Effects of Tannery Effluent on Seed Germination and Growth Performance of Selected Varieties of Maize (Zea mays L.)

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***Abstract*:** Industrial effluents with heavy metals adversely affect the growth and development of crops when it is used for irrigation. So this study was carried out to assess the effect of tannery effluent on seed germination and growth performance of selected varieties (BHQPY545 and Malkesa-2) of Maize using different effluent treatments. The treatments were made by mixing measured amount of tannery effluent in distilled water i.e. 0, 25, 50, 75 and 100%. The experiment was carried out in Completely Randomized Design with five effluent treatments, each replicated three times. The effluent is dark bluish green in colour with high biological oxygen demand(182mg/kg) along with much higher concentrations of total suspended solids (13,100 mg/kg) and total dissolved solids (3000 mg/kg) but concentration of some metals were found under normal range recommended by Food and Agriculture Organization and United Nations Environmental Protection Agency. Tannery effluent was tested for its effect on maize in laboratory and greenhouse conditions. The result showed that a maximum reduction 26.67% and 33.33% in germination percentage, 81.69% and 75.69% in radicle length and 64.79% and 75% in plumule length was observed in BHQPY545 and Malkesa-2 respectively at 100% tannery effluent treatments. Vegetative growth parameters like shoot length, root length and number of leaves per plant were reduced with increasing levels of effluent treatments. Yield parameters of plant were also reduced due to increase in level of effluent treatments. Generally the effects of tannery effluent on germination and growth performance showed that effluent was not fit for irrigation due to higher concentration of organic and in organic matter and heavy metal contents. It is concluded that tannery effluent can't be used for irrigation purpose unless properly treated and diluted.

Index Terms- Germination percentage, Plumule, Radicle, Vegetative growth, Yield

I. INTRODUCTION

Water pollution is one of the most serious problems due to the addition of large amounts of waste materials to the water bodies. Especially, most of the industries dump their toxic effluents and pollute different water bodies such as lakes, rivers, oceans and ground water. These effluents contain toxic organic and inorganic suspended or dissolved solids, which have adverse effects on environment and human health (Begum *et al.*, 2010). Industries discharge a variety of pollutants in their wastewater including heavy metals, resin pellets, organic toxins, oils, nutrient and solids. These pollutants cause the contamination of soil, water and air, which are associated with many diseases (Huma *et al.*, 2012).

The effluent discharging industries are distilleries, sugar mills, pulp and paper mills, detergent, chemical factories, textile dyeing industries, tanneries, electroplating, pharmaceuticals and dairy industries. Among these, tanneries play a major role in creating serious pollution problems than other industries. The release of effluents without proper treatment into the nearby rivers, irrigation canals and streams adjacent to agricultural fields cause serious hazards intensifying the adverse effects on ecosystems like water, soils and plants (Shukry, 2001)

Tannery is one of the major foreign currencies earning industry in Ethiopia. Consequently, during the past 20 years the industries had significant government support and increase the number throughout the country. Moreover, tanning industry involves chemical reactions and mechanical changes which use a lot of water. It generates waste most of the time which are, in developing countries discharged to rivers or other water areas or to open field land. It could have adverse effect on the environment and human health if it is not properly managed due to the presence of dangerous chemical elements such as chromium, sulfur, etc. (Favazzi, 2003).

Moreover, the river nearby the tanneries will be polluted since they are serving as recipient of effluent from the factories. In Ethiopia, Akaki Kaliti and Modjo rivers that are tributaries of Awash River are best examples of polluted water bodies by tanneries. The residents around the river and /or the tannery reported the death of their cattle, drying up of green plants, waterborne diseases and bad smell that resulted due to the death of organisms and action of microorganisms that in turn caused by depletion of dissolved oxygen are due to tannery effluent. With the ever increasing demand for irrigation water supply, farmlands close to tanneries are frequently irrigated with poor quality water (Eskindir, 2002). In several arid and semiarid regions, water shortage is limiting factor, the farmers nearby tannery industries are forced to use the tannery effluents for irrigation purpose. In this scenario, the alternative technique is the use of diluted effluent for irrigation. This not only solves its disposal problem, but also will serve as natural fertilizer for several crops if it is used at proper concentration (Rajendra *et al.*, 2010). The effect of various industrial effluent and metal elements on seed germination and growth and yield of crop plants have gained the attention of many researchers (Rahman, *et al.*, 2002). However, the effect of tannery effluent on Maize crop plants has not been reported in Ethiopia.

