaries of Awash River are best examples of polluted water body. The residents around the river and /or the tannery reported the death of their cattle, dried up of green plants, waterborne diseases and bad smell resulted due to the death of microorganisms that in turn caused by depletion of dissolved oxygen. Even though the incidences are merely the result of discharges from tanneries but it is impossible to deny the fact that the discharge from tanneries has its own contribution [3].

In Ethiopia industrial effluents containing high contents of organic matter, nitrogen and heavy metals are discharged into inland surface waters with little or no pretreatment. Significant pollution concerns related to these effluents include dissolved oxygen depletion, toxicity and eutrophication of the receiving water. This has not only forced the government to formulate regulations and standards for discharge limits but also resulted in an increasing interest and development of methods and systems by which waste water can be recycled and use sustainably. The need for technologies for environmentally friendly treatment of industrial wastes such as tannery wastewaters is therefore obvious [7].

Therefore this study aims to assess the status of the Ethiopian tannery industry's pollution and to recommend the possible measures and strategies.

2. Materials and methods

2.1. Study area

The study area was encompassed of 8 tannery industry. Most of the industries are located in Oromia special zone, Oromia reginal state, Ethiopia. One tannery is located in Sululta city which is 35 km away from the capital city and the rest of the tannery industries are located in Mojo town which is called the power house of tannery industries in the country. This town approximately 30 km away from the capital city and it has a latitude and longitude of 8°39′N 39°5′E with an elevation between 1788 and 1825 meters above sea level. The town gets name after the nearby Mojo River which is now a days the recipient of the waste water effluent discharge of the tannery industries. The tannery industries regularly carries out activities in a building that has great capacity. They are located at a distance of 100-200 m from the river bank. Most of the industries use less active primary treatment plant. So their effluent directly discharged to the river. The river was used as a source for irrigation, fish production and recreation center for the community currently it is degraded by the waste water discharge from the industries.

2.2. Method of data Analysis

Sample of the tannery industrial effluent was taken on effluent discharge flow from the treatment plant. The physico-chemical parameters which were analyzed are the following: PH, chemical oxygen demand (COD), biological oxygen dissolved (BOD), Ammonia (NH_3), total suspended solids (TSS), Phenol, chlorides, sulfides and phosphate (P-PO4) and their comparison to wastewater quality standard according to the Ethiopian tannery effluent discharge limit value standard methods. The method used for the analysis of the physico-chemical parameters are presented in table (2).

Table 2: Instruments (methods) Used for the Determination of the Parameters of Effluents of tannery industry

Sl No.	Parameter	Abbreviations	Method or instrument of Analysis
1	PH	----	PH meter
2	Chemical Oxygen Demand	COD	Titrimetric Method
3	Biological Oxygen Demand	BOD5	Microbiological titration method
4	Total Suspended Solid	TSS	Gravimetric Method
5	Chloride	Cl^-	Colorimetric method
6	Ammonia	NH_3	Colorimetric Method
7	Sulphate	$SO4^{--}$	UV- visible Spectrophotometer
8	Phosphorous	PO_4^{---}	Molybdo - vanadophoshphoric acid method
9	Pheno	---	Gas chromatography

3. Result and Discussion

The Experimental results of analysis of tannery industries effluent for various physical and chemical parameter and comparison with the Ethiopian tannery effluent discharge limit value is presented in Table (3) and the graphical analysis were analyzed using excel data sheet. A copy of the survey standard limit values used can be found in Appendix.

Table 3: Results of effluent discharge values versus the standard Limit Value

Parameters	Name of the Tannery Industries								Limit Value
	China-Africa	Friendship	Mojo	Hora	Mesako	Farida	Gelan	Colba	
PH	6.5	7.4	8.5	10	9	7.5	11	7.3	6-9
TSS	265	3687.5	2100	1520	690	1150	240	740	50 mg/L
$PO4^3$	20.6	41	215	183	90	185	30	135	10 mg/L
NH_3	126.3	63.75	174	69	476	416	684	352	30 mg/l
COD	1424	1700	6450	2605	3775	5950	3740	3650	500 mg/l
BOD	1280	580	960	1840	1670	1900	2000	1480	200 mg/l
Phenol	1.3	2.1	7.35	2.7	6.3	21.45	15	19.8	1 mg/L
Sulfides	1.161	4.54	25.3	4.88	106.5	159	100.3	194	1 mg/L
Cl^-	2660	1954	3575	1425	3887	5387	3025	3800	1000 mg/l

