Study of Heavy and Transition Elements in Tannery Effluents and its Impact on Soil around Kanpur, India

Dr.Nivedita Agrawal and Raviraj Singh

Abstract— Kanpur City has become a large tannery complex with nearly 450 tannery .The tannery industries are causing severe environmental pollution. Water and Soil pollution through the discharge of industrial effluents is causing severe problems. The pollutants include As, Cr, Cd, Cu, Fe, Hg, Pb and Zn, which are considered as toxicants. The presence of heavy and transition metal significantly changes the water and soil characteristics. The present studies were conducted in summer season of 2015 in 08 locations of tannery affected area Jajmau, Kanpur and it deals with the assessment of pollution due to toxic heavy metals in the industrial waste water effluents collected from Jajmau, Kanpur. The concentration level of BOD, COD, TS, TSS, magnesium, phosphate, nitrate, fluoride, phenol, oil and grease were above the permissible limit. The metals like Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn were found in significant quantities. We found the soils are highly contaminated due to tannery activity at Jajmau, Kanpur.

Index Terms—contamination, heavy metals, soil, Tannery effluents, transition metal

1 INTRODUCTION

TANNERY waste is generated in huge amounts during the process of tanning by leather industries throughout the world. It has been considered one of the most polluted industrial wastes and contains high amounts of metals which are very toxic to plants, animals and soil. Tannery wastes are of serious consequence since it has a role in pollution of fresh water
bodies, streams and land.
Tanneries, oil refineries and metal industries are causing depletion of surface and ground water quality [1]. The discharge of various sub processes of tanneries like bathing, pickling, tanning, dyeing and fat liquoring may cause water pollution severely. The pollution of a particular water body can always be link to an industry or sewage or agricultural run-off [2].

The current pattern of industrial activity alters the natural flow of materials and introduces novel chemicals into the environment. The released organic compounds and heavy metals are one of the key factors that exert negative influences on man and environment causing toxicity to plants and other forms of biotics and abiotics that are continually exposed to potentially toxic heavy metals [3]. The pollution of heavy metal ions in the environment is a critical problem because of their toxicity and other adverse effects on the receiving waters and /or soils [4]. Unlike organic pollutants which may degrade to less harmful components as a result of biological or chemical processes, metals are not degradable by natural processes especially when elemental metallic content is considered. The effects of metal pollution on local environments and organisms may therefore be substantial and long lasting in spite of extensive remediation efforts (Amiard 1995).

In the environment, Heavy metals are toxic and resist to biodegradation which are discharging pollutants from industrial wastewater. Disposal of effluents from the industries has resulted in serious contamination of numerous sites. Numerous metals such as Pb, Cr, Cu, Zn, Hg, Cd etc. have toxic effects on human's health and also non-renewable resources. Contamination of lakes and streams by the presence of heavy metals from the natural ecosystem, as pollutants adsorption onto the soil and then to lakes etc. has cause the serious problem to human health [5].
Heavy metal content of soil is of major significance in relation to their fetility and nutrient status. Many metals such as Zn, Cu and Se are essential elements for normal growth of plants and living organisms. However, defficiency or excess of these metals could lead to a number of disorders. Metals other than essential elements such as Pb or Cr, may be tolerated by the environment in low concentrations, become toxic in higher concentrations. [6].
Studies have documented that direct disposal of effluents to land and water bodies has potential to contaminate air, surface, ground water as well as soils and crops grown on these soils which will have bearing on human health [7].
Long-term disposal of tannery wastes has resulted in extensive contamination of agricultural land and water sources in many parts of India. The tannery industry mushrooming in North India has converted the Ganga River into a dumping ground. Pollution becomes acute when tanneries are concentrated in

- *Nivedita Agarwal, Pt.Shambhu Nath Shukla Government P.G.College, Shahdol, Madhya Pradesh, India, E-mail: dr_nivedita2005@rediffmail.com*
- *Raviraj Singh , Pt.Shambhu Nath Shukla Government P.G.College, Shahdol, Madhya Pradesh, India*

clusters in small area like Kanpur [8]. Chromium (Cr), a toxic heavy metal, is a major contaminant in tannery wastes, and its accumulation in soil and water is an environmental issue of increasing public concern in India. In the present study emphasis is placed on the status of metals in tannery effluents and the soil of agricultural fields irrigated with treated tannery effluents from Jajmau area of Kanpur.