II. MATERIALS AND METHODS

2.1. Description of the Study Area

The laboratory experiment was conducted in the Botanical Science Laboratory, School of Biological Sciences and Biotechnology, Haramaya University, Ethiopia. The greenhouse experiment was conducted at Haramaya University greenhouse stations *Rarre*. The station at *Rarre* is 1980m above sea level and located at latitude of 9° 26 ' N and longitude 42° 3 ' E. It is situated in the semi-arid tropical belt of eastern Ethiopia. The mean annual rainfall, as recorded from meteorology station located in Haramaya University, received ranges from 600 to 1260 mm and is bimodal. The short rainy season usually starts in March and extends to May, while the main/long rainy season stretches from end of June to September. Minimum and maximum annual temperatures range from 6 to 12 and 17 to 25 ^{0}C, respectively. The soil of the experimental site is classified as fluvisol. The major food crops grown are cereals mainly maize and sorghum (Kibebew, 2014).

2.2. Description of effluent Sampling Site

The sample was collected from Modjo tanning industry, which is found in Modjo town and located 80 km south of Addis Ababa. It is a medium-sized leather industry in Ethiopia with installed capacity of processing 844,000 and 1, 656,000 sheep and goat skins, respectively, per annum. The volume of wastewater discharged into the Modjo River varies between 3500-5500 cubic meters per day. Apart from its unfortunate use as open waste disposal site the river is also used as a source of irrigation for the rural population living around the Modjo River (Amanial, 2015).

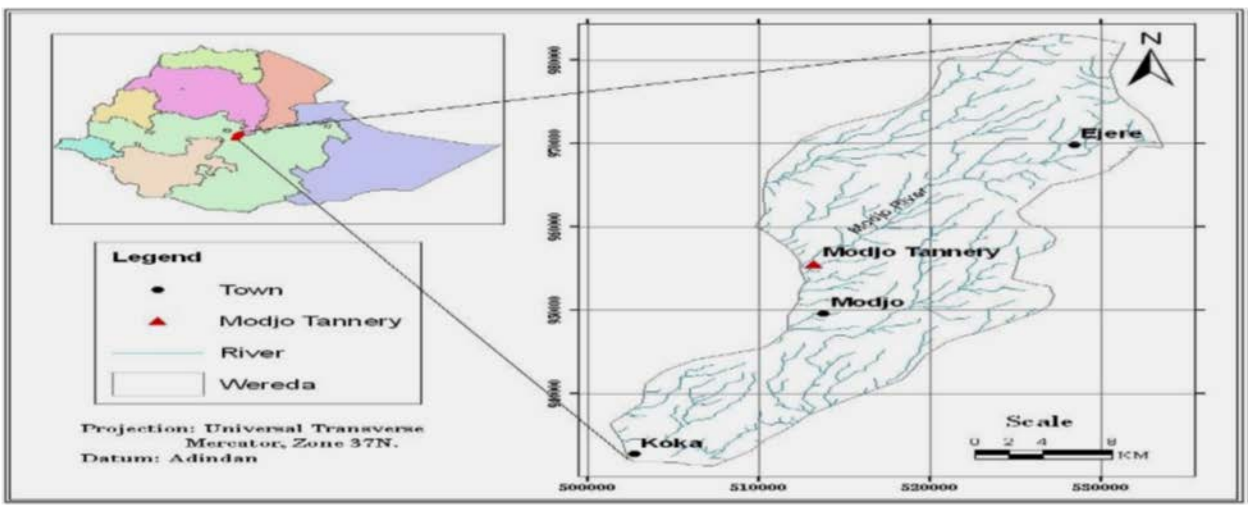


Figure 1: Map of sample site (Lume Woreda, Oromia region)

2.3. Plant Materials

The selection of the crop plant was based on its economic importance as well as availability in Haramaya University, Ethiopia. Accordingly, two available varieties of Maize BHQPY545 and Malkesa-2 were used in this study.

2.4. Experimental Design

The study involved laboratory as well as greenhouse experiments. The laboratory study was based on bioassay in order to assess effect of tannery effluent on seed germination percentage and seedling growth. The greenhouse experiment was mainly focused on identifying the effect of tannery effluent on growth performance of selected varieties of Maize BHQPY545 and Malkesa-2. The experimental design is based on completely randomized design (CRD) with three replications for each treatment and control.

