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# Analysis of Kasur Tannery Pre Treated Wastewater for Rendering it Fit for Irrigation

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## ABSTRACT

*This article presents the results of physicochemical analysis of pretreated tannery wastewater discharging form Common Effluent Pre Treatment Plant (CEPTP) of Kasur is analyzed to find out its suitability for irrigation purposes and subsequent techno-economic evaluation to fit this wastewater for agriculture. The concentrations of various parameters such as pH, EC, TDS, SAR, RSC, $SO_4^{2-}$ and $Cl^-$ were determined using standard methods, computed and compared with the standards of wastewater for irrigation purposes proposed by WWF. The results reveal that the concentrations of EC 18.6 $dS.m^{-1}$, TDS 13020 mg $L^{-1}$, SAR 91.7, RSC 35.86), $SO_4^{2-}$ (8061.3mg $L^{-1}$) and $Cl^-$ (8930.7mg $L^{-1}$) are much above the permissible limits and thus it is suggest that the pretreated wastewater investigated here cannot be used for irrigation purposes without proper treatment such as reverse osmosis (RO), that being very expensive, is not feasible for a developing country like Pakistan.*

**Keywords:** Pretreated, Wastewater, CEPTP, Kasur, Reverse, Osmosis, irrigation.

## INTRODUCTION

Kasur district of Pakistan is famous for its leather and leather products worldwide. Leather industries not only consume huge amount of water during production but also discharge wastewater in near water bodies especially in developing countries like Pakistan where no properly designed system is for industrial wastewater disposal [1]. Common effluent pre treatment plant has been launched in Kasur since 2001, where 9000$m^3$/day pretreated wastewater is discharged per day in green channel that ultimately disposes it off in river Sutlej. The city underground water has also become contaminated, with hazardous pollutants which have a strong impact on all biota. As Pakistan is situated in semi arid area, there is a great need to reuse this wastewater for agricultural purposes, to overcome water scarcity in the region [2, 3].

Different methods have been developed to treat tannery wastewater for its reuse. One of these methods is treatment of tannery wastewater with chemicals e.g. electrochemical method using graphite electrodes for the removal of total kjeldahl nitrogen (TKN) and chemical oxygen demand (COD) [4]. Similarly electro coagulation (EC) method is used to treat the wastewater to achieve the international standards of wastewater reuse. Different coagulants like, lime, alum and ferric chloride were used to remove dissolved solids, alkalinity, salinity, chloride, biological oxygen demand (BOD) and chemical oxygen demand. By using alum, ferric sulphate and their combination. The results revealed that use of alum 80mg/L, gave the removal of TSS, $BOD_5$, COD and Cr 91%, 89%, 78% and 90% respectively at pH 8, while the use of ferric sulphate at the dosage of 100mg/L showed 87% removal of TSS, 82% of $BOD_5$, 71% of COD and 78 % of Cr. At optimum dosage of alum (70mg/L) + ferric sulphate showed effective results of removal, i.e. 95% of TSS, 91% of $BOD_5$, 80% of COD, and 92% of Cr. [5]. Coagulation, flocculation, sedimentation technique is also used to treat tannery wastewater. Alum when used with cationic and anionic polymers showed results better than the use of alum alone; 5 mg/L cationic polymer C-496 with 100 mg/L alum showed 97% removal of turbidity, 93.5%, 36.2% and 98.4% removal of TSS, COD and Cr respectively, while 5mg/L anionic polymer A-100 with 160mg/L alum indicated 99.7%, 96.3%, 48.3% and 99.7% removal of turbidity, TSS, COD and chromium respectively [6]. Another most important emerging method to treat wastewater is membrane technology. The Ultrafiltration (UF) and Reverse Osmosis (RO) membrane treatment is used to treat wastewater which can be further applied on irrigational lands. The best technology to remove toxic salt content from wastewater is RO [7, 8].

With reference to the background highlighted above, it was planned to undertake this study with the aim to work out a strategy to determine the status of the pretreated tannery wastewater discharged in the green channel leading to River Sutlej for ultimate disposal for its suitability for irrigation of land in use for agriculture; if not suitable then look into feasibility of its transformation to make it suitable for irrigation by methods currently in use.

## MATERIALS AND METHODS

**Samples Collection**: The pretreated wastewater samples were collected from sixteen different points. Green channel (1.7Km) originates from the CEPTP leads to the Pandoki drain where it finally disposes off in River Sutlej. Each wastewater sample was collected at a distance of 2Km. Table 1 demonstrates the sampling points, where the samples have been collected for analysis.

