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Effects of Tannery Effluents on Crop Production

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Abstract

The production of leather involves a lengthy producing chain and has a wider impact on the economy. Large amounts of solid waste are produced during the various phases of leather manufacturing. Due to the release of untreated effluent, the tannery industry is a major environmental polluter and has a high potential to pollute land and water. When leather is produced, more than 250 chemicals are used, and a complex mixture of toxic organic chlorinated phenols, toxic Cr(VI), and other toxic pollutants are released, including formaldehyde resins, pesticide residues, mineral salts, dyes, and solvents like grease and oils, as well as sulphides, phenolic compounds, magnesium, sodium, potassium, azo-dyes, cadmium compounds, cobalt, copper, antimony, barium, lead.The two most common types of sewage that are harmful to humans, biota, other habitats, and ecosystems are Cr(VI) and chlorinated phenols. Almost all (more than 99.99%) of the Cr(VI) is over the legal level of WHO, FAO, EPA, and other nations' maximum discharging and existing limitations, according to various researchers on various countries and environmental samples such soils, waterways, and crops. The positive and potentially harmful consequences of tannery effluents are briefly discussed.

Introduction

The other elements of habitats exposed to industrial effluents and heavy metals include vegetables. They could absorb and collect harmful metals like Cr(VI) at concentrations from various industries, including metal cleaning, plating baths, refineries, mining, electroplating, paper and pulp, paint, textile, and tanneries, as they grow at contaminated areas. From these, the tannery industry is the main environmental polluter and has a high potential to pollute soil, water, plants, vegetables, terrestrial, and atmospheric systems due to the discharge of untreated effluent, which has a high oxygen demand, discoloration, and toxic chemical constituents (Song *et al.*, 2000). The chemical process known as tanning turns animal hides and skin into the durable and indestructible goods we know as leather (Hayelom and Adhena, 2014).Typically, tanning compounds are used to turn hides into leather, and the process produces effluent that is extremely turbid, colourful, and odoriferous (Hayelom and Adhena, 2014; Buljan and Kral, 2011). There are three categories of wastes produced throughout the tanning process: air pollutants, water pollutants, and solid pollutants. These wastes are released during the processes of beam house operations, tan yard activities, post tanning operations, and finishing operations (Durai and Rajasimman, 2011). According to the size of the tannery, the chemicals used for a particular process, the quantity of water required, and the kind of finished product a tannery produces, the properties of tannery effluent vary significantly from one tannery to the next.The leather business depends heavily on tanning, and the majority of tanneries worldwide (approximately 90%) employ chromium salts to provide leather more elasticity, improved water resistance, and a high shrinkage temperature. Sadly, chromium salts are not completely removed from skins and some are left behind in the used tanning liquor (approximately 30% of the original amount) (Alfredo *et al.*, 2007) very high concentrations of Cr(VI) are teratogenic, mutagenic, and carcinogenic to humans, several aquatic species, plants, and microbes (Naik*et al.*, 2007). Temporary side effects include fainting, headaches, eye, skin, or respiratory irritation; allergic responses; liver, kidney, or nervous system poisoning; and collapse from lack of oxygen.Vegetable tanning, which does not contain chromium and is used to prepare heavy leather such as shoe soles, handbags, straps, and belts, and chrome tanning, which does contain chromium and is used to prepare light leather, are the two types of tanneries' effluents that are ranked as the most polluting among all industrial wastes. In developing nations like Ethiopia and Sudan, which have more tannery businesses, as well as India, Pakistan, Burkina Faso, South Africa, Latin America, and Asia, the tanning industry is a major source of chromium contamination. Due to the fact that nearly all leather companies produce large amounts of waste that contains hazardous chromium and phenolic solutions.