2.5. Collection and Preparation of Effluent for Treatments

The effluents were collected in plastic containers directly from the outlet of Modjo tannery in East Showa, Oromia region, Ethiopia and prepared in different treatments. Different treatments of tannery effluent were made by mixing with distilled water with following percentage.

T0 = 100% distilled water (control)

T1 = 25% effluent + 75% distilled water

T2 = 50% effluent + 50% distilled water

T3 = 75% effluent + 25% distilled water

T4 = 100% effluent

Additionally, two liters of effluent were collected and brought to central laboratory, Haramaya University, Ethiopia for different chemical analyses. The effluent was filtered through whtaman No. 1 filter paper to remove solids and stored at 4°C.

2.6. Laboratory Examination

2.6.1. Determination of Physicochemical Parameters

The raw or untreated tannery effluent was analyzed for various physicochemical properties by standard method of analysis as per the guidelines of American Public Health Association (APHA, 1998). PH was determined by pH meter, EC (Electrical conductivity) by EC meter, TDS (Total dissolved solids) by gravimetric method, BOD (Biological oxygen demand) by dissolved oxygen meter (incubator), and AAS (atomic absorption spectrophotometer) was used to determine heavy metals such as Cd, Cr, Cu, Fe, Pb, and Zn.

To determine the presence of heavy metals in the collected effluent samples 100ml of each of the effluent samples were filtered using Whatman No. 1 filter paper then transferred into beakers containing 10ml of concentrated HNO_3. The samples were boiled slowly and then evaporated on a hot plate to the lowest possible volume (about 20ml). The beakers were allowed to cool and another 5ml of concentrated HNO_3 was added. Heating was continuous with the addition of concentrated HNO_3 as necessary until digestion was complete. The samples were evaporated again to dryness (but not baked) and the beakers were cooled, followed by the addition of 5ml of HCl solution. The solutions were then warmed and 5ml of NaOH was added, then filtered. The filtrates were transferred to 100ml volumetric flasks and diluted to the mark with distilled water. The solutions were then used for elemental analysis. A total of six metallic elements Cd, Cr, Cu, Fe, Pb and Zn were determined.

2.6.2. Seed germination test

The bioassay studies were carried out following the method of Heisey (1990). Seeds were surface sterilized with antifungal 15% sodium hypochlorite for two minutes and then washed with distilled water for several times to remove the sodium hypochlorite. Five surface sterilized seeds were placed on whatman No. 1 filter paper 9cm diameter petridishes and the petriplate were arranged on the table following CRD with three replications. Each petriplate was moistened with 2ml tannery effluent with different concentration (25%, 50%, 75% and 100%) and the control was treated with distilled water and incubated at room temperature. The moisture of petriplate was maintained by adding 2ml of respective tannery effluent in each consecutive day.

Germination percentage, plumule and radical length were measured after 6 days of incubation. The germination percentage was calculated by using the following formula.

Germination (%) =

2.7. Green House Experiments

Seeds were surface sterilized with antifungal 15% sodium hypochlorite for two minutes and then washed with distilled water for several times to remove the sodium hypochlorite. Three surface sterilized seeds were sown in plastic pots that filled with equal amount of soil (1:1:1 garden soil, cow dung manure and sand); in green house using CRD design with three replications along with their respective controls. The experimental plants were treated with 1000 ml of respective tannery effluent (25%, 50%, 75% and 100%) every 3 days after 5th leaf emergence (17th day after sowing) and the control was treated with normal water. All the plants were grown under the greenhouse condition in Haramaya University.

Observations on morphological parameters like shoot length, root length, number of leaves, fresh weight and dry weight of shoot and root and yield parameters like ear per plant, seed number per plant, seed weight per ear and 100seed weight per ear were recorded at the end of the experiment after five months of sowing.

Root and shoot length: - Three plants were taken from each pots and their shoot and root lengths in cm were measured by using a measuring ruler and the values were recorded. Since the maize root was fibrous, the largest root was used for measurement.

Fresh and dry weight: - Three plants were collected from each pot and their fresh weights in mg were measured with the help of an electrical single pan balance. Their dry weights in mg were taken after keeping them in a hot air oven at 80 ^{0}C for 24 hours by using an electrical single pan balance.