**Table 1:** Samples collected from different points of the collection area with their designated numbers.

| **Serial No. of Sample** | **Designated as** | **Collection Point/ Area** |
|---|---|---|
| 1 | $S_1$ | After settling tank |
| 2 | $S_2$ | Lagoon no. 15 |
| 3 | $S_3$ | Green channel |
| 4 | $S_4$ | Main hole (at a distance of 2km) |
| 5 | $S_5$ | Main hole (at a distance of 2km from the previous point |
| 6 | $S_6$ | Before mixing in Pandoki drain |
| 7 | $S_7$ | Tannery wastewater enters in Pandoki drain |
| 8 | $S_8$ | Pandoki drain Upper stream |
| 9 | $S_9$ | Pandoki drain Upper stream |
| 10 | $S_{10}$ | Pandoki drain Upper stream |
| 11 | $S_{11}$ | Pandoki drain Lower stream |
| 12 | $S_{12}$ | Pandoki drain Lower stream |
| 13 | $S_{13}$ | Pandoki drain Lower stream |
| 14 | $S_{14}$ | Pandoki drain before mixing in the Sutlej river |
| 15 | $S_{15}$ | Sutlej river |
| 16 | $S_{16}$ | Sutlej river |

**Parameters determined:** The selected parameters for the physicochemical analysis of pretreated tannery wastewater samples after its discharge from CEPTP were pH, electrical conductivity (EC), total dissolved solids(TDS), sulphate ($SO_4^{2-}$), sodium absorption ratio (SAR), residual sodium carbonate (RSC) and chloride ($Cl^-$).

**Sampling procedure and preservation:** Samples were collected and preserved according to the standard methods for water and wastewater (APHA, 2005).

**Laboratory Analysis**

**pH:** pH of the sample was determined by HI 2210 pH meter (company HANNA instruments).

**Electrical conductivity and total dissolved solids:** Electrical conductivity of wastewater samples was measured by Conductivity meter (HANNA HI8633). To obtain the readings for total dissolved solids in ppm, the EC readings were multiplied by factor 0.7.

**Sulphate**: Sulphates were determined by gravimetric method (4500-C APHA/AWWA, 2005).

**Chloride:** Chloride was determined by Argentometric Method (4500-B APHA/AWWA, 2005).

**Residual Sodium Carbonate (RSC):** Residual Sodium Carbonate (RSC) was calculated applying the following formula: RSC (mEq/liter) = ($CO_3^{2-}$ + $HCO_3^-$) □ ($Ca^{2+}$ +$Mg^{2+}$). Carbonates and bicarbonates were determined by acidimetric titration and Ca and Mg were determined by EDTA method.

**Sodium Adsorption Ratio (SAR):** was calculated by the following formula:

$$\text{S.A.R.} = \frac{Na^+}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

**Sodium** was measured using flame photometer. The Flame Photometer was standardized with 100ppm, 50ppm and 10ppm Sodium standards. Then the water samples were fed into Flame Photometer and Sodium contents were recorded in ppm. Dilutions of samples were made as and when required.

**Data analysis and interpretation:** After the completion of sampling and analysis, the data was compared with international standards for wastewater for irrigation. The data was presented in the form of graphs for which mean and standard deviation were also calculated**.** One way Anova (Analysis of Variance) was also applied.

## RESULTS AND DISCUSSION

Fig. 1 exhibits the graph showing the values of pH for samples as compared with the proposed standards of wastewater for irrigation by WWF. The international standard of pH for wastewater for irrigation is 6.5-8.4 (2007). Within these limits the pH value is safe. The maximum averaged pH value with standard deviation (SD) recorded for sample No.$S_2$ is 8.48± 0.05568 and averaged minimum value is measured as ± SD; 8± 0.03215 for sample No. $S_5$. The pH is in acceptable range for all samples, except for sample No.$S_2$. pH of the pre-treated tannery wastewater is alkaline when compared to the WWF standards (2007). It indicates the presence of abnormal salt content in wastewater due to the addition of ammonium salts, chloride and lime, etc, in leather tanning operation. The uncontrolled usage of salts in leather tanning renders the pH of wastewater alkaline [9, 10].