Use Of Tannery Waste In Agriculture

The availability of nutrients in the soil during a crop's development affects productivity. Fertilizers must be added to the soil to ensure that it contains all of the macronutrients and micronutrients necessary for the plant's growth process (Ruthrof*et al*., 2018). Due to the abundance of nitrogen and organic matter present, tanning wastes have been extensively utilised as fertilisers to increase agricultural yield (Barylska and Plucinska, 2015). Various applications for this waste have been suggested by studies, as shown in the diagram in Figure 1. Nabavinia*et al.* (2015) examined the effects of the mixture of biochar and hair removal residues on the development and growth of radishes.The amount of nitrogen and phosphorus in the soil was observed to increase as a result of the fertiliser, increasing the fresh and dry mass of the vegetable. Due to their high nutritional content, they are especially effective in areas with carbon-deficient soils (arid and semiarid soils), where they increase plant output. It has also been investigated how goat leather waste, which consists of complicated protein molecules, can be converted by bacteria into simple, soluble compounds. Tannery waste was fermented using Selenomonasruminantium bacteria in both a submerged state (treatment 1) and a solid state (treatment 2). There were two further treatments with mineral fertiliser and controls.Better results were found with the fermented hydrolysates. Because the solid-state hydrolysate provided the plants with a higher nitrogen content, the tomatoes' growth, stem diameter, and number of leaves were all affected more (Ravindran*et al*., 2015).