III. RESULTS AND DISCUSSION

3.1 Physicochemical Characteristics of Tannery Effluent

The physicochemical parameters such as color, odor, pH, BOD, EC, total dissolved solids, total suspended solid and total solid were analyzed and the results are indicated in table 1 with maximum concentration recommended for crop production (FAO, 1985 and USEPA, 2012).

Table 1: Physicochemical characteristics of tannery effluent

Parameters	Unit	Values	Standard set for crop production
Colour	-	Dark bluish green	-
Odour	-	Pungent (offensive)	-
pH	-	5.88	6-9
BOD	mg/L	182	<30
EC	*µS/cm*	13,090	<3,000
TDS	mg/L	13,100	<2000
TSS	mg/L	3,000	<30
TS	mg/L	16,100	-

The tannery effluent used in this study was dark bluish green in colour. This is may be due to presence of high TSS and TDS. Kambole (2003) reported that high colour detected could be attributed due to the high TSS and TDS. The dark bluish green color of the effluent is the major problem to the natural environment. It reduces light penetration in water bodies which in turn affect the aquatic life (Pazouki *et al.,* 2008). The odour of the effluent was pungent. The offensive odour of effluent is due to reduction of sulphate compounds to hydrogen sulphide by sulphate-reducing bacteria (Mahimaraja and Bolan, 2004). The effluent was acidic in nature with pH recorded as 5.88. Kohli and Malaviya (2013) reported that raw tannery effluent was acidic with pH of 3.61. However, a report from different investigation has shown the basic nature of tannery effluents (Aklilu *et al.,* 2012; Mandakini and Khillare, 2016). The acidic pH of the tannery effluent may be due to the presence of high concentration of chrome, which is in line with Reddy *et al.* (2014) who reported that chrome effluent is highly acidic in nature. The pH obtained was lower than that of the permissible level for crop production (FAO, 1985; USEPA, 2012).

The effluent contains much higher amount of total dissolved solid, suspended solid, electrical conductivity and BOD than that of the limit prescribed by FAO (1985) and USEPA (2012). The electrical conductivity value of the tannery effluent recorded was 13090µS/cm. Similarly, higher electrical conductivity of tannery effluent was reported by Aklilu *et al.* (2012). The higher electrical conductivity of the effluent is due to presence of high concentration of dissolved salts in the effluent (Bhasin *et al.,* 2007).

Determination of BOD is one of the important parameters used in water pollution to evaluate the impact of wastewaters on receiving water bodies. The value obtained for BOD was 182 mg/L. Aklilu *et al.* (2012) also reported higher amount of BOD (147.29 mg/L) which is lower than the present report. In contrast to this study, Zereen *et al.* (2013) reported much higher amount BOD which was 987 mg/L. Increase in BOD which is a reflection of microbial oxygen demand leads to depletion of DO which may cause hypoxia conditions with consequent adverse effects on aquatic biota (An *et al.,* 2006). High values of BOD might be due to presence of higher amounts of organic compounds in the effluents (Bhasin *et al.,* 2007).

The result obtained for TDS and TSS of effluent were 13100 and 3000 mg/L respectively. Kohli and Malaviya (2013) also reported higher amount of TSS (1580 mg/L) which was lower than the recent study. However, Zereen *et al.* (2013) reported much higher amount of TDS and TSS which was 85500mg/L and 2150 mg/L respectively. The presence of high level of TSS and TDS may be due to the soluble and insoluble organic and inorganics present in the effluent (Nagarajan *et al.,* 2005). The result of effluent analysis for those parameters shows conformity with the other studies (Aklilu *et al.,* 2012 and Mandakini and khillare, 2016).

3.2 Heavy Metal Analysis in Tannery Effluent

The heavy metal concentration of 100% (untreated) tannery effluent was presented in Table 2 and the results were compared to the standard prescribed for crop production (FAO, 1985 and USEPA, 2012). The result of study indicates that chromium had the highest concentrations in the tannery effluent, while Zn had the least concentrations.

