

# Physicochemical Characterization of Distillery Effluent from One of the Distilleries Found in Addis Ababa, Ethiopia

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## Abstract

Effluents released from distillery industries are known for the damage they cause to the natural ecosystem if proper pretreatment procedure is not performed. A study is required to assess the physicochemical property of the effluent such as colour, odour, total dissolved solid (TDS), chemical oxygen demand (COD), pH, biochemical oxygen demand (BOD), electrical conductivity, and heavy metals which are considered as the mostly reported parameters to indicate the level of pollution from industrial effluents. The present study was conducted to investigate the physicochemical characteristic of one of the distillery effluent found in Addis Ababa, Ethiopia. In our investigation lower pH, higher temperature, higher concentration of chemical oxygen demand (COD) and biochemical oxygen demand (BOD) have been recorded.

**Keywords:** Physicochemical, Distillery-Effluent, Total Dissolved Solid

## 1. Introduction

Industries as paper, textile, tannery, dye and distilleries are known for the considerable amount of wastewater they discharged to the environment (Narasimha and Chittaranjan, 2012; Pawan *et al.* 2013; Neşe *et al.* 2007; Jolly *et al.* 2012). Distilleries releases enormous amount of waste water known as spent wash which is around 80 % of the raw material to the environment (Rattan *et al.* 2005; Farid and Ajay, 2012; Amar *et al.* 2003). The physicochemical characteristics of distillery effluent can be determined by the type of raw material utilized and treatment methods performed prior to the discharge of the effluent to the environment. Generally distillery effluents can be characterized by high level of biochemical oxygen demand (BOD), chemical oxygen demand (COD), phenolic compounds, sulphates, heavy metals, intense brown colour, lower pH, obnoxious odour, high electrical conductivity (EC) and high inorganic and organic salts (Susheel *et al.* 2007).

Distillery effluent is most of the time disposed into the nearby water and land bodies. This effluent induces higher amount of foreign substances as heavy and toxic metals to the soil and water bodies which poses an adverse effect on the animals, plants and aquatic life (Musee *et al.* 2007).

Spent wash from distilleries is not only known for the environmental problem it causes. It is also known as a rich source of nutrients viz., potassium, sulphur, nitrogen, calcium, iron, magnesium, Zinc and biodegradable organic matter which plays significant role in enhancing soil fertility (Malaviya *et al.* 2007; Kannan and Upreti, 2008; Shyamand Swami, 2014). Therefore distillery effluents can be used for ferti-irrigation purpose and there are various reports supporting this fact. The result from different investigation showed the importance of distillery effluent in enhancing seed germination, seedling growth, shoot length, root length, nutritional quality, chlorophyll content and crop yield of agricultural crops as: gram nut (*Cicer arietinum*), kidney bean (*Phaseolus mungo*) (Amit, 2013), ground nut (*Arachis hypogaea* L.) (Amar *et al.* 2003), rice (*Oryza sativa*) (Devarajan and Oblisami, 1995), gobi sarson (*Brassica napus* L.) (Piyush, 2011), wheat (*Triticum aestivum*) (Pathak *et al.* 1998), okra (*Abelmoschus esculentus*) (Chopra *et al.* 2012), chickpea (*Cicer arietinum* L.) (Parvathi *et al.* 2014), finger millet (*Eleusine coracana* L.) (Tharakeshwari and Shobha, 2006), mustard (*Brassica juncea* L.) (Vinod and Chopra, 2014), faba bean (*Vicia faba* L.) (Vinod and Chopra, 2013), and sugarcane (*Sacharum officinarum*) (Zalawadia *et al.* 1997; Rath, 2010) to list some.

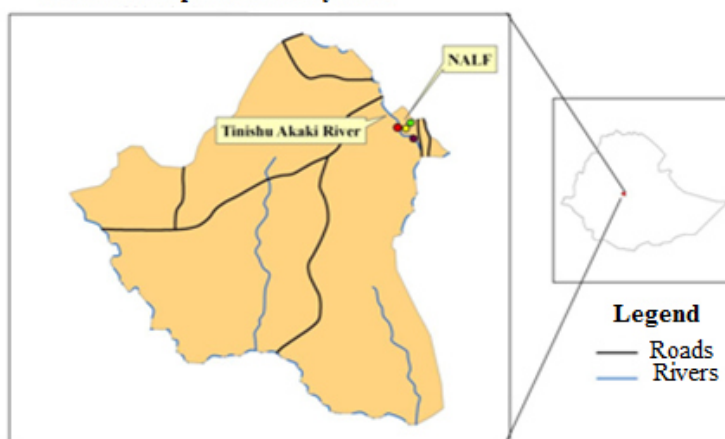
Utilization of distillery effluent for irrigation purpose must be done with great cares. This is because, distillery effluent imparts higher amount of heavy metals to the soil which will result in various environmental and health problems. Heavy metals can also affect the plant by inhibiting seed germination, seedling growth, nutrient availability and enzymatic activity (Rajaram *et al.* 1988; Ramana *et al.* 2002b; Anuradha and Nagendra, 2012; Pandey, 2008). Accumulation of heavy metal in plant can reach animals through food chain and results in various health problems to the animals (Rashid *et al.* 1988).

