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Impact of Sewage and Tannery Effluents on Agriculture

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Abstract

Environmental pollution is one of the major problems of the world and it is increasing day to day due to urbanization and industrialization. Tannery effluent is one of the major pollutants that is affecting our environment in present times and has a strong potential to cause soil and water pollution owing to the discharge of untreated effluent. It uses more than 250 chemicals for leather production and release a complex mixture of toxic organic chlorinated phenols, toxic Cr(VI), and other toxic pollutants such as sulphides, Cadmium and phenolic compounds, magnesium, potassium, sodium, cadmium compounds, cobalt, copper, antimony, barium, selenium, mercury, zinc, arsenic, PCB, nickel, formaldehyde resins, pesticides residues, mineral salts, dyes and solvents like grease and oils. Cr(VI) and chlorinated phenols are the basic prominent sewage toxic to biota and humans as well as other environments or ecosystems. The present study deals with the effects of sewage and tannery effluents on various types of crops in India.

Keywords- Impact of Sewage, Tannery Effluents, Agriculture

Introduction

Sewage and tannery effluent is one of the major problems throughout the world which is increasing at a rapid pace due to urbanization and industrialization. With the growth of population, the increasing requirement of leather and its products led to the establishment of large commercial tanneries. Water used in these industries creates huge quantity of effluent that has potential to hazard environmental because of the toxic chemical and heavy metals in their effluent. The effluent from the tannery industry considered as a severe environmental threat throughout the world. Significant problems of tannery effluent are toxic heavy metals like chromium, chloride, lime with high dissolved and suspended solids and other pollutants. The continuous input of wastes containing poisonous metals on the agricultural land causes an imbalance in the ecosystem. The crops growing under such habitats accumulate high amount of toxic metals, which in turn are being assimilated and transferred within food chain. Wastewater from industries also destroys our productive land by adding chemical compounds to these soils. Delayed germination and earlier leaf senescence are the two most important parameters which correspond to the final yield loss at the end of the season. In the present study, an attempt has been made to investigate the effect of tannery effluents in various dilutions on seed germination and seed growth of important cultivated crops species.

Sewage water

Raw sewage water available from cities is a mixture of domestic, commercial and industrial activities. Currently more than 450 cities in India generate more than 17 million cubic meters of raw sewage water per day (Bijay-Singh, 2002). Since the raw sewage water is rich in organic matter and essential nutrients, sewage farming is quite common in all urban areas. In the country as a whole, about

200 sewage farms, covering as area of about 50,000 ha, are utilizing sewage waters to supplement the nutrients and water supply. Some city sewage waters where industrial effluent is discharged in to sewer system may contain toxic metals in high amounts. Thus the composition of domestic sewage may be changed with the type of industries discharging their effluents.