The metal concentrations in effluent samples were in the order of Cr > Pb > Fe > Cd > Cu > Zn. The concentrations of heavy metals such as Cd, Cu and Cr in the tannery effluent were above the maximum concentration recommended for crop production, while the concentration Fe, Pb and Zn are within normal range recommended by FAO (1985) and USEPA (2012). Moreover, the heavy metals such as copper, zinc, iron 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. Several researchers reported the effect of heavy metals on plant. It has been revealed that high concentration of heavy metals affects the plant by inhibit the seed germination, seedling growth, root growth, shoot growth and plant biomass (Aklilu *et al.,* 2012; Zereen *et al.,* 2013; Mandakini and Khillare, 2016)

Table 2: Heavy metal concentrations in tannery effluent

Heavy metals	Unit	Concentration in effluent	Standard set for crop production
Cadmium, Cd	mg/L	0.33	0.01
Copper, Cu	mg/L	0.22	0.20
Chromium, Cr	mg/L	2.74	0.10
Iron, Fe	mg/L	1.38	5
Lead, Pb	mg/L	1.50	5
Zinc, Zn	mg/L	0.12	2

3.3. Effects of Tannery Effluent on Seed Germination Percentage

Impacts of different concentration of tannery effluents on seed germination of two selected varieties of Maize (Zea mays) were indicated in table 3. The seed germination percentage was decreased with increasing concentration of effluent. A maximum of 26.67% and 33.33% reduction in germination percentage was observed in BHQPY545 and Malkesa-2 varieties respectively at 100% tannery effluent treatments. Among the selected varieties, BHQPY545 showed better performance in seed germination percentage as compared to Malkesa-2. Inhibition of seed germination at higher concentrations of the effluent may be due to high levels of dissolved solids which enhance the salinity and conductivity of absorbed solute by the seeds (Sundaramoorthy and Kunjithapatham, 2000).

Moreover, similar observations were reported by Mandakini and Khillare (2016) for seed germination in tomato, Aklilu *et al.* (2012) for seed germination in selected vegetables, and Kohli and Malaviya (2013) for seed germination in wheat treated with concentration of tannery effluents.

Table 3: Effects of tannery effluent on the germination potential of maize

Maize Varieties	Treatments	Germination %			
		3 Day*	4 Day*	5 Day*	6 Day*
	T0(Control)	53.33±6.67^{a}	93.33a±6.67^{a}	100.00±0.00^{a}	100.00±0.00^{a}
BHQPY545	T1 (25%)	33.33± 6.67^{b}	60.00±11.55^{b}	73.33± 6.67^{b}	93.33±6.67^{ab}
	T2 (50%)	13.33 ±6.67^{c}	46.67±6.67^{bc}	66.67±6.67^{bc}	86.67±6.67^{ab}
	T3 (75%)	6.67±6.67^{c}	26.67±6.67^{cd}	53.33±6.67^{cd}	80.00±11.55^{ab}
	T4 (100%)	0.00±00	6.67±6.67^{d}	46.67±6.67^{d}	73.33±6.67^{b}
	T0(Control)	46.67± 6.67^{a}	73.33±13.3^{a}	100.00 ±0.00^{a}	100.00 ±0.00^{a}
Malkes2	T1 (25%)	33.33 ± 6.67^{a}	60.00±0.00^{b}	80.00±0.00^{ab}	86.67±6.67^{ab}
	T2 (50%)	13.33 ±6.67^{b}	33.33±6.67^{b}	60.00±11.55^{bc}	80.00±*11.55*^{ab}
	T3 (75%)	0.00±0.00	20.00±0.00^{bc}	46.67± 6.67^{c}	73.33 ±6.67^{b}
	T4 (100%)	0.00±0.00	6.67±6.67^{c}	40.00±11.55^{c}	66.67 ±6.67^{b}

Mean followed by different letters in the same column are significantly different at p=0.05 according to Duncan's new multiple range test, ± = Standard error, * Days after sowing. T0 = 100% distilled water (control), T1 = 25% effluent + 75% distilled water, T2 = 50% effluent + 50% distilled water, T3 = 75% effluent + 25% distilled water, T4 = 100% effluent

3.4. Effects of Tannery Effluent on Radicle and Plumule Length

The data presented in Table 4 shows, the effects of tannery effluents on radicle and plumule length of selected varieties of Maize (Zea mays). The result showed that radicle and plumule length was decreased with increasing concentrations of effluent treatment. A maximum of 81.69% and 75.69% reduction in radicle length and 64.79% and 75% reduction in plumule length was observed in BHQPY545 and Malkesa-2 respectively at 100% tannery effluent treatments.