PH: The collected sample PH was analyzed by a PH meter. The results are presented in Table 3 and Fig (1).The observed PH values in some of tannery industries were shown with in the PH standard limit value 6-9 in table 3 and Fig (1). The measured values indicated that the PH value of 10 PH for Hora and 10 PH for Gelan factory was above the upper limit value of 6-9 Fig (1). The pH of wastewater effluent discharge of the tanneries is generally towards basic side. Excesses of pH of wastewater are commonly not tolerable as excesses of pH cause problems to persistence of aquatic life. Water with high or low pH is not appropriate for agricultural purposes.

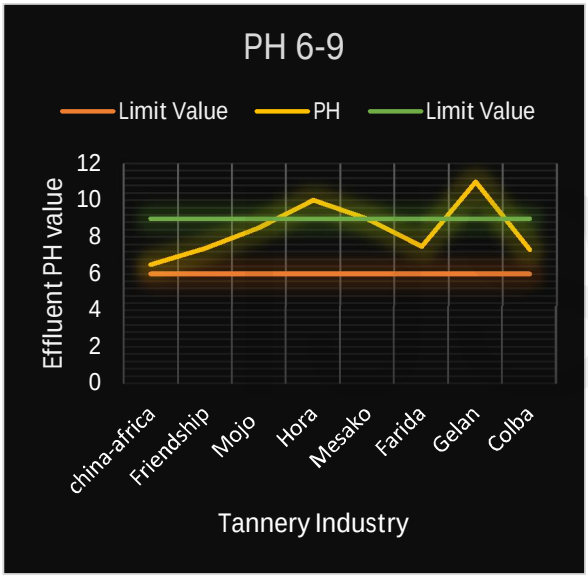

Fig.1. Comparison between effluent PH and Ethiopian tannery effluent discharge limit value

Total suspended solids (TSS) and Phenol

TSS and Phosphorus are one of the main factors that affect water quality. Suspended solids are floating substances as well as they have the ability to remain in the water bodies under suspension. The result values of TSS is revealed in the table (3) which shows that the discharge value was higher than the national standard limit value which is 50 mg/l for TSS and 10 mg/l for phosphate. The observed values were ranged between 265 -3687.5 mg/L for TSS Fig. (2) And 2.1 – 21.45 mg/l for Phenol Fig. (3). Discharge of these parameters without any treatment cause depletion of the nearby river aquatic system.

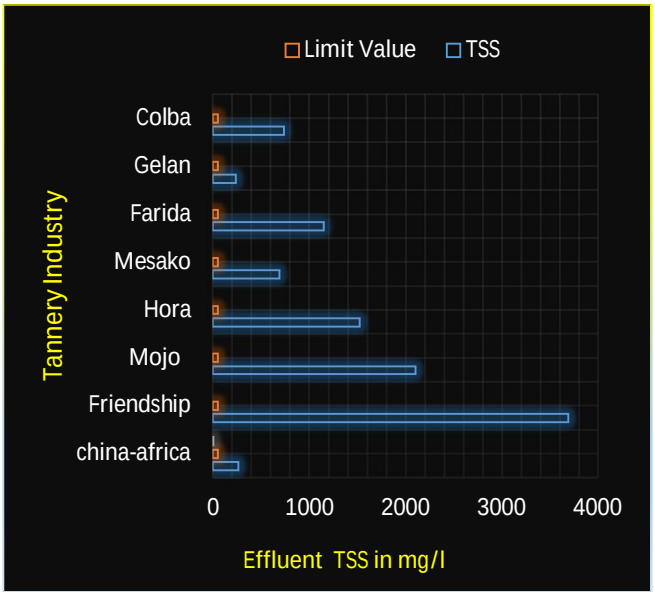

Fig. 2. Comparison between effluent TSS and Ethiopian tannery effluent discharge limit value

