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Research Article

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Physico-Chemical Characterization of Electroplating Industrial Effluents of Chandigarh and Haryana Region

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Abstract

The present study deals with one of India's major concerns is the increasing level of land pollution largely due to the uncontrolled disposal of industrial solid and hazardous waste. The present work carried out on monitoring of various physico-chemical parameters and to evaluate the impact of disposal of electroplating industrial effluent on water quality in Chandigarh and nine districts of Haryana. The various parameters like pH, temperature, Electrical Conductivity (Ec), Total Suspended Solids (TSS), Total Dissolved Solid (TDS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), sulphate, oil and grease, phosphate along with heavy metals viz. chromium, zinc, lead, nickel, cadmium, copper, were tested from effluent treatment plant (ETP) of plating industries. Further, the effects of these constituents on land, groundwater, and surface water bodies were correlated. The results observed from samples indicated that the heavy metal concentrations of chromium from 21.5 to 47 ppm, nickel from 72 to 243 ppm, lead from 5.3 to 9.7 ppm, zinc from 97 to 731 ppm and copper from 8.4 to 20.7 ppm in effluents in Haryana needs a proper preventive mechanism for sludge treatment, recovery and disposal.

Keywords: Contamination; Electroplating effluent; Hazardous waste; Heavy metals

Introduction

Environmental pollution with metal perhaps begins with the discovery of fire and gradually aggravated to its present alarming level with industrial development and advancement of society. Rapid urbanization and industrialization has led to increased disposal of heavy metals radio nucleotide into the environment [1]. A remarkable increase in use of heavy metals over the past few decades has inevitably redacted in an increased flux of metallic substance concern because of their known accumulation in the food chain and resistance in nature [2,3]. Electroplating process involves pretreatment and other preparation, plating, rinsing, passivating and drying. The cleaning and pretreatments stages involve a variety of solvents and surface stripping agents, including caustic soda and a range of strong acids, depending on the metal surface to be plated [4]. In the plating process, the object to be plated is usually used as the cathode in an electrolytic bath [5]. Plating solutions are acid or alkaline and may contain complexing agents such as cyanides. The mixing of cyanide and acidic wastewater can generate lethal hydrogen cyanide gas [6]. Heavy metals such as nickel, copper, zinc chromium, lead, cadmium in wastewater are hazardous to the environment are generated from electroplating industrial effluents, cool burning industries, refining, insecticides, fungicides, iron and steel producing industries [7,8]. The solvent and vapors from hot plating bath results in elevated levels of volatile organic compounds (VOC's) and, in some cases, volatile metal compounds, which may contain chromates or metallic ions [9]. Approximately 30% of the solvent and degreasing chemicals used can be released as VOC's [10,11]. Air emissions may contain toxic organics such as trichloroethylene and trichloroethane. Cleaning or changing of process tanks and treatment of wastewater can generate substantial quantity of wet sludge containing high levels of toxic organics or metals. The limited values given by WHO are as under chromium is 0.1 mg/L, nickel is 0.1 mg/L and zinc is 5-15 mg/L in drinking water [8,12]. According to IS: 2296-1974 the maximum permissible limit of copper in inland surface water used for public water supply and bathing is 10 mg/L and according to IS: 3306 1976 and IS: 7968-1976, tolerance limit of copper for industrial effluent discharge is 3.0 mg/L [11,13]. The electroplating industries are normally focused in this study. The Indian standards for chromium (0.05 mg/L) and zinc (5.0 mg/L) in drinking water are Indian standard: 10500-1991 [2,13,14]. According to MINAS standards for nickel is 3.0 mg/L, zinc is 5.0 mg/L and chromium is 0.1 mg/L in electroplating waste. Various methods employed for removal of heavy metals from effluent such as physicochemical, precipitation of metals as hydroxide, carbonates and sulphides, adsorption on the activated carbon, use of ion exchange resins and membrane separation processes are encountered with certain major disadvantages such as high energy requirements, incomplete metal removal, and generation of a large quantities of toxic waste sludge, which necessitates careful disposal in further steps [10,11,13]. Therefore, in present work the effluent samples were collected from effluent treatment plant (ETP) of electroplating industries of Haryana and Chandigarh. Further the characterization of probable parameters including heavy metals investigating and compared with the Indian standard and USEPA standards.