Table 4: Effects of tannery effluent on plumule and radicle length of maize

Maize Varieties	Treatments	Plumule Length	Radicle Length
	T0 (Control)	1.42± 0.3[a]	5.79 ± 0.48[a]
BHQPY545	T1 (25%)	1.37± 0.23[a]	2.29 ± 0.27[b]
	T2 (50%)	0.72± 0.03[b]	1.71 ± 0.36[bc]
	T3 (75%)	0.69 ± 0.07[b]	1.63 ± 0.36[bc]
	T4 (100%)	0.50 ± 0.09[b]	1.06 ±0.19[c]
	T0 (Control)	2.04 ±0.2139[a]	4.69 ±0.10[a]
Malkesa-2	T1 (25%)	1.03 ±0.1507[b]	2.49 ±0.16[b]
	T2 (50%)	0.97 ±0.1122[bc]	2.12 ±0.26[bc]
	T3 (75%)	0.73 ± 0.18[bc]	1.72 ±0.28[cd]
	T4 (100%)	0.51 ±0.06[c]	1.14 ±0.10[d]

Mean followed by different letters in the same column are significantly different at p=0.05 according to Duncan's new multiple range test. ± Standard error, T0 = 100% distilled water (control), T1 = 25% effluent + 75% distilled water, T2 = 50% effluent + 50% distilled water, T3 = 75% effluent + 25% distilled water, T4 = 100% effluent

Among these two varieties, at the lowest concentration radicle and plumule growth was also inhibited as compared with control groups. But the inhibitory effect was less as compared with highest concentration of effluent treatment.

3.5. Effects of Tannery Effluent on Vegetative Growth and Biomass

The effects of tannery effluents on vegetative growth performance and biomass were observed and the results were presented in table 5. Increasing levels of effluents treatments caused reduction in all the selected parameters of vegetative growth and biomass in the selected varieties of maize (BHQPY-545 and Malkesa-2) as compared to control groups.

The morphological appearance of plants from the control and T1 treatments of all the two selected varieties were healthier, lush green with well-developed and expanded leaves as compared to T2, T3 and T4 treatments. The comparison of leaf number in the treatments and control groups, showed that mean values significantly (P = 0.05) decreased with increasing the concentration as compared with control groups in both varieties. The inhibitory effect on leaf number was highly significant in T3 and T4 concentration when compared with control. However, in the lowest concentration (T1) inhibitory effect on leaf number was not significantly (p = 0.05) different as compared with control groups. The maximum (165.42) and minimum (138.62cm) shoot length was observed in T1 and T4 treated plants in BHQPY-545 varieties as compared to control groups. The inhibitory effect was highly significant at highest levels of concentration as compared to control and lowest concentration. Moreover, shoot length range was observed from 163.71 to 93.69 cm in malkesa-2 varieties. But the inhibitory effect on shoot length was higher as compared to BHQPY-545 varieties.

Root growth was also observed; it showed the ranges from 37.11 to 31.06 cm and 37.74 to 26.56cm for BHQPY-545 and Malkesa-2 varieties respectively. However, a maximum of 25.84% and 45.81% reduction in shoot length and 43.53% and 39.99% reduction in root length was observed in BHQPY545 and Malkesa-2 respectively at 100% tannery effluent treatments. The results are in agreement with the finding of Zereen *et al.* (2013) who reported that tannery effluent adversely affected the root and shoot development of all the cultivars of sunflower in higher treatment concentration as compared to controls groups.

Finally, shoot and root biomass fresh and dry weight were also recorded and indicated in table 5. It indicates both root and shoots biomass weight decreased with increasing the concentrations of effluent treatment. The drastic changes in the shoot and root biomass weight were observed at highest concentration (T4) and the effect was significant (P = 0.05) compared to control and T1.