2 Materials and Methods:

2.1Sampling of the tannery effluent

The tannery effluent was collected from common effluent treatment plant (CETP), Jajmau, Kanpur, U.P. (India) in sterile glass bottles and transported on ice to the laboratory and processed within 6 h of collection. The effluent was analysed for different physico-chemical properties viz. pH, temperature, BOD, COD, sulphate, phosphate and presence of different heavy metals. The concentration of each of the component was determined as per the procedure outlined in APHA [9].

2.2 Sampling of Soil:

Soil samples were collected from agricultural fields irrigated with treated tannery effluents from the Jajmau area of Kanpur in summer. Soil samples were collected in sterilised polyethylene bags with the help of a sterilised spatula. Site S1 and S2 (Jajmau) 02 Different sampling station with 500 meters distance in peundi village, Site-S3 and S4 (Jajmau) 02 different sampling station with 500 meters distance in Sekhpura village, Site-S5 and S6 (Jajmau) 02 Different sampling station with 500 meters distance in Wajidpur and 02 different sampling station with 500 meters distance near CETP Canal.

Site-S1 and S2 (Jajmau) Peundi Village
Site-S3 and S4 (Jajmau) Sekhpura Village
Site-S5 and S6 (Jajmau) Wajidpur
Site-S7 and S8 (Jajmau) Near CETP Canal

Samples were analyzed for physico-chemical properties and heavy metals concentrations. Heavy metals were determined using Atomic Absorption Spectrophotometer as described The determined parameters were Temperature, pH, TOC, PO_4, K, S, Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn.

3 Results and Discussion:

3.1 Tannery effluent's characterisation

The physico-chemical characteristics of the treated tannery effluent from CETP are shown in Table 1. The results of this study show that the wastewater of tannery process is one of the most important sources of environmental pollutants.
The concentration of Heavy and transition metals in the wastewater is extremely high. The pH of effluent was 8.1 having conductivity is 15860 moles/cm. The level of alkalinity, BOD, COD, TS, TSS, magnesium, phosphate, nitrate, fluoride, phenol, oil and grease were above the permissible limits. The Heavy metal such as As, Co, Fe, Cu, Mn, Zn, Pb, Cd and Ni were present in significant quantities. Total Cr concentrations in the tannery wastewater 5.12 mg/l, respectively, which were above the statutory limit of Indian Standards IS: 2296.

TABLE 1
PHYSICO-CHEMICAL ANALYSES OF THE TREATED TANNERY EFFLUENT.

Parameter	Result	Parameter	Result
pH	8.1	Fluoride (mg/l)	4.5
Conductivity (moles/cm)	15860	Phenol (mg/l)	8
Alkalinity	796	Oil and Grease	14
Total solid (TS; mg/l)	5056	As (mg/l)	0.10
Total dissolved solid (TDS; mg/l)	4975	Pb (mg/l)	0.07
Total soluble solid (TSS; mg/l)	281	Cd (mg/l)	1.15
DO (mg/l)	1.8	Zn (mg/l)	1.20
BOD (mg/l)	310	Pb (mg/l)	0.05
COD (mg/l)	950	Ni (mg/l)	1.00
Cl- (mg/l)	750	Cu (mg/l)	0.35
Mg (mg/l)	260	Cr (mg/l)	5.12
Phosphate (mg/l)	4.8	Co (mg/l)	0.08
Nitrate (mg/l)	14	Fe (mg/l)	3.55

3.2 Soil characterisation:

Soil polluted due to direct discharge of industrial effluents without treatment may have affected the physico-chemical and biological properties of soil . The soil samples collected from Site-1 to site -8 different locations of Jsjmau area of Kanpur and analysed for selected metals. The results of analyses are summarized in **Table 2.**
The parameters like organic matter total nitrogen, phosphorus, potassium, sulphur, and heavy metals are analysed and found that the soil around Jajmau area are highly contaminated due to tannery activity .

The pH of the test soil was from 7.2 to 8.0. In few location Polluted soil become alkaline in nature due to the continuous receiving of tannery effluents. Annual aver
age concentrations of TOC is 0.52, 0.45, 0.78, 0.30, 0.37, 0.25, 0.42 and 0.59 mg/kg in site 1 to site 8. Phosphate is found minimum 9.0 and maximum 21.6 , Potassium found minimum 210 and maximum 300 mg/kg and sulphur 14.63 to 84.58 mg/kg in different sites. The organic matter decreased due to the receiving of contaminated wastewater and its effect on the plant growth in effected area.