Methodology

The various effluent parameters from electroplating industries require to be monitored for safe disposal of treated effluent. The effluent samples from outlet of effluent treatment plant (ETP) of electroplating industries were collected and stored at 4°C in laboratory. The samples were collected a portion of material small enough in volume to be conveniently transported to a non-reactive bottle for the estimation. This implies, firstly, that the relative portions of the concentrations of all pertinent components must be the same in the sample as in the material being sampled and secondly, that the sample must be handled in such a way that no significant changes in composition occurs before the tests are performed. The various effluent parameters such as pH, E_c, temperature, total suspended solids (TSS), total dissolved

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solids (TDS), chemical oxygen demand, biochemical oxygen demand, phosphate, sulphate and heavy metals were tested as per the standard method [12]. pH and E_c were estimated by the digital pH meter and electrical conductivity meter. TDS and TSS were measured by the oven method. Phosphate and sulphate were estimated by spectrophotometric method and gravimetric method respectively. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of effluent were analyzed by the five day BOD bottle method and titration methods, respectively. The heavy metals analysis such as chromium, zinc, lead, nickel, cadmium, copper, also investigated to evaluate metals concentrations in the effluent and was analyzed using atomic absorption spectrophotometer (AAS). Effluent was characterized using AR grade chemicals as per standard method [12]. Table 1 shows the composition of various tested chemicals from electroplating industry.

Results and Discussion

This study deals with monitoring of various physico-chemical parameters and to evaluate the effect of the disposal of electroplating industrial effluent on water quality in Haryana and Chandigarh. During sampling 9 districts of Haryana and Union territory (Chandigarh) were chosen because these districts have large number of electroplating industries. Wastewater samples were collected in pre-acid clean plastic containers from the selected locations. Three samples were taken from each location [15,16]. Samples were stored with all due precautions in laboratory before estimation. The studied parameters are pH, temperature, E_c, TSS, TDS, COD, BOD, Cr, Cu, Zn, Ni, Pb, Cd, oil and grease, sulphate and phosphate. Table 1 represents the composition of electroplating industrial effluents from different locations of Haryana and Chandigarh (Figure 1).

Parameters	Faridabad	Gurgaon	Yamunanagar	Karnal	Chandigarh	Jagadhri	Panchkula	Panipat	Ambala	Sirsa
pH	2.2	3.2	2.8	2.5	3.8	2.9	3.2	2.8	3.2	2.6
Temperature	24	26	25	26	24	25	25	26	23	18
E_c	1680	1238	1254	1366	1385	1250	1283	1272	1315	1241
TSS	675	1495	1122	968	1277	1440	1107	1267	1011	1299
TDS	360	623	360	344	316	447	452	356	343	392
COD	473	560	496	520	371	458	561	530	571	506
BOD	64	96	90	102	101	100	93	101	97	95
Oil & Grease	20.1	20	20.6	19.6	19.8	19.7	19.7	17.8	22.5	22.6
Sulphate	380	387	347	390	313	286	337	300	248	325
Phosphate	3.5	0.6	1.1	1.5	1.2	0.78	0.77	0.8	1.18	1.1
Chromium	35	34	35	34.4	29	27.3	47	33	28	21.5
Copper	16.6	8.4	13.8	20.7	18	16.2	12	16.9	13	11.9
Zinc	191.6	190	200	158	118	731	331	210	97	160
Nickel	93.16	72	90	96	99	215	205	194	243	208
Lead	7.5	9.7	7.7	6.1	6.6	6.6	5.3	5.9	7.7	8.3
Cadmium	7.4	6.4	7.8	6.7	8	6.2	8.2	10.3	11.9	6.1
All values are in ppm except pH (range), temperature (°C), electrical conductivity (mS/m)										

Table 1: Characterization of electroplating industry effluents from Chandigarh and Haryana.