Table 5: Effects of tannery effluent on vegetative growth and biomass of maize

Maize variety	Tr.	No. of leaves	Shoot length	Root length	Fresh weight		Dry weight	
					Shoot	Root	Shoot	Root
BHQPY-545	T0	14.32±0.19[a]	186.93±17.06[a]	55.00±0.51[a]	498.48±46.40[a]	214.85±13.19[a]	290.09±27.67[a]	147.12±19.37[a]
	T1	13.66± 0.20[a]	165.42±10.03[ab]	37.11±0.40[b]	311.78±28.87[b]	120.09 ±2.83[b]	183.78±36.47[b]	92.45±4.64[b]
	T2	13.10±0.10[a]	151.31±2.70[b]	32.55±0.40[c]	181.75± 6.98[c]	92.15± 2.39[c]	109.93±5.72[c]	62.21±4.37[c]
	T3	11.76±0.79[b]	139.28±1.60[b]	31.56±0.99[c]	150.6± 3.80[c]	54.72± 5.63[d]	102.90±2.37[c]	27.65±5.72[d]
	T4	10.53±0.23[b]	138.62±4.37[b]	31.06±0.53[c]	120.49± 4.21[c]	33.70 ±1.81[d]	69.59±3.21[c]	23.61±2.98[d]
Malkesa-2	T0	17.00±0.57[a]	172.89±4.52[a]	44.26±0.49[a]	443.40±36.95a	202.27±17.72[a]	254.99±9.62[a]	161.17±18.14[a]
	T1	15.32±0.50[ab]	163.71±0.63[a]	37.74±0.26[b]	297.62±5.71b	116.72±2.35[b]	199.66±10.13[b]	71.84±3.73[b]
	T2	13.43±0.72[bc]	134.11±1.28[b]	33.67±0.38[c]	178.47± 5.04c	93.39±3.23[b]	164.96±10.93[c]	46.34±1.46[bc]
	T3	12.66±0.50[cd]	117.15±1.85[b]	27.94±0.45[d]	142.96 ±6.00c	53.99± 6.23[c]	78.97± 3.06[d]	38.25±4.09[c]
	T4	10.66±0.84[d]	93.69±12.66[c]	26.56±0.58[d]	113.92 ±5.81c	31.10 ±1.89[c]	61.76±3.48[d]	31.86±1.67[c]

Mean followed by different letters in the same column are significantly different at p=0.05 according to Duncan's new multiple range test, ± = Standard error, Tr = treatments, T0 = 100% tap water (control), T1 = 25% effluent + 75% tap water, T2 = 50% effluent + 50% tap water, T3 = 75% effluent + 25% tap water, T4 = 100% effluent

The results are in accordance with the findings of Khan *et al.* (2000) who reported that fresh and dry weight of shoot showed significant decrease with increase in concentration of tannery effluent. This may be due to the presence of heavy metals such as Cu and Cr.

3.6. Impacts of Tannery Effluent on Yield of Selected Varieties of Maize

Table 6: Effect of tannery effluents on yield parameters of maize

Maize varieties	Treatments	Ear/ plant	Seed no./ear	Seed wt/ear	100seed wt/ear
	T0(Control)	2.66±0.20^{a}	309.00±5.51^{a}	84.37±4.71^{a}	28.60±0.15^{a}
	T1 (25%)	1.32±0.19^{b}	272.32±2.42^{a}	74.84±3.78^{ab}	27.52±0.75^{a}
BHQPY545	T2 (50%)	1.00±00 ^{b}	197.55±3.31^{b}	61.46±0.81^{b}	25.93±0.34^{a}
	T3 (75%)	0.78±0.11^{bc}	123.32±16.39^{c}	45.24±5.31^{c}	19.94±2.85^{ab}
	T4 (100%)	0.45±0.22^{c}	71.67±35.86^{c}	16.05±8.04^{d}	13.98±7.51^{b}
	T0(Control)	2.66±0.20^{a}	303.34±5.70^{a}	83.58±2.17^{a}	27.68±0.23^{a}
Malkesa2	T1 (25%)	1.55±0.12^{b}	273.78±7.12^{a}	67.57±0.94^{ab}	27.35±0.54^{a}
	T2 (50%)	1.10±0.10^{bc}	175.56±5.84^{b}	62.33±1.61^{b}	25.83±0.45^{a}
	T3 (75%)	0.78±0.11^{c}	122.67±15.70^{bc}	37.67±9.79^{c}	19.96±2.56^{ab}
	T4 (100%)	0.66±0.38^{c}	70.89±35.48^{c}	18.61±9.33^{c}	11.57±5.79^{b}

