Measurement of physical and transport properties of tannery effluent (soak liquor) ☆

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Abstract

Treatment of effluents is a serious issue for present process industries. Several new techniques are being developed which require the knowledge of effluent physical and transport properties for design and development of treatment plants. In this work density, kinematic viscosity, thermal conductivity and specific heat capacity of the tannery effluent (soak liquor) were measured for various salt concentrations of soak liquor ranging from 3% to 20%. A non-linear regression analysis has been carried out using these experimental data and the empirical correlations are presented.
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Keywords: Soak liquor; Salt concentration; Density; Viscosity; Thermal conductivity; Specific heat capacity

1. Introduction

Leather tanning industry is highly polluting as it produces large amount of organic and inorganic pollutants [1]. It has a strong potential to cause land and water pollution due to the disposal of untreated effluent. Prior to tanning process, the raw skin is preserved by adding sodium chloride salt and transported from various places like slaughter houses, rural areas etc., to the tanning industry. In the tanneries the hides are washed with water to remove the salt and other particles. After washing, a large quantity of water is let out as wastewater. This wastewater consisting 2–4% sodium chloride, traces of calcium chloride along with bio-particles like blood, flesh, skin and other suspended particles is called 'soak liquor'. The dissolved salts especially chlorides, are a matter of concern when the effluent is discharged into nearby lands or stored in the ponds. In the long run, it converts fertile land to barren besides polluting the surrounding groundwater. Therefore, it becomes necessary to tackle the problem on priority basis to control the severe environmental degradation caused by the soak liquor.

Most general method of disposing the soak liquor is evaporating in shallow solar ponds. The soak liquor is let into shallow solar ponds and the water in it gets evaporated by natural evaporation process. In the recent years various researchers studied the safe disposal of soak liquor by using new techniques [2–4]. The process involved in the evaporation of soak liquor is heat and mass transfer process. A thorough knowledge of the physical and transport properties of the soak

Nomenclature

C	specific heat capacity (kJ kg^{-1} K^{-1})
m	mass (kg)
q	heat transfer rate (W m^{-1})
s	salt concentration (%, g/kg)
T	temperature (K)
t	time (s)
$a, b, c, d, e, f, g, h, i, j$	coefficients for empirical correlation

Greek symbols

ρ	density (kg m^{-3})
v	kinematic viscosity (mm^2 s^{-1})
λ	thermal conductivity (W m^{-1} K^{-1})

Subscripts

cu	copper
L	soak liquor
eq	equivalent
st	steel
w	water
1	empirical constant for density correlation
2	empirical constant for viscosity correlation
3	empirical constant for thermal conductivity correlation
4	empirical constant for specific heat capacity correlation

liquor is essential to carry out either experimental or theoretical analysis of this treatment process. But the properties of soak liquor available are scanty [5–8]. Previously some researchers have used the properties of seawater as soak liquor properties [3,4]. This work presents the density, thermal conductivity, specific heat capacity of soak liquor at various concentrations and kinematic viscosity at various temperatures and concentrations. Using these experimental data a non-linear regression analysis has been carried out using the software "DATAFIT" and the empirical correlations for the physical and transport properties were obtained. From the correlations the properties at any desired concentrations and temperatures in the given range could be evaluated.

2. Materials and methods

2.1. Soak liquor preparation

The soak liquor that is let out consists of dissolved salts, suspended particles along with hair, blood and flesh. Sets of samples were collected at regular intervals from M/s C.Kalyanam and Co., tannery, Chennai, India. Prior to property evaluation, the soak liquor was clarified [9]. This process is similar to that of preliminary treatment process carried out in tanneries. The purpose of clarifying the soak liquor before treatment in industries is to remove the suspended dirt and other solid particles. In the present work the soak liquor was clarified in a test apparatus by adding 100 ppm of poly aluminum chloride and 200 ppm of alum for 30 min. The clarified liquor was allowed to settle down for 3 h. The skin, hair and other suspended particles got settled down and almost pure soak liquor was collected from the top portion. More clarification in terms of added alum and polyelectrolyte and settling process is needed depending on the variation in the presence of above particles. The constituents found in the soak liquor before and after clarification are found to be as shown in Table 1. The soak liquor thus obtained contained about 2.9% salt concentration. The soak liquor was heated without crystallization in a container to achieve the desired concentration ranging from 2.99% to 18.97% to carry out measurements at various concentrations. Crystallization of soak liquor will occur at a concentration of 19% and will create clogging problem when pumped. Hence the measurements have been carried out up to 18.97 % concentration. Measurements were carried out a number of times until consistency of results was obtained.