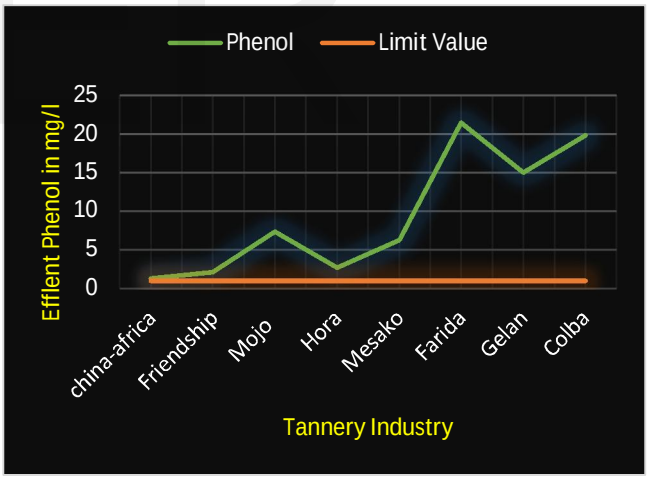

Fig. 3: Comparison between effluent Phenol and Ethiopian tannery effluent discharge limit value

Phosphate and ammonia (NH_3)

Phosphate and Ammonia value of the effluent of the tannery industries was extremely higher than the national standard limit value of 10 mg/l and 30 mg/l respectively table 3. The observed ranges values were between 20.6 – 215 mg/l for Phosphate Fig. (4) and 63.75 - 684 mg/l for Ammonia Fig (5). The effluent from the tannery industries showed that the

waste water effluents discharge to the environment was without adequate treatment. Excess discharge of phosphate and ammonia to the environment cause pollution in wastewater ponds, reservoirs and rivers. The potential environmental effect include unwarranted algae growth, and extreme sludge generation producing poor water quality for the sustenance of river aquatic system.

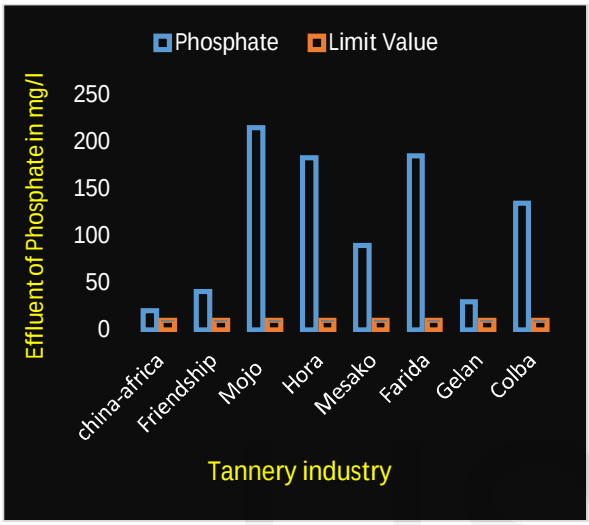

Fig 4. Comparison between effluent Phosphate and Ethiopian tannery effluent discharge limit value

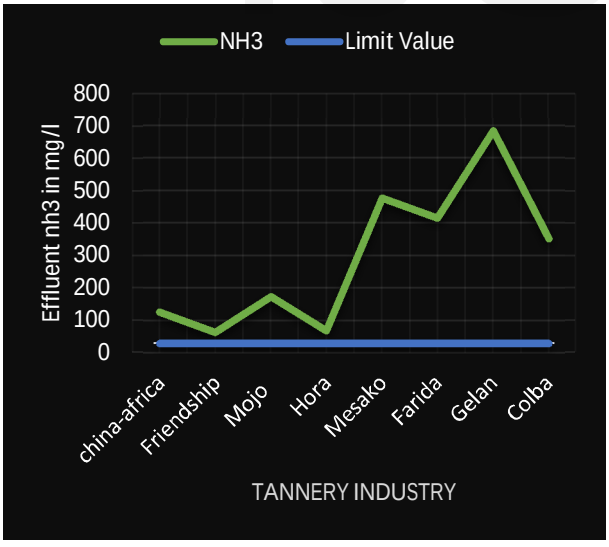

Fig. 5. Comparison between effluent Ammonia and Ethiopian tannery effluent discharge limit value

Chemical oxygen demand (COD) and Biological Oxygen Demand (BOD)