Mean followed by different letters in the same column are significantly different at p=0.05 according to Duncan's new multiple range test. ± Standard error, Tr = treatments, T0 = 100% tap water (control), T1 = 25% effluent + 75% tap water, T2 = 50% effluent + 50% tap water, T3 = 75% effluent + 25% tap water, T4 = 100% effluent

All the selected yield parameters decreased from T1 to T4 effluent concentrations in both varieties of maize. Highest inhibitory effect was observed on all the yield parameters at higher effluent treatment. Decreasing in ear of plant was found with the increase of tannery treatment compared to T0 (control). A maximum of 83.08% and 75.19% reduction in ear of plant was observed in BHQPY545 and Malkesa-2 respectively at 100% tannery effluent treatments. Seed number was higher in control (T0) plants while gradual reduction in seeds number was observed in all the effluent treated plants. However, drastic change in seed number was observed in higher concentration (T3 and T4) and effect is significant (P = 0.05). The reduction in seed number of T4 treated plants in BHQPY545 was 76.80% while it was 76.63% in Malkesa-2.

Plants treated with T3 and T4 were extremely stunted. Therefore, it produced fewer number of light weight seeds. Seed weight was also higher in T0 and T1 treatments as compared to seeds produced in T3and T4 treatments. A maximum of 80.98% and 77.73% reduction in seed weight was observed in BHQPY545 and Malkesa-2 respectively at 100% tannery effluent treatments. 100 Seed weight was also gradually reduced in consecutive effluent treatment. The magnitude of reduction in 100 seed weight per plant in T4 compared to control was 51.10%, but it was a higher value in Malkesa-2 (58.20%). The results are in line with Turner (2002) who reported that effluent caused severe growth reduction in crops, particularly in cereals with marked depression in biomass (50 - 70%). In another study, Davies and Linsey (2001) reported grain yield reduction of 69 and 78% in two wheat cultivars due to effluent irrigation. Similarly, Sundaramurthi (*et al.*, 2010) reported that plant yield is dependent on leaf growth, leaf area, and number. As Cr affects most of the biochemical and physiological process in plants, productivity and yield are also affected. Cr (VI) in irrigation water decreased significantly grain weight and yield of paddy (Oriza sativa) up to 80% under 200 mg/L of Cr (Sundaramurthi *et al.*, 2010).

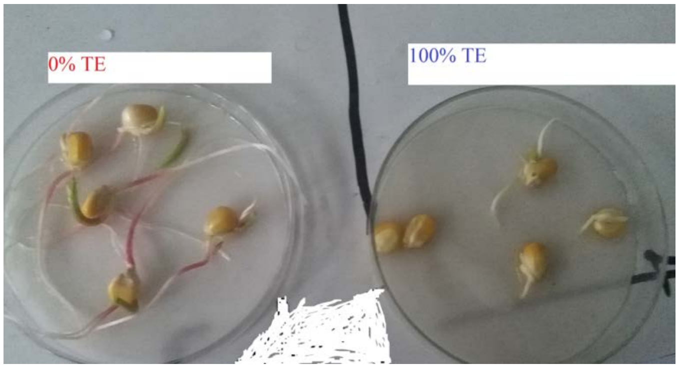
IV. Conclusions

From the present study it can be concluded that tannery effluent are characterized by high load of pollutants. The effluent was dark bluish green in colour with unpleasant odour and also characterized with high value of total dissolved solids, electrical conductivity, BOD and acidic PH. Both physical and chemical parameters are higher than that of the permissible limits set for irrigation except some heavy metal. Consequently, it shows that the effluent is not suitable for irrigation purpose.

In both maize varieties, each tannery effluent treatments showed inhibitory effects on vegetative and reproductive growth. Seed germination, plumule length, Radicle length; shoot length, root length, fresh and dry weight of shoot and root, leaf number and all components of yield showed inhibitory effect for each effluent treatment. The inhibitory effect of effluent treatment is directly proportional to the increasing percentage of effluent treatments (25%, 50%, 75%, and 100%). The lower effluent treatment shows a bit inhibitory effect on each vegetative and reproductive growth parameters compared to the higher effluent treatments. This indicates tannery effluent can be used for crop growth if properly treated and diluted effluents.

APPENDIX

Appendix Figure1: Germination test



Appendix Figure 2: Growth characteristics of Maize in green house before starting treatment after 14 days of cultivation

Appendix Figure3: During reproductive growth

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