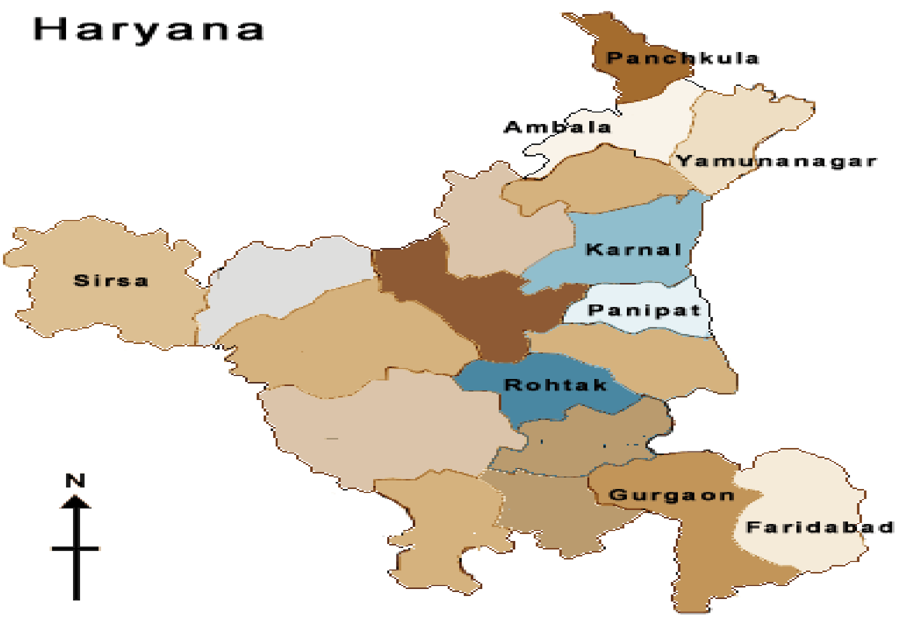

Figure 1: Map shows the various locations of sample taken from different district of Haryana.

pH, electrical conductivity, total dissolved solids and chemical oxygen demand

Figure 2 (part A) shows variation in pH of effluents of all the districts of Haryana varies from 2.2 to 3.8. The minimum pH value 2.2 that is of industry situated in district Faridabad shows high acidic condition of wastewater. pH is a simple parameter, but it is extremely important, as most chemical reactions in aquatic environments are controlled by any change in its value. Aquatic organisms are sensitive towards pH changes, and biological treatment requires pH control before treatment. Further, the toxicity of heavy metals is also influenced by change in pH values [17]. pH therefore affects the quality of wastewater, and any value higher or lower than 6.5-8.5 limit could be harmful to the environment as per World Health Organization [18].

This is because of using high concentration of acid in the process of cleaning and residual water is drained out. In case of Chandigarh electroplating industry shows pH 3.8 which is also in acidic nature. The permissible limit of pH of the discharge of electroplating industrial effluent in the range of 7 to 10. High acidic condition increases the tendency to leach the heavy metal, which are toxic to living being and contaminate the groundwater and soil. The temperature of wastewater varied in the range from 18°C to 28°C. The permissible limits shall not exceed 40°C in any sector of stream within 15 meter down streams. It ranges from 18°C to 26°C. Further, electrical conductivity (Figure 2C) were examined and samples ranged from 1228 mS to 1680 mS were found. The range of total dissolved solids of effluent sample varies from 343 to 623 mg/L and shown in Figure 2C. Maximum TDS 950 mg/L was observed in sample taken from district Gurgaon. The minimum value observed in Ambala and maximum value of TDS observed in Gurgaon and Chandigarh 316. The value of COD varies from 371 to 571 mg/L and given in Figure 2D and in Chandigarh the concentration is around is 371 mg/L. The minimum value of COD was observed in wastewater of Chandigarh electroplating industries and maximum value observed in Ambala. The prescribed standard of COD is 250 mg/L in case of industries. The earlier studies also indicated the COD and BOD in metal contaminated industrial effluents [19].

Total suspended solids, biochemical oxygen demand, chromium and phosphate

Figures 3A-3D represents the variations in the total suspended solid, biochemical oxygen demand, chromium and phosphate. Total suspended solids were represents the variations in the range of entire samples were between 675 to 1495 mg/L. The permissible limits of TSS are 25 mg/L as per the Indian standards. Minimum value of TSS observed in Faridabad district and maximum value observed in Gurgaon districts Chandigarh ranges at 1277 mg/L. Authors [20,21] investigation on nickel based electroplating industry shows higher amounts of suspended solids. Higher amount of suspended solids may elevate the density and turbidity of water, which in turn may affect the osmoregulation and also interfere with the photosynthesis [20]. Total suspended solids when exceeding the limits are aesthetically unsatisfactory and may cause distress among human beings and livestock [21].