BOD and COD are one of the most important factors for determination of waste water quality. The study investigates that COD levels of all the tannery effluent were extremely higher than the national standard limit value of 500 mg/l shown in the table 3. The observed ranges of the values were 1424 - 5950 mg/L Fig. (7). Discharging of excess Chemical oxygen demand (COD) torpid organic matter, and displays the oxygen needed to oxidize all organic material into carbon dioxide and water. Like COD, BOD of all the tannery industries effluent discharge were extremely higher than the standard limit value of 200 mg/l shown in the table 3. The observed ranges of the values were between 580 -2000 mg/L Fig (6). The recorded high values of BOD are due to high concentration of organic pollutants from daily activities. Discharging excess BOD level in to the surrounding environment has a great impact on aquatic environment, because it will decrease oxygen level in water by hastening bacterial growth in the river which reduce the occurrence of most fish and many aquatic ecosystems.

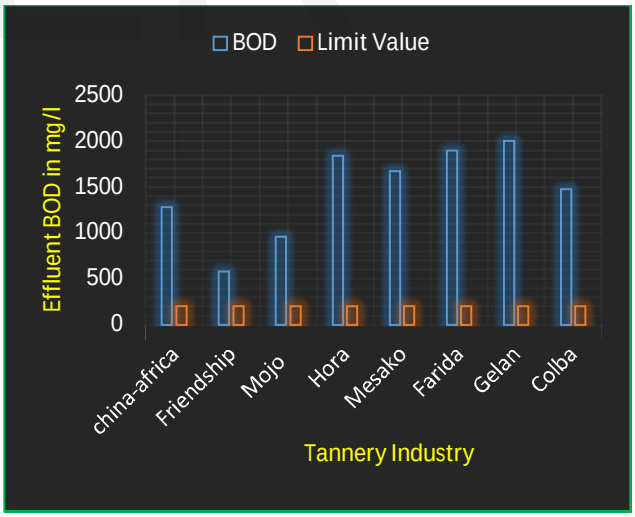

Fig. 6. Comparison between effluent BOD and Ethiopian tannery effluent discharge limit value

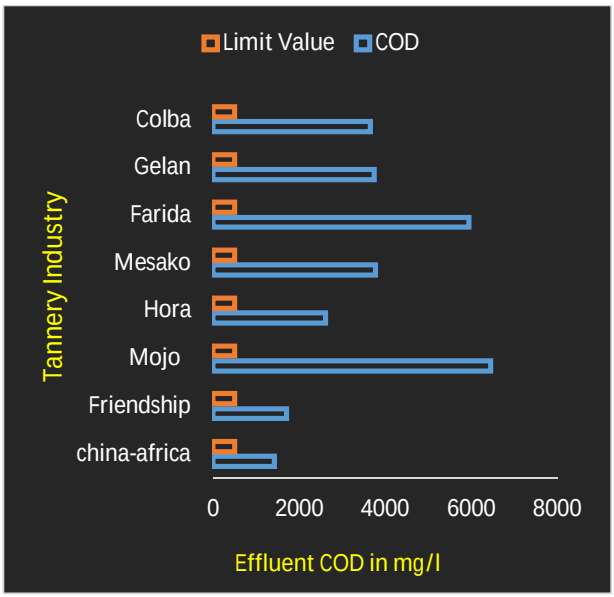

Fig. 7. Comparison between effluent COD and Ethiopian tannery effluent discharge limit value

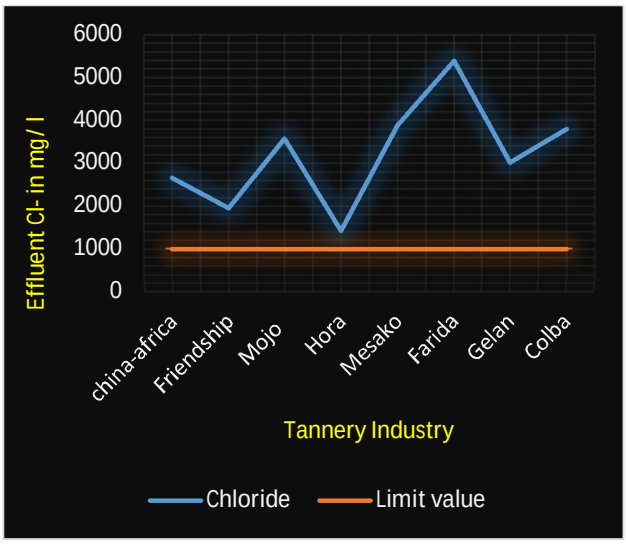

Fig. 8. Comparison between effluent Chloride and Ethiopian tannery effluent discharge limit value