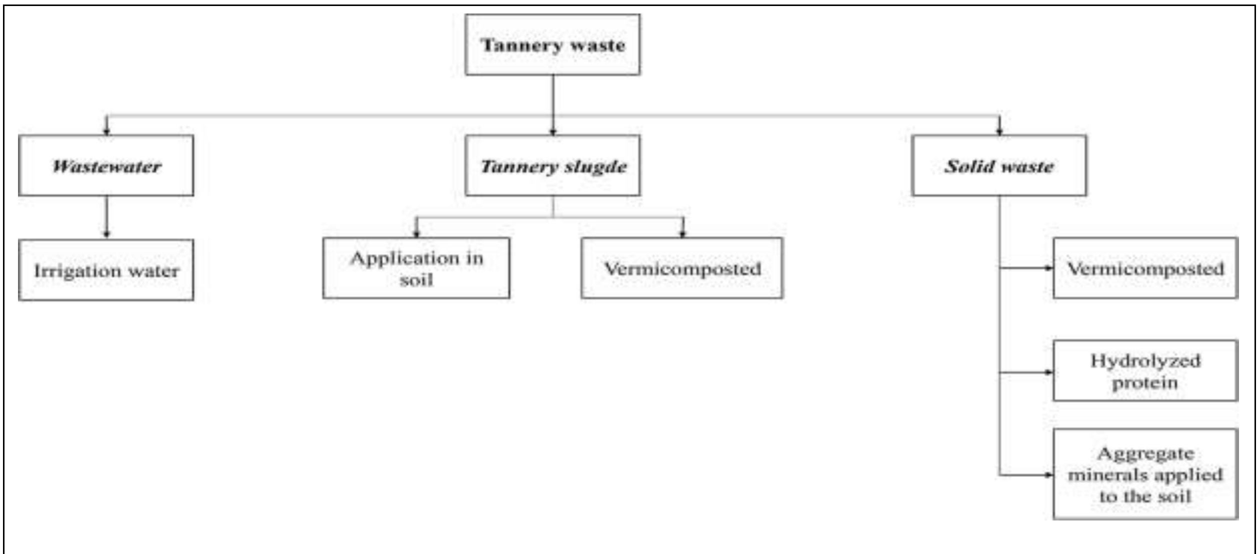

Fig. 1. Origin and destination of tannery wastes for application in agriculture

Although the concentrations of phosphorus, potassium, magnesium, and calcium increased (which impacts the increase in soil fertility), Malafaia*et al.* (2016) used tannery sludge produced during the skin hair removal step in the corn crop; however, there was no increase in the corn crop's yield when compared to mineral fertilisation. A method for enhancing the biochemical qualities of the fertiliser made from tannery waste is vermicomposting. The method is summed up by the addition of earthworms, which have mesophilic microbes in their intestines that can bioxidize and stabilise organic matter, turning it into a substance rich in nutrients. Vermicompost is the term used to describe the waste products of earthworms. A plan for vermicomposting with tannery waste is shown in Figure 2. In order to create fertiliser, Ravindran*et al*. (2016) combined goat leather waste with cow manure and sawdust. To prepare the residue for receiving earthworms for vermicomposting, it was decalcified and fermented in a solid and immersed state. The same components were used to administer a therapy without the usage of earthworms. The findings showed that vermicomposting can increase the availability of nutrients including indole 3-acetic acid, kinetin, and gibberellic acid, which are crucial for plant growth.In a different investigation, Nunes*et al*. (2018) investigated the vermicomposting of tanned leather shavings combined with cow dung and sawdust to grow organic sweet peppers. The authors compared this fertiliser to two other treatments: one using mineral fertiliser and the other serving merely as a control treatment (soil use) (NPK). When compared to mineral fertiliser in a 3:1 ratio, it was found that the vermicomposted fertiliser had a favourable effect on plant development and produced more fruits per plant. Chromium was found in the fruits at amounts ranging from 145.06 to 165.20 g/kg, however these levels are too low to pose a threat to human health (ATSDR, 2012).

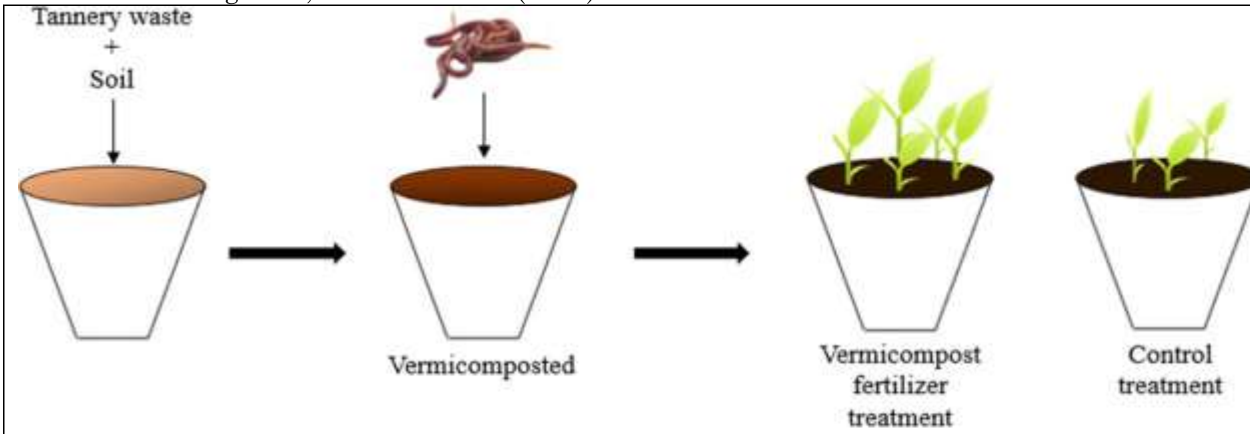

Fig. 2. Stages of vermicompost production from tannery waste

The possibility of tannery hair removal wastes to be vermicomposted to generate tomatoes was assessed by Ravindran*et al*. in 2019. The hydrolyzed wastes were employed by the authors to create compound and vermicompost in both a solid and submerged state. The substance was sprayed on the soil, and tomato growth, production, and chemical make-up were assessed. When compared to the hydrolysate in submerged form, it was shown that the hydrolyzed wastes in solid state produced better outcomes for composting and vermicomposting. Vermicompost treatments resulted in a 10% rise in plant height, an 8.9% increase in stem diameter, and a 14% increase in leaf count.