Composition of sewage water

The composition of sewage water is quite variable depending upon the contributing source, mode of collection and treatment provided. Although a large proportions of these sewage waters is organic in nature and contains essential plant nutrients but sometimes toxic metals are also present in appreciable amounts. The sewage water generated in India contains more than 90% water. The solid portion contains 40-50% organics, 30-40% inert materials, 10-15% bio-resistant organics and 5-8% miscellaneous substances on oven dry weight basis (Antil & Narwal, 2008). The composition of sewage waters is not constant and changes within the year due to several factors. The extent of the contaminants will be least during the rainy seasons. During the same year, the pH of the sewage water of one location of Hisar varied from 7.3 to 8.7 and EC from 0.52 to 1.55 dSm-1 (Antil & Narwal, 2008). The chemical composition of sewage waters varied from site to site which was in accordance with the type of industries discharging their effluents. Some city sewage waters where industrial effluent is discharged in to sewage system may contain toxic metals in high amounts. Many investigations have found variations in pH, electrical conductivity (EC), suspended solids, organic C, CO3, HCO3, Ca++, Mg++ and other essential and toxic elements in the sewage water from Indian cities. The pH of the sewage water of different cities ranged from 7.2 to 8.3 (Table 1) and it was within normal range and irrigation with these waters in not going to cause any significant change in the soil pH due to high buffering capacity of the soils. The EC of sewage waters collected from different cities varied from 1.1 to 3.8 dSm^{-1} and their continuous use in the agricultural fields may cause increase in salinity of the soils and ultimately restricting the plant growth. Organic C content of sewage waters of different cities ranged from 59 to 480 mg L-1 being lowest in sewage water from Bhatinda and highest in sewage water of Gurgaon. Since organic C has a direct relationship with biochemical oxygen demand (BOD), their harmful effects may be due to high BOD values. The sodium absorption ratio (SAR) ranged from 0.8 to 10.4 m mol-½L-½ and some of these waters are not suitable for irrigation. Apart from these properties, the sewage waters contained appreciable amount of N, P and K. However, their content in sewage water varied from city to city. The amounts of N, P and K in sewage waters ranged from 8 to 106, 4.2 to 53 and 19 to 2500 mg L-1 respectively. Sewage waters of many cities also contained appreciable amounts of micro-nutrients and toxic metals. In general the content of heavy metals was higher in cities of Haryana and West Bengal than cities of Punjab.

Properties and Effect of Tannery effluents

About 3,000 tanneries are spread all over India mostly in the states of Karnataka, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. About 80 million pieces of hides and 130 million pieces of skins are processed by tanneries of India every year for finished and semifinished leather. About 700 leather finishing units in India produce about 1 billion square metres of finished leather annually. In this process, about 30-40 litres water for every kilogram of skin / hide is used and afterwards discharged by the tanneries and manufacturing units as tannery effluents.

Effect on water bodies

Effluents discharged from tanneries ultimately reach groundwater to deteriorate its quality heavily. Chemical analyses have revealed that pH and electrical conductivity of effluent mixed groundwater ranged from 2.4 to 8.8 and 1.5 to 10.0 mmhos/cm respectively. Quantities of various mineral components in effluent affected water such as carbonate, bicarbonate, sulphate, chloride, sodium and SAR also varied from 30-150, 122-1160, 8.60-103.2, 318.6-3115.2, 210-1430 and 1.5-16.8 mg/L respectively. The electrical conductivity of analyzed samples was 3mmhos/cm in most of the places falling in the severe problem range. As a result, the agriculture production in most of the affected regions reduced by upto 75% within a period of just 15 years.

Effect on Soil

These effluents very adversely affect the quality and health of the soil that is used for farming in the country. The untreated tannery effluents contain mainly tannins, deplete oxygen level and exert high BOD and COD. When the effluents are mixed in the soil, the total porosity and hydraulic conductivity of the soil is decreased while the bulk density of soil gets increased. Furthermore, the nitrogen level of soil declines. Due to this, large quantities of inorganic and organic materials are accumulated directly into the soil. This causes the deflocculation of soil particles. The soil quality is hence highly adversely affected.

Effect on Crop Production

A study conducted on the cytological effect of tannery effluents on *Allium cepa* revealed that the mitotic process was severely affected by the tannery effluents. The increase in inhibition corresponded with increase in effluents concentration. It was also observed that directly collected effluents were more toxic than the ones collected from the point of mixing with irrigation canal. Even the effluents collected about 1 km away downstream canal was moderate in toxicity. This indicates that recovery of the water was not achieved. This could be attributed to various organic and inorganic substances present in the effluents. Since the downstream sample had mitotoxic effects, the effluents may have chronic effects on the crops and other biota in the agricultural ecosystem.

Treatment of Tannery and Textile Industry Effluents

Since the physico-chemical characteristics of tannery and textile effluents cannot be directly disposed into either inland surface water or land for irrigation, they require some treatment before used further.