Chlorides and Sulfide

The discharge recorded value of the effluent had still extremely high level of chlorides and phenol which couldn't be released directly to Mojo River without additional treatment to avoid substantial effect on the river ecosystem and to the environment in general. The effluent discharge limit value for Chlorides and Sulfide to water bodies is limited to 1000 mg/l and 1 mg/l respectively; nevertheless, all tanneries produce effluents by extremely higher than these limited value. The observed ranges of the values are between 1425 - 3885 mg/L for chloride Fig. (8) and 1.161 – 194 mg/l for Sulfide Fig. (9). High discharge of chloride and sulfide enhance the salinity and acidity of water and causing depletion of the aquatic system of the river.

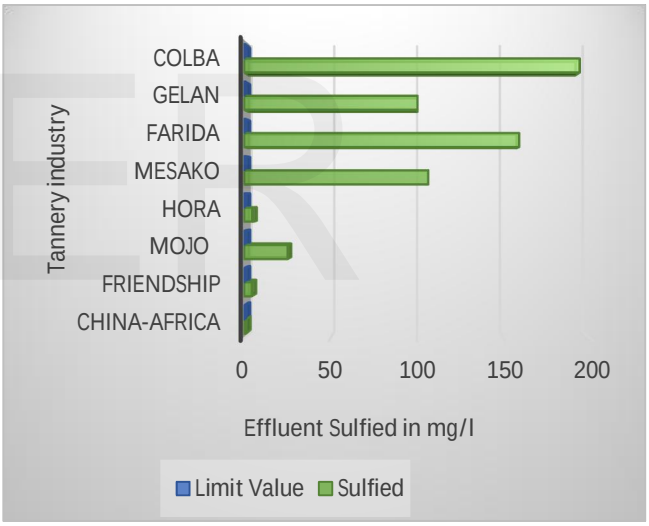

Fig. 9. Comparison between effluent Sulfide and Ethiopian tannery effluent discharge limit value

4. Conclusion and recommendation

The status of tannery industry effluent discharge level were analyzed. All the analyzed Physico chemical parameters from the 8 industry showed that all tanneries are released their effluent surpassed the Ethiopian tannery effluent discharge limit value. The Mojo River nearby the tanneries are extremely polluted river since it is serving as recipient of effluent from the industries. Now a days Mojo River is one of the polluted rivers of the tributaries of Awash River because of high potential load of untreated effluents are discharging to the river. To solve the problem the factories have to apply secondary and tertiary treatment plants and follow the right procedures to treat the waste water by applying accurate amounts of chemical, good maintenance, and continuous checking and evaluation. For some of the factories establishing these treatment plants may be expensive; however they can install common effluent treatment plant which is cost effective and sustainable manner that can provide better wastewater treatment performs. The Ethiopian government is also initiating to launch eco-friendly oriented Modjo leather industrial park in the area to have them common waste water treatment plant but till this project realize measures should be taken to the industries to reduce their effluent discharge because they are surpassed the standard limit value and polluting the nearby Mojo River.

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Supporting Information:-

APPENDIX. Ethiopian tannery effluent discharge limit value.

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20 °C	90% removal or 200 mg/l, whichever is less
COD	500 mg/l
Suspended solids	50 mg/l
Total ammonia (as N)	30 mg/l
Total nitrogen (as N)	80% removal or 60 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 10 mg/l, whichever is less
Oils, fats, and grease	15 mg/l
Mineral oils at oil trap or interceptors	20 mg/l
Chromium (as total Cr)	2 mg/l
Chromium (as Cr VI)	0.1 mg/l
Chlorides (as Cl)	1000 mg/l
Sulphides (as S)	1 mg/l
Phenols	1 mg/l