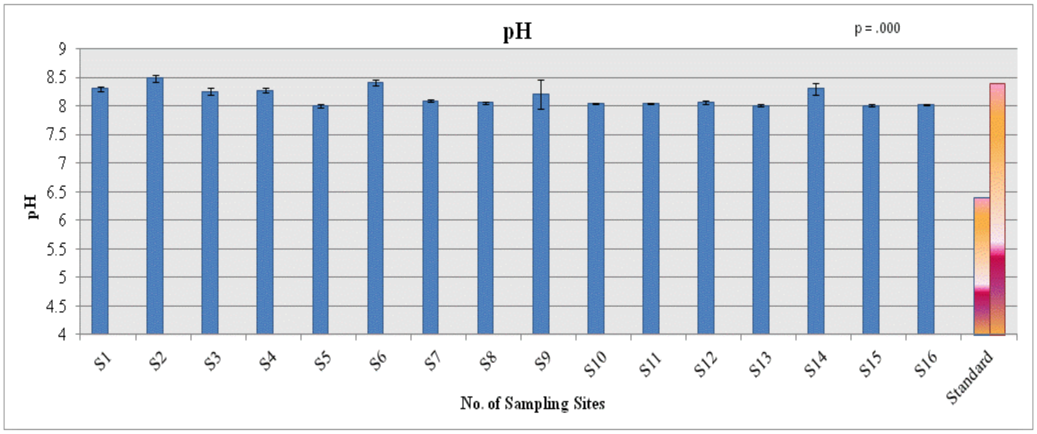


**Fig.1:** The averaged values of pH for samples and their comparison with the proposed standard of wastewater for irrigation by WWF.

Fig.2 delineates the graph showing the values of electrical conductivity (EC dS $m^{-1}$) for samples and compared with the proposed standards of wastewater for irrigation by WWF. Electrical conductivity (EC) is an important parameter to test the quality of wastewater especially when it is used for irrigation purposes. The international standard for electrical conductivity is 1.5 dS $m^{-1}$ (2007). Results indicate maximum averaged value of electrical conductivity with ±SD is for sample No.$S_2$ i.e. 18.8±0.25166 dS $m^{-1}$ and the minimum averaged value is indicated for sample No.$S_{16}$ with ± SD i.e. 0.316±0.01528 dS $m^{-1}$. The results indicate that, trend is decreasing gradually at the end of sampling sites.

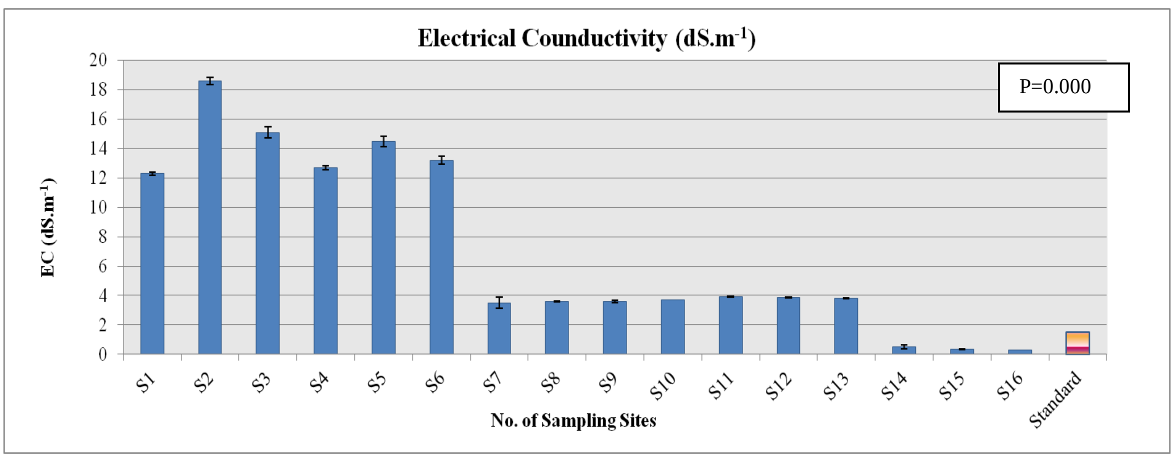


**Fig. 2:** The averaged values of electrical conductivity for samples and their comparison with the proposed standard of wastewater for irrigation by WWF.