Biochemical oxygen demand is the most widely used parameter of organic pollution applied to both wastewater and surface water is 5 day BOD bottle test. This determination involves the measurement of dissolved oxygen used by microorganism in biochemical oxidation of organic matter for 5 days. The widely recommended limits of BOD are 30 ppm. The value of BOD varies from 64 to 102 mg/L. Maximum value of BOD was observed in Karnal is 120 mg/L and minimum in the

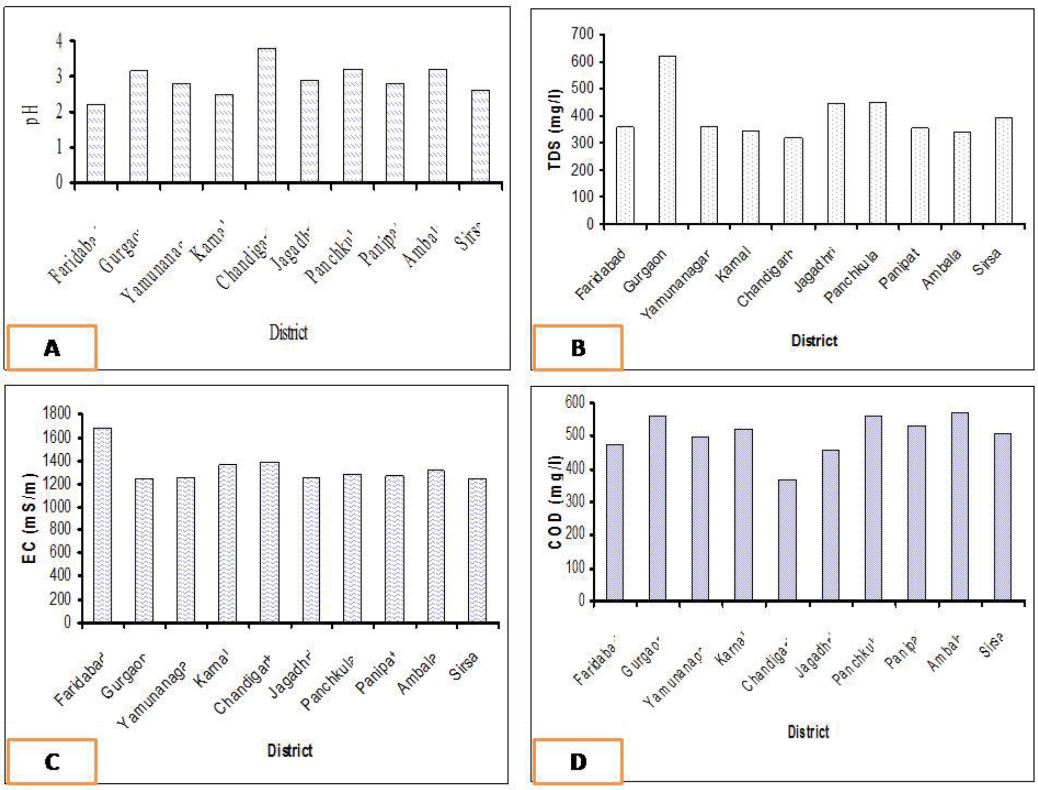

Figure 2: Characterization of electroplating effluents from different district of Haryana and Chandigarh (A). pH (B). TDS (C). E_c (D). COD.