Plant and Vegetables growth

Wastewater laden irrigation water affects the plant growth and yield (Barman and Lal, 1994) and the accumulation of toxic heavy metals are biomagnified at different trophic levels through food chain. Tannery wastewater produces phytotoxic effects, and high accumulation of heavy metals resulting in stress for plants. Stresses like salinity affect various metabolic processes and it results in the reduction of reproductive growth of the plant along with and greatly affecting the process of respiration, photosynthesis, shorten germ sprouting and mitotic activity (Camplin, 2001). The production of reactive oxygen species is also increased (Moore and Ramamoorthy (2001). According to Arifa *et al*. (2013) parameters of vegetative growth and biomass in plants is reduced due to use of effluent discharge (in irrigation) from tanneries and wastewater. Effluents adversely affect the root and shoot development of plants. Very similar effects of wastewater on the growth of maize, soybean and wheat plant were reported by Rusan *et al*. (2007), Kilicel and Dag (2006) and Hewitt and Keller, (2003). The higher level of salts like chlorides and sulphates in a tannery waste which might inhibit the average crop growth and developments of maize as reported by Nath (2009). Presence of excess amount of chromium, dissolved solids, chlorides, sulphides, high BOD and COD values in the effluents beyond the tolerance limit makes it unsuitable for crop growth as studied by Bera and Bokaria (1999). According to the study conducted by Mishra and Bera (1995) more than 80% high concentrations of effluents proved deleterious to plant growth, both at vegetative and reproductive stages. Tannery sludge is a combination of hair, fleshing, shavings, splits, hide/skin trimmings, leather trimmings, buffing dust, leather finishing residues, general plant wastes, and affects the mitotic process and reduces seed germination in extensively cultivated pulse crops.

Atmospheric Systems

The air we breathe is an essential ingredient for our wellbeing and a healthy life. Unfortunately polluted air is common throughout the world especially in developed countries from 1960s. Polluted air contains one, or more, hazardous substance, pollutant, or contaminant that creates a hazard to general human health. The main pollutants found in the air we breathe include, particulate matter, PAHs, lead, ground-level ozone, heavy metals, sulphur dioxide, benzene, carbon monoxide, nitrogen dioxide, H_2S and NH_3 waste discharging from tanning during unhearing limning and deliming bating process respectively affect atmospheric air (Mashhood and Arsalan, 2011 and Kan, 2009). Chromium present in the atmosphere originates from anthropogenic sources, which account for 60-70%, as well as from natural sources, which account for the remaining 30-40%. Industrial activities still remain the major source of pollution to atmosphere. Average atmospheric concentrations of Chromium are 1 ng/m^3 in rural to 10 ng/m^3 in polluted urban areas and that their retention in the lung can pose carcinogenic risk.

Effect on Human Health

Chronic exposure of tannery workers from a period of five months to fourteen years represents a relevant risk factor for the development of diseases associated with genetic damage. Due to their unawareness of the toxic effluents of chromium, hydrogen sulphide, lead, zinc, cadmium and formaldehyde released from tanneries have a temporary effects such as dizziness, headache, irritation of eyes, skin or lungs, allergic reactions, poisoning of liver, kidney or nervous system or collapse due to lack of oxygen as well as long term illness like occupational asthma, ulcers, bronchitis, genetic defects and dermatitis in humans and animals health (Rajendran, 2010).

Chromium Impacts on the Environment

Chromium is an essential metal that is involved in the metabolism of glucose in humans and animals, but in Cr (VI) form, it is very toxic, mutagenic, and carcinogenic (Rahmaty *et al*., 2011 and Lee *et al*., 2008). Cr (VI) is also highly mobile in most environments, mainly due to its soluble nature (Fukai, 1967). It affects the environment adversely because of its eminent solubility and mobility. Soils and groundwater surrounds are the most fictile to Cr(VI) pollution from spills, unlawful disposition and unguarded stock piles of new techniques chromium products. Cr(VI) is extremely accessible to animals through multiple paths of entrance such as consumption, epidermal adjoin, breathing in, and absorption (in the case of plants and root ages). Cr(VI) affects enzyme amylase in plants and shortens seed sprouting (Towill et al., 1978; Anon, 1974).