Fig.3 illustrates the graph showing the values of total dissolved solids (TDS mg $L^{-1}$) for samples as compared with the proposed standards of wastewater for irrigation by WWF. Total dissolved solids (TDS) are the sum of the cations and anions which are present in the dissolved form in water. In international standards of wastewater for irrigation, permissible value of total dissolved solid is 1000 mg $L^{-1}$ (2007). While the averaged maximum value of TDS as ± SD is for sample No.$S_2$ i.e. 13020±176.1628 mg $L^{-1}$ and the averaged minimum value is recorded for sample No.$S_{16}$ as ± SD i.e. 221.2±10.69268 mg $L^{-1}$. The concentration of TDS is decreasing as the No. of sampling sites goes towards Sutlej River. The tannery wastewater samples collected from the Sialkot region exhibits total dissolved solids, electrical conductivity and sodium as 91972mg $L^{-1}$, 43.7mS $cm^{-1}$ and 127.6 mg $L^{-1}$ respectively [11]. the results of tannery wastewater samples from the Chennai leather industry reported the range of pH, chloride, total dissolved solids as 6.2, 1136mg $L^{-1}$, and 4950mg $L^{-1}$ respectively [12].

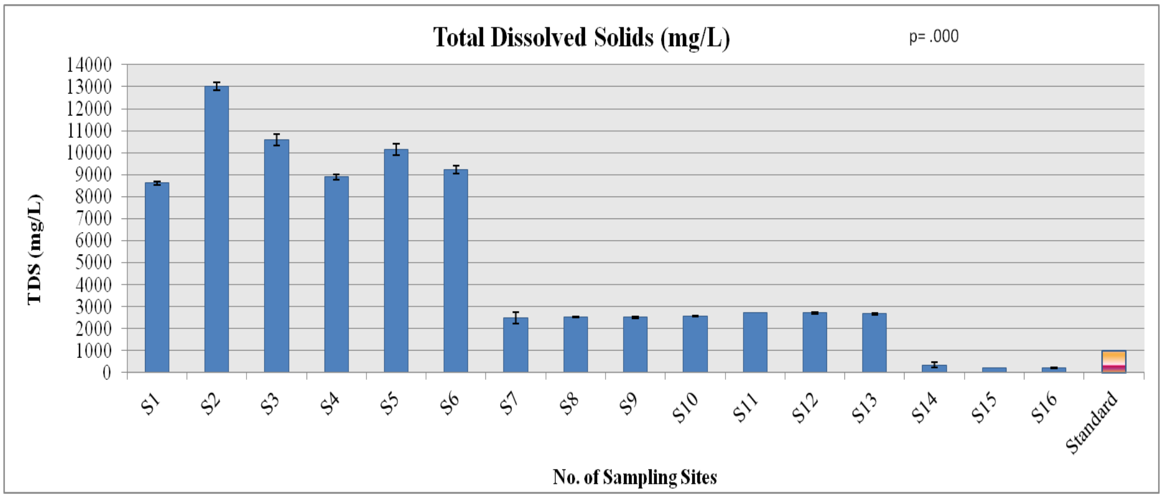


**Fig. 3:** Graph The averaged values of total dissolved solids for samples and their comparison with the proposed standard of wastewater for irrigation by WWF.

Fig. 4 presents the graph showing the values of sulphate ($SO_4^{2-}$mg $L^{-1}$) for samples as compared to the proposed standards of wastewater for irrigation by WWF. The permissible limit for sulphate ($SO_4^{2-}$) in the international standard of wastewater for irrigation is 600 mg $L^{-1}$ (2007). The maximum averaged value of sulphate with ±SD is calculated for sample No.$S_2$ i.e. 8061.3±9.11976 mg $L^{-1}$ and the minimum averaged value with SD is calculated for sample No.$S_{16}$ i.e. 435.6± 6.02771 mg $L^{-1}$. The value of $SO_4^{2-}$ is decreasing as move towards the end of sampling sites.