The heavy metals concentrations of Cd found minimum 2.1 and maximum 3.45 gm/kg, Cr found minimum 195 and maximum 435 gm/kg, Cu found minimum 10.2 and maximum 32.5 gm/kg, Fe minimum 310 and maximum 815 gm/kg, Mn found minimum 7 and maximum 28 gm/kg, Ni found minimum 5 and maximum 14.2 gm/kg, Pb found minimum 22.5 and maximum 40.2 gm/kg, and Zn found minimum 44.5 and maximum 72.5 gm/kg (Table no. 4.15). The concentration of chromium was very high in the soil as these agricultural lands are irrigated with wastewater rich in tannery effluents, which contains high concentration of chromium sulphate. Other researchers have also reported high concentrations of chromium in the same area [13].

TABLE 2
TOTAL CONCENTRATIONS OF HEAVY METAL IN SOIL SAMPLES COLLECTED FROM EIGHT DIFFERENT SITES OF JAJMAU, KANPUR

S. no.	Parameter	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6	Site-7	Site-8
1	pH	7.7	7.9	7.2	8	7.9	8.2	7.8	7.6
2	TOC	0.52	0.45	0.78	0.3	0.37	0.25	0.42	0.59
3	PO_4	19.8	18	21.6	13.5	9.9	9	10.8	20.7
4	K	270	300	220	240	210	225	235	255
5	S	35.91	39	23.94	14.63	22.61	84.58	19.95	15.96
6	Cd	2.85	2.45	2.1	3.1	3.45	2.86	2.65	3.35
7	Cr	325	195	215	265	235	270	435	380
8	Cu	10.2	15.35	28.6	18.5	12.1	32.5	18.8	10.5
9	Fe	310	415	325	515	420	815	630	520
10	Mn	7	8.6	18	17.5	25	28	13	15
11	Ni	5	10.2	12.5	14.2	8.5	7.6	6.8	8.5
12	Pb	24.5	32.5	28.2	32.5	22.5	40.2	26.5	25.2
13	Zn	44.5	56.2	72.5	68.2	62.5	58.21	70	62

ALL VALUES ARE IN MG/KG EXCEPT PH

An investigation has been made by Deepali and Gangwar [14] to ascertain the metals concentration in the effluents and associated soil and groundwater samples collected from textile and tannery industries located near Haridwar. The results showed that all metals such as Cr, Fe, Mn, Cu, Pb and Cd exceeded the standard limits in effluents of textile and tannery industries and associated soil samples, while Cr contamination in groundwater samples was observed only in samples collected from nearby areas of tannery. The findings also indicate that the Cr contamination was more than other metals. Agricultural fields in the Jajmau area, Kanpur have been receiving industrial wastewater rich in tannery effluent for a long time. For this reason, they are contaminated with different types of heavy metals.

When the polluted water is used for irrigation it is evaporated and leaves salts cakes on the surface, it finally spoil the texture of soil. Salts with poor internal drainage facilities are mainly responsible for accumulation of salt in the root zone. Mining, manufacturing, and the use of synthetic products (e.g. pesticides, paints, batteries, industrial waste, and land application of industrial or domestic sludge) can result in heavy metal contamination of urban and agricultural soils. Heavy metals also occur naturally, but rarely at toxic levels. Potentially contaminated soils may occur at old landfill sites (particularly those that accepted industrial wastes Excess heavy metal accumulation in soils is toxic to humans and other animals. Exposure to heavy metals is normally chronic (exposure over a longer period of time), due to food chain transfer. Acute (immediate) poisoning from heavy metals is rare through ingestion or dermal contact, but is possible.

Once metals are introduced and contaminate the environment, they will remain. Metals do not degrade like carbon-based (organic) molecules. The only exceptions are mercury and selenium, which can be transformed and volatilized by microorganisms. However, in general it is very difficult to eliminate metals from the environment [15].

4 Conclusion

The results reveal that the soils of the study area is extremely contaminated due to receiving of hazarduous industrial wastes through many years. The high concentration of heavy metals in treated tannery effluent and the associated soil is alarming and require immediate remediation to minimize the future pollution problems.

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