The physicochemical parameters are important in evaluating the level of toxicity of distillery effluents. Parameters such as color, turbidity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, Electrical conductivity, temperature, oxygen saturation, nitrogen, phosphorus, ion concentrations, organic contaminants and metal levels are mostly determined parameters. The main objective of the present study is also to evaluate the physicochemical characteristics of one of the distillery effluents from the National alcohol and Liquor factory in Addis Ababa, Ethiopia.

## 2. Materials and Methods

The effluent samples were collected from one of the National Alcohol and Liquor Factory (NALF) found in Addis Ababa, Ethiopia. Materials used for water sampling were washed thoroughly with detergent solution, 10% HNO<sub>3</sub>, and finally with distilled water prior to sample collection. Samples were collected properly by using plastic bottles prepared for sampling. The collected samples were coded, stored and transported to the laboratory where further investigation is performed. The pH and temperature of the water was recorded in-situ before the sample taken to the laboratory. Every procedure performed during sample collection and sample handling was according to standard set by American public health association (APHA, 1998).

**Location Map of the Study Area**



**Figure 1.** Location map of the study area including sampling sites of effluent.

The most commonly determined physicochemical parameters as: pH, temperature, dissolved oxygen (DO), total dissolved solids (TDS), total nitrogen (TN), electrical conductivity (EC), colour, odour, biological oxygen demand (BOD), chemical oxygen demand (COD), were measured as per standard method APHA, 1989.

The heavy metal concentrations of the distillery effluent from NALF were estimated by using Atomic Absorption Spectrophotometric (AAS) method. Heavy metal analysis was performed after calibrating the instrument with the respective standard solutions of each metal. The results obtained were compared with standards.

## 3. Results and Discussion

### 3.1 Physicochemical Characteristics of the effluent

The physicochemical characteristic of distillery effluent obtained from the end pipe of National Alcohol and Liquor Factory (NALF) was analyzed. The result obtained from the analysis of parameters as: colour, odour, temperature, pH, BOD, COD, EC, DO, total dissolved solids, total nitrogen, sulphates, potassium, and sodium were tabulated in Table 1 along with standards set for irrigation (Pescod, 1992; FAO, 1985).

**Table 1.** Physicochemical characteristics of distillery effluent

Parameters	Unit	Spent Wash	Standards set for irrigation
Colour	-	Brown	-
Odour	-	Strongly alcoholic	-
pH	-	3.4±0.03	6.5-8.4
Temperature	°C	55±1	-
DO	mg/L	0.1±0.01	<9
TDS	mg/L	34900±12.1	2,000
Total Nitrogen	mg/L	872±43	30
EC	µS/cm	80000	<3000
SO <sub>4</sub> <sup>2-</sup>	mg/L	2500±8.9	1000
K+	mg/L	985±45	0.2
Na+	mg/L	188.8±0.01	900
BOD	mg/L	14704±25.9	100
COD	mg/L	33710±39.8	80-500

Values are represented as mean (n=3) ± SD.

The colour of raw effluent sample obtained directly from the end-pipe of National Alcohol and Liquor Factory (NALF) was dark brown in colour. The color of the spent wash is due to formation of caramelized sugar during the process of distillation which is termed as melanoidin (Ramchandra and Pandey, 2000; Pazouki *et al.*,

2008). The dark brown colour of the effluent is the major problem to the natural environment. It reduces light penetration in water bodies as lakes, rivers or lagoons which in turn affect the aquatic life (Pazouki *et al.*, 2008).

The odour of the effluent was offensive with strong alcoholic odour. Distillery effluents are offensive in odour due to reduction of sulphate compounds to hydrogen sulphide by sulphate-reducing bacteria (Mahimaraja and Bolan, 2004; Qatibi *et al.*, 1990, 1991). The high odour index of distillery effluent can also be due to the presence of organic compounds such as glycerol and organic acids as lactic and tartaric acids (Decloux and Bories, 2002). These compounds can be fermented by anaerobic bacteria to produce compounds as free volatile fatty acids (VFA) such as butyric and valeric acid which is responsible for the high odour index of the effluent (Padmapriya *et al.* 2014; Desauziers *et al.* 2000).

The temperature of raw effluent was recorded as 55°C. Prasad *et al.* also reported the temperature of raw distillery effluent as 62.51°C which was closer to the value obtained in the present study (Prasad *et al.* 2007). Higher temperature of effluent can affect aquatic life if it is released to the nearby water body prior to any dilution procedure.

The raw spent wash was acidic in nature with pH recorded as 3.4. Padmapriya *et al.* also reported the pH of 3.5 for raw distillery effluent which is closer to the present report (Padmapriya *et al.* 2014). A report from different investigation has shown the acidic nature of distillery effluents (Farid *et al.* 2012b; Sah *et al.* 2000; Bories *et al.* 2005). The lower pH of the effluent is suspected due to presence of weak organic acids as acetic acid CH<sub>3</sub>COOH (Rita *et al.* 2008). The pH obtained was lower than that of the permissible level for irrigation (Pescod, 1992; FAO, 1985).