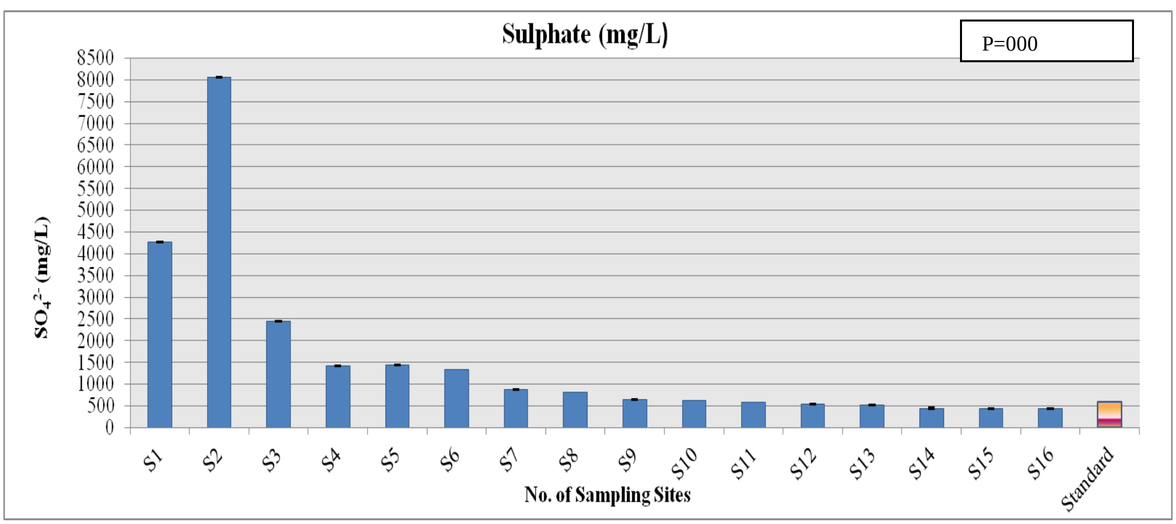


**Fig. 4** The averaged values of sulphate for samples and their comparison with the proposed standard of wastewater for irrigation by WWF.

Fig. 5 depicts the graph showing the values of residual sodium carbonate (RSC mEq $L^{-1}$) for samples as compared to the proposed standard of wastewater for irrigation by WWF. Residual sodium carbonate

(RSC mEq $L^{-1}$) is used to assess the sodium permeability hazard, and takes into account the bicarbonate/carbonate and calcium/magnesium concentrations in irrigation water. The permissible value of residual sodium carbonate is 1.25mEq $L^{-1}$ for the wastewater used in irrigation (2007). The maximum averaged value of residual sodium carbonate (RSC) with ±SD calculated for sample No.$S_1$ is 35.86±0.80208 mEq $L^{-1}$ and the minimum averaged value as ± SD is calculated for sample No.$S_{16}$ is1.11±0.01 mEq $L^{-1}$. The value of RSC decreases as the water runs off towards the last sampling point. Wastewaters with high RSC have alkaline pH and if the soil is irrigated with this water, it renders the color of the soil black [13].

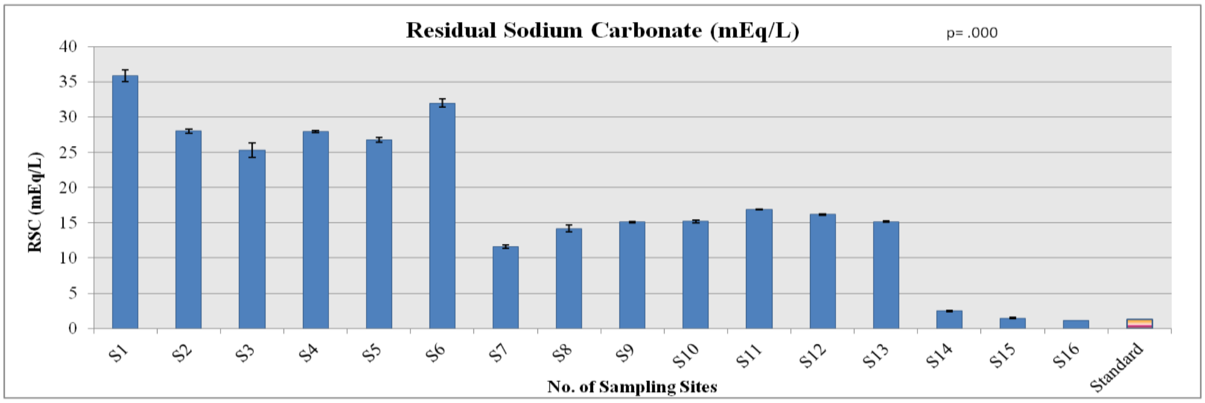


**Fig. 5:** The averaged values of residual sodium carbonate for samples and their comparison with the proposed standard of wastewater for irrigation by WWF.