Nogueira*et al*. investigated a fertiliser made from leftover chromium-tanned leather that also included phosphorus (P) and potassium (K) (2010). Through acid hydrolysis at a temperature of 50 °C, the authors were able to remove the chromium that was present in the waste. The hydrolyzed residue was submerged in P and K solutions, dried, and crushed into various sized particles. To measure the development of rice plants, treatments using commercial fertiliser made from residue were carried out. Less dry mass was created by formulations with residue, but plants yielded more grain, demonstrating that they were a source of nutrients for the crop.

Another technology that has showed promise for application in agriculture is fertiliser encapsulation. Its benefit over traditional application is the gradual release of the nutrient from the capsules as the plant requires it. This increases the effectiveness of the plant's mineral absorption and prevents leaching of the substance into the soil. Encapsulation takes place when a membrane or film forms over the active ingredient, such as mineral salts or fertiliser. Polymers including chitosan, starch, and gelatin are used in the coating process, among others. Both dropping a liquid solution in water or oil and spraying the coating polymer onto fertiliser grains can yield the capsule.The disclosure When water enters through the polymer wall, the difference in osmotic pressure between the inside and outside of the capsule results in the release of the contents into the environment.

Dang *et al*. employed gelatin that was derived from waste chromium-tanned leather as an encapsulating agent (2019). The substance was applied to fertiliser granules and tested for growth in a bean culture. When compared to the control treatment, it was seen that the height and germination rate rose. Since gelatin possesses hydrophilic properties, starch was added in this experiment to make it less soluble when exposed to the environment. Bean productivity was observed to be higher in treatments with increased gelatin compositions. There are still significant uncertainties around the usage of tannery wastes, despite the fact that they show promise for uses such as fertilisers. According to Ali *et al*. (2018), the application of tannery effluent treatment plant wastewater inhibited the growth and development of wheat biomass. Such a result can be attributed to the buildup of metals in the soil, such chromium, which promote plant stress and inhibit the activity of antioxidant molecules. The reader should be made aware that the mobility and availability of other organic and inorganic components present in the residue or soil also affects how negatively chromium affects plant growth and even its oxidation into Cr6+. For the metal in question to harm flora, microbial fauna, and even human health, specific circumstances must exist (Barylska*et al*., 2015).Also, some substances can be added to reduce the toxic effect of chromium such as fulvic acid.

Impact On Crop Growth

Wastewater-contaminated irrigation water has an impact on plant growth and yield, and the buildup of hazardous heavy metals is biomagnified at various trophic levels across the food chain. Tannery wastewater has phytotoxic effects, a high concentration of heavy metals, stresses plants (for example, salinity stress reduces vegetative and later reproductive growth of the plant), adversely affects respiration and photosynthesis, shortens mitotic activity, and increases reactive oxygen species production), and has phytotoxic effects (Camplin, 2001). Nevertheless, the accumulation is influenced by the type of plant, the elements, its bioavailability, redox, pH, cation exchange capacity, dissolved oxygen, temperature, and root secretion. According to (Arifa*et al*., 2013), wastewater adversely affected the root and shoot development of all sunflower cultivars in greater treatment concentration as compared to counterparts grown in controls, which resulted in a reduction in all vegetative growth and biomass parameters in all cultivars. Similar effects of wastewater on the growth of maize, soybean, and wheat plants were documented by (Rusan*et al*., 2007). According to reports, a tannery waste's increased concentration of salts like chlorides and sulphates could impede maize's normal crop growth and development (Nath, 2009).The effluent is unfavourable for crop growth and inhibits seed germination and seedling growth at lower effluent dilutions when it contains excessive amounts of chromium, dissolved solids, chlorides, sulphides, high BOD, and COD values. Therefore, high effluent concentrations of more than 80% were found to be detrimental to plant growth at both the vegetative and reproductive stages. The mitotic process is severely affected by tannery sludge, which is a mixture of hair, fleshing, shavings, splits, hide/skin trimmings, leather trimmings, buffing dust, leather finishing residues, general plant wastes, and waste water treatment sludge. Tannery sludge also significantly reduces seed germination in widely cultivated pulse crops.