The average value of electrical conductivity of the spent wash was recorded as 80000µS/cm. Similarly, higher electrical conductivity of effluent from Haryana distillery was reported by Bhasin *et al.* 2007. The high electrical conductivity of the effluent is due to presence of high concentration of dissolved salts in the effluent (Bhasin *et al.* 2007).

The result obtained for total dissolved solids (TDS) of spent wash were 34900 mg/L. Prasad *et al.* also reported higher amount of TDS which was 46800 mg/L (Parsad *et al.* 2007). The result of total dissolved solid obtained for the present distillery effluent was much higher than the maximum recommended limit set for irrigation.

The dissolved oxygen (DO) recorded for the raw distillery effluent was 0.10 mg/L. The result obtained was very low and similarly lower amount of DO were recorded by Rita *et al.* (Rita *et al.* 2008). The lower concentration of DO might be due to presence of high oxygen demanding organic matter. Some studies have shown the effect of higher temperature on dissolved oxygen. According to those reports an increase in water temperature decreased the oxygen saturation percentage and at the same time accelerated the lowering of DO levels (Moehl and Davice, 1993). The reduction in the amount of dissolved oxygen (DO) in the water poses significant effect on the aquatic life.

The result obtained for BOD and COD for the effluent were 14704 mg/L and 33710.33 mg/L respectively. The value of chemical oxygen demand and biochemical oxygen demand were found to be much higher than that of the limit prescribed by EPA and FAO (EPA, 2009; FAO, 1985). High values of COD and BOD might be due to presence of higher amounts of organic compounds in distillery effluents (Bhasin *et al.* 2007).

The concentration of Na and K were recorded as 188.8 mg/L and 985 mg/L respectively. Higher concentration of Na and K has also been reported by Vasanthi *et al.* (Vasanthi *et al.*, 2004). Higher concentration of sodium in irrigation affects the growth of the plant by affecting soil characteristic such as by reducing its permeability (Nemade and Shrivastava, 1996(b)).

The raw distillery effluent also contains high amount of total nitrogen and sulphates which is 872 mg/L and 2500 mg/L respectively. Ali also reported higher concentration of sulphates in distillery effluent (Ali, 2000).

### 3.2 Heavy Metal Analysis

The heavy metal concentration of raw effluent from NALF distillery where presented in Table 2 and the results were compared to the standard prescribed for irrigation (Pescod, 1992; FAO, 1985).

**Table 2.** Heavy metal concentrations in distillery effluent

Metals	Concentration in Effluent (mg/L)	Standards set for irrigation
Fe	247±0.006	5.0
Mn	7.5±0.005	0.2
Cr	2.76±0.001	0.1
Cd	0.57±0.008	0.01
Ni	2.07±0.013	5.0
Cu	0.58±0.001	0.1
Ag	0.56±0.003	-
Co	1.51±0.007	0.05
Zn	1.63±0.009	2.0

Values are represented as means (n=5) ± SD.

The concentrations of Fe in the raw effluent were found to be 247 mg/L. Rita *et al.* also reported higher amount of iron in the distillery effluent which were reported as 115 mg/L (Rita *et al.* 2008). The concentration of other heavy metals such as Mn, Cr, Cd, Ni, Cu, Co, Ag and Zn were found in considerable amount ranging from 0.1 to 7.5 mg/L. The concentrations of heavy metals in the effluent analysed in the present study were above the standard set for irrigation purpose except zinc which is in the permissible level (Pescod, 1992; FAO, 1985).

Some of the heavy metals such as copper, manganese, zinc, iron, nickel and chromium are essential for biochemical and physiological function of plants and animals at trace amount (Nagajyoti *et al.* 2010). Higher concentration of heavy metals poses an adverse effect to plant as well as animals. Different investigation has showed the effect of heavy metals on plant. In those reports it has been revealed that high concentration of heavy metals affects the plant by inhibiting (decreasing) seed germination, seedling growth, root growth, nutrient uptake, lipid content, enzyme activity, plant growth, rate of photosynthesis and chlorophyll and carotenoids (Zoran *et al.* 2015; Srinivas *et al.* 2013; Meenu *et al.* 2013)

#### 4.0. Conclusion

From the present study it can be concluded that spent wash from distilleries are characterized by high load of pollutants. The effluent was dark brown in colour, turbid and had strongly alcoholic odour and also characterized with high value of total dissolved solids, electrical conductivity, BOD, COD and highly acidic pH and lower concentration of dissolved oxygen. Both physical and chemical parameters are reported as higher than that of the permissible limits set for irrigation. From the result it is understood that the effluent is not suitable for irrigation purpose. Generally spent wash from distillery effluent needs to be treated before they are discharged into a water or land bodies in order to minimize its effect on fauna and flora.

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