Fig. 6 displays the graph showing the values of sodium absorption ratio (SAR mEq $L^{-1}$) for samples as compared with the proposed standard of wastewater for irrigation by WWF. Sodium absorption ratio (SAR) is the relative ratio of concentrations of sodium, calcium, and magnesium which are important determinants of irrigation water quality. In international standards of wastewater for irrigation, the acceptable sodium absorption ratio is 5mEq $L^{-1}$ (2007). The maximum averaged value of SAR recorded for sample No.$S_2$ with ±SD is 91.7±1.03944 mEq $L^{-1}$ and the minimum averaged value recorded for sample No.$S_{15}$ with ±SD is 0.97 ±0.02 mEq $L^{-1}$. The value of SAR decreases at the end of sampling sites. The analysis of the surface wastewater quality in India indicated the values of SAR, EC and RSC as 0.39mEq $L^{-1}$, 7430µmohs $cm^{-1}$ and 12.99mEq $L^{-1}$ respectively. From these values it can be concluded that if a piece of land is irrigated with this wastewater, the soil will be subject to salinity hazards [14].

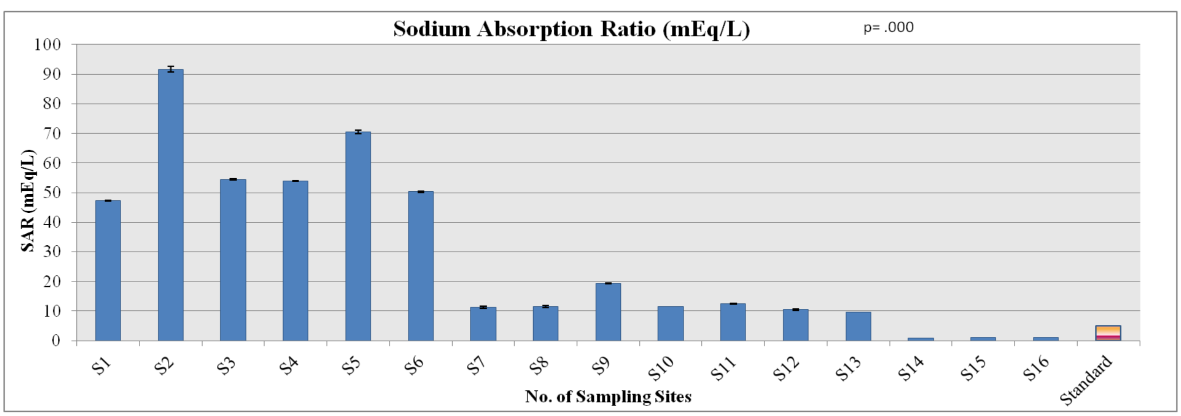


**Fig. 6:** The averaged values of sodium absorption ratio for samples and their comparison with the proposed standard of wastewater for irrigation by WWF.

Fig. 7 exhibits the graph showing the values of Chloride ($Cl^-$ mg $L^{-1}$) for samples as compared with the proposed standard of wastewater for irrigation by WWF. Chloride ($Cl^-$) contributes to salinity in irrigation water, and it can be toxic to plants when concentrations are high. The acceptable limit for chloride is 100 mg $L^{-1}$ in the international standards of wastewater for irrigation (2007). The maximum averaged value of chloride measured with ± SD is for sample No.S2 i.e. 8930.7± 26.867 mg $L^{-1}$, while the minimum averaged value with ± SD measured for sample No.S16 is 36.1±0.67484 mg$L^{-1}$. The concentration of chloride decreases as the water runs off towards the Sutlej River. Due to its highly solubility and stability in water, chloride remains unchanged by most of the wastewater treatment processes. Chloride stops plant and bacterial growth whereas its high concentration causes the breakage of cell structure. If the chloride is present in irrigation water, it increases the soil salinity due to water evaporation which damages the crop yield [15].