Tannery Effluent Treatments Technology

Tannery wastewater is generally treated by various physico-chemical and biological methods and by a combination of both. Physical and chemical processes are frequently employed to treat contaminated sites, but often do not destroy contaminants (Bouwer *et al.*, 1994). Treatment of tannery effluent through the use of activated sludge process has been reported by many research workers (Tare *et al.*, 2003; Ahmad et al., 2002). All these studies indicate a BOD5 removal of 90 to 97% for the tannery effluent concluding activated sludge process as highly useful for such treatment purpose. Removal of Cr(VI) from industrial effluents is not only essential because of its toxicity to humans but also it affects soil fertility by inhibiting biodegradation of organic pollutants due to its ability to inactivating enzymes and precipitating proteins of soil microbial organisms. Various physic-chemical methods such as Precipitation by hydroxides, carbonates and sulfides, ion-exchange resins, adsorption on activated carbon, and membrane separation and bioremediation can be used to remove the heavy metals from the effluents/sludge emerging out of the leather industries (Srivastava, 2006). Low-waste advanced methods such as the use of salt-free preserved raw hides and skins, hair-save liming, lowammonia or ammonia-free deliming and bating, advanced chrome management systems, etc. are significantly beneficial to decrease the pollution of COD and BOD5 by more than 30%, sulphides (S2-) by 80-90%, ammonia nitrogen by 80%, total Kjeldahl nitrogen (TKN) by 50%, chlorides by 70%, sulphates by 65%, and chromium by up to 90%. In general, a number of tannery effluent treatment methods are used in common effluent treatment plants for examining tannery clusters often found in developing countries to remove large particles, sand/grit and grease. These methods also significantly reduce the chrome and sulphides content before the effluent is discharged into the collection tank. Physical-chemical treatment is a common method used basically for removing settleable organic and inorganic solids by sedimentation, and removal of materials that will float (scum) by skimming.

Approximately 25-50% of BOD5, 50-70% of TSS, and 65% of the oil and grease are removed during primary treatment. The effluent and sludge from primary sedimentation are referred to as primary effluent and sludge. Biological treatment is then used for the removal of biodegradable dissolved and colloidal organic matter using aerobic biological treatment (in the presence of oxygen) processes by aerobic micro-organisms that metabolize the organic matter in the wastewater, thereby producing more micro-organisms and inorganic end products (principally CO_2, NH_3, and H_2O). Advanced treatment is finally implied to reduce residual COD load and/or when specific waste water constituents are not removed by previous treatment stages. Sludge handling and disposal: Effluent treatment plants produce treated, “cleaned” effluent and sludge, because the primary aim of waste water treatment is the removal of solids and potentially hazardous substances. Furthermore, biologically degradable organic substances in waste water are converted into bacterial cells, and removed.

Conclusion-

Tannery industry uses an enormous amount of fresh water for processing of leather and other purposes and releases a huge amount of toxic effluent every day. The physico-chemical analysis of effluent reveals that the concentration of total hardness, total solids, Mg, Fe, Cr and Zn were very high, so the dilutions of tannery effluent can be used for the cultivation of selected crops species. The tannery effluent at lower doses of diluted samples showed better results in terms of seed germination, seedling growth, fresh weight, dry weight, chlorophyll content and protein content of Pennisetum typhoidis (Millet), Hordeum vulgare (Barley), Vigna mungo (Urad), Cicer arietinum (Gram) and Trigonella foenumgraecum (Methi). Full strength effluent concentration caused reduction in biomass accumulation and reproductive growth. The accumulation of metal from effluent to crop after 10 days did not follow any particular pattern and had very little or no concentration on it. The treatment W4 (25% effluent + 75% Tap water) showed a reasonable rate of germination, growth of seedlings and can be used for the cultivation of selected crop species.

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