Table 1 shows how tannery sludge affected the levels of heavy metals in sorghum and millet crops over the course of the two years. Except for sorghum grain, which had the lowest concentration, it is shown that Mn concentrations are not significantly different across the board in other plant sections. However, the concentration is highest in millet stalks. The concentration of Co was not significantly different in sorghum stalk, sorghum grain, and millet grain (Tudunwada*et al*., 2007). The highest lead concentrations (3.34 mg/kg) were detected in the millet grain, although lead contents varied widely. Zn concentrations were comparable in sorghum stalk, grain, and millet, but significantly different in millet stalks (which had the highest).Fe concentrations were significantly different between the two crops. Copper concentrations were significantly different between the crops but millet had the highest concentrations especially in the stalk. Chromium followed similar trend but millet grains had highest concentration.

Table 1. Effect of tannery sludge on heavy metals concentration in cereals (aggregate of two years)

Treatment	Heavy metals						
	Mn	Co	Pb	Zn	Fe	Cu	Cr
Sorghum stalk	3.26 a	2.02 ab	2.02 bc	1.60 b	3.78 a	3.70 b	0.63 ab
Sorghum grains	2.22 b	1.99 ab	1.60 c	1.73 b	3.10 b	2.70 c	0.31 b
Millet stalks	2.95 a	2.21 a	2.78 ab	2.24 a	1.02 c	4.75 a	0.80 a
Millet grains	2.97 a	1.85 b	3.34 a	1.72 b	0.64 c	4.17 ab	0.98 a

Table 2 shows the effects of various tannery effluent concentrations on the germination of two distinct kinds of maize (*Zea mays*) (Hailu*et al.*, 2019). The proportion of seed germination shrank as effluent concentration increased. At 100% tannery effluent treatments, the germination percentage of the BHQPY545 and Malkesa-2 types, respectively, decreased by a maximum of 26.67% and 33.33%. In terms of seed germination % among the chosen varieties, BHQPY545 outperformed Malkesa-2. High quantities of dissolved particles that increase the salinity and conductivity of the solute absorbed by the seeds may be the cause of the effluent's ability to prevent seed germination at greater concentrations (Sundaramoorthy and Kunjithapatham, 2000).Additionally, similar findings for seed germination in tomato were reported by Mandakini and Khillare (2016), for seed germination in various vegetables by Aklilu*et al.* (2012), and for seed germination in wheat treated with tannery effluent concentration by Kohli and Malaviya (2013).

Table 2. Effects of tannery effluent on the germination potential of maize

Maize Varieties	Treatments	Germination %			
		3 Day*	4 Day*	5 Day*	6 Day*
BHQPY545	T0(Control)	53.33±6.67^{a}	93.33a±6.67^{a}	100.00±0.00^{a}	100.00±0.00^{a}
	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}
Malkes2	T0(Control)	46.67± 6.67^{a}	73.33±13.3^{a}	100.00 ±0.00^{a}	100.00 ±0.00^{a}
	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

Conclusion

The tannery effluents either contain vital nutrients or have qualities that make them suitable for irrigating field crops. However, the sewage systems in many cities where tannery wastewater is mixed with contains harmful metals. Continuous usage of this effluent irrigation system showed improvements in soil microbial count, hydraulic conductivity, organic C, and accessible N, P, and K nutrient status. Due to the prolonged usage of tannery wastes, it was discovered that harmful metals like Cd, Cr, and Ni had accumulated in the soil and plants. When compared to grain crops, leafy vegetables have a higher concentration of these metals.This justifies the possible risk to the health of the soil and plants, indicating the need for their safe usage following pretreatment to protect soil health and lower the risk of harm to human and animal health. To use tannery effluents as a cheap prospective alternative supply of plant nutrients in agriculture, ongoing monitoring of the quality of tannery effluents available in the country and their impact on soil plant health is required. The long-term impacts of tannery effluents on salt and toxic metal accumulation in soils, as well as their impact on soil biological health and crop productivity, should be researched.

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