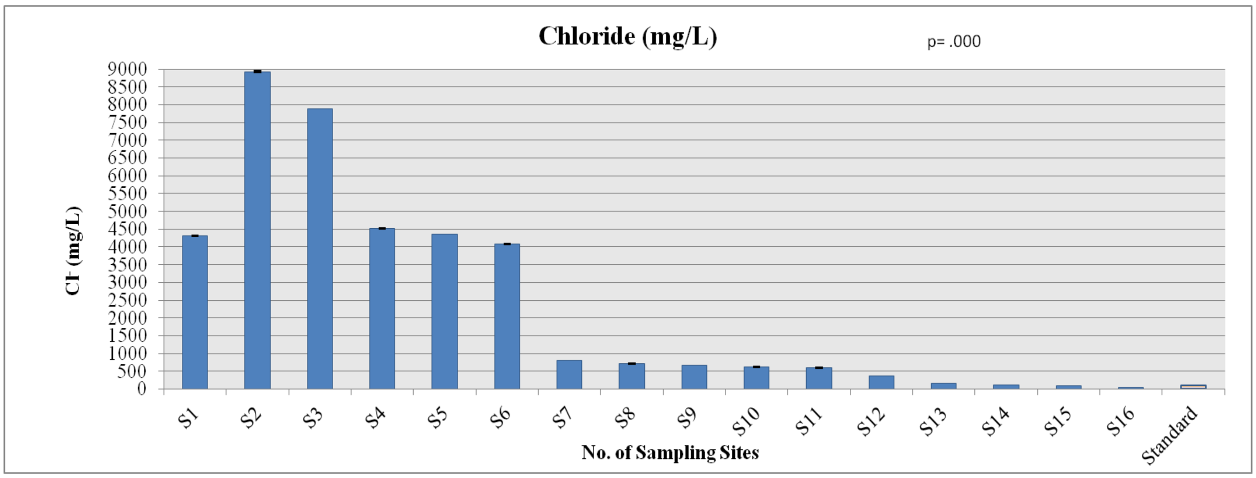


**Fig. 7:** The averaged values of chloride for samples and their comparison with the proposed standard of wastewater for irrigation by WWF.

**Proposed Treatment of Kasur Pretreated Tannery Wastewater for Its Reuse in Agriculture:** From the present study it is clear that, one of the major problems in pretreated wastewater is the TDS which includes salts like chloride, sulphate, carbonates, bicarbonates, calcium, magnesium and sodium above acceptable limits. For the removal of TDS from tannery effluents one of the most effective technology is Reverse Osmosis (RO).

The operation and maintenance cost of the treatment plant with RO per cubic meter is calculated as below:

| | |
|---|---|
| Chemical cost | PKR 14 -17 $m^{-3}$ |
| Power cost | PKR 5 –7 $m^{-3}$ |
| Sludge handling | PKR 1.5 –3.5 $m^{-3}$ |
| Manpower | PKR 3.5 –5 $m^{-3}$ |
| Filters and cartridges (spares) | PKR 10 –20 $m^{-3}$ |
| RO/NF membrane maintenance | PKR 34 – 42 $m^{-3}$ |
| Principal and interest paid on the loan | PKR 67 –84 $m^{-3}$ |

The overall cost of treatment of tannery wastewater with RO technology including its operation and maintenance thus comes out to be 135-178.5 $m^{-3}$. As the pre treated wastewater generated from the CEPTP of Kasur is 9000 $m^{-3}$per day the total cost of treatment will be 1,215,000-1,606,500 per day, 36,450,000-48,195,000 per month and 437.400.000,- 578.340.000, per annum. Thus the total expenditure calculated with RO technology to treat pretreated wastewater for Kasur being very high is not affordable for a developing country like Pakistan.

## APPLICATIONS

The results of the work been reported are applicable to decide whether the tannery wastewater is fit for irrigation of land to produce agricultural crops; first by conducting its physicochemical analysis to determine different parameters such as pH, EC, TDS, $SO_4^{2-}$ etc, compare the results with international standards of wastewater for irrigation to know the status of tannery wastewater for its fitness and subsequently suggests some method for its treatment to render it fit for irrigation.

## CONCLUSIONS

From the foregoing discussion it is concluded that pretreated tannery wastewater of Kasur is not suitable for irrigation purposes even after mixing with municipal wastewater of Pandoki drain. The major threat from wastewater is its high salt content i.e. RSC, SAR, $Cl^-$ and $SO_4^{2-}$ which causes soil salinity and contributes to crop damage and halting of growth. All the selected parameters when compared with international standards of wastewater for irrigation purposes proposed by WWF (2007), suggest that, this water is not usable without proper treatment. The economic and electricity crisis of the country is not in favor of expending huge expenditures on the RO technology, which is the best option to remove salinity hazards from the wastewater.

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