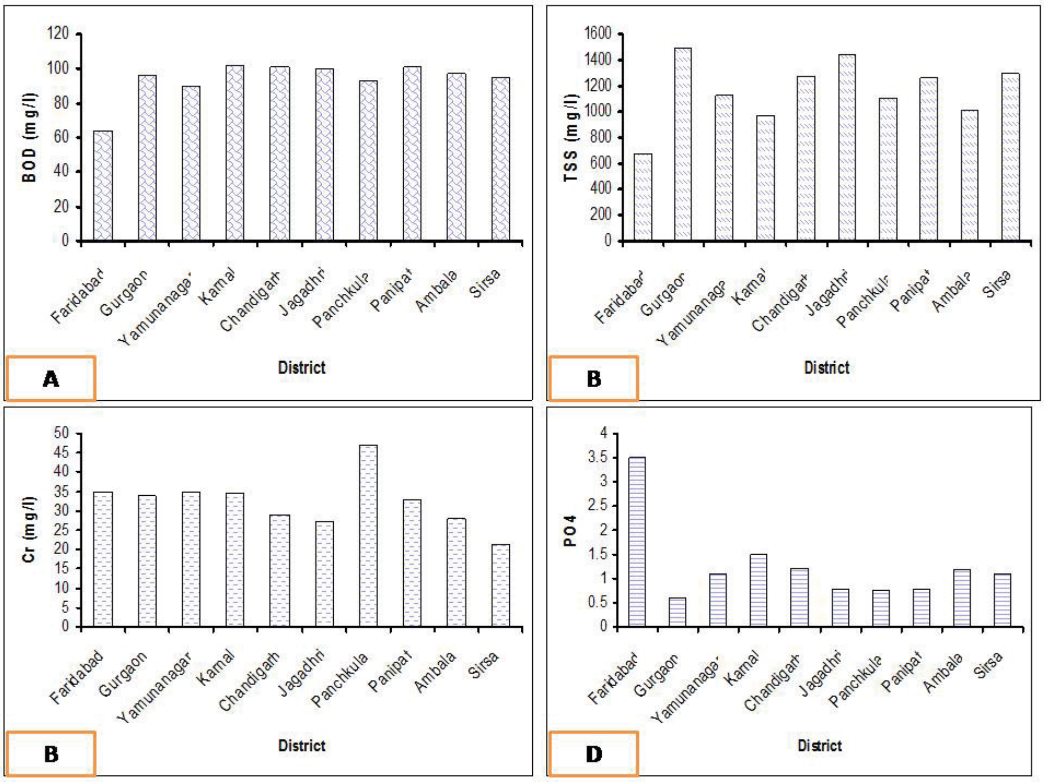

Figure 3: Characterization of electroplating effluents from different district of Haryana and Chandigarh (A). BOD (B). TSS (C). Chromium (D). Phosphate.

district Faridabad. Chromium is present in the effluents primary in the form of its trivalent chromium (III) and hexavalent chromium (VI), plays a vital role in insulin metabolism as the glucose tolerance factor (GTF). Supplementation of chromium (III) has improved the glucose tolerance in diabetes, malnourished children and elder people. The value of chromium varies from 21.5 to 47 mg/L. The Indian standard recommends 0.05 mg/L of chromium in drinking water. One study reveals that the heavy metals are generated in effluents of tannery industry and their toxic effects are very well established [21]. Further, the phosphate parameters the acceptable limits of phosphate are 5 mg/L. The range of sample varies from 0.6 to 3.5 mg/L. The maximum concentration of phosphate in Faridabad and minimum in Gurgaon was observed.

Concentration of heavy metals, oil and grease and sulphate

The heavy metals such as copper, zinc, lead and cadmium were analyzed by the atomic absorption spectrophotometer in collected samples. The concentration of various parameters measured in different industries across Haryana and Chandigarh shown in Figure 4. The range of copper as heavy metal across the Haryana varies from 8.4 to 20.7 mg/L. The maximum value observed in district Karnal whereas and minimum observed in Gurgaon. Chandigarh region electroplating unit has copper value is 18 mg/L.

The maximum value of zinc observed in Jagadhri and minimum in districts of Ambala. The range of zinc varies across the Haryana is 97 to 731 mg/L. The acceptable limit is 5 mg/L. Samples collected from Chandigarh region shows zinc level 118 mg/L. Lead cause serious damage to the nervous system and the brains of unborn children. The range of lead varies from 5.3 to 9.7 mg/L. Maximum concentration of lead in Gurgaon district and minimum concentration of lead in Panchkula district. Chandigarh unit have observed ranges 6.6 mg/L. The acceptable limit is 0.2 mg/L. Figure 5 shows the variation in cadmium, nickel, oil and grease and sulphate etc. The concentrations of cadmium were observed in the range of 6.1 to 10.3 mg/L. The maximum concentration of cadmium was observed in district Panipat and minimum in Sirsa. The acceptable limit of cadmium is 0.1 mg/L. The heavy metal such as nickel was observed in the range of 68 to 291 mg/L in the district of Haryana. Maximum value was observed in district Ambala while minimum in district Gurgaon. The acceptable limit is 2 mg/L. The oil and grease concentration of maximum value of oil and grease observed in Ambala i.e. 26.5 mg/L, and minimum in Chandigarh i.e., 17 mg/L. The acceptable limits of oil and grease are 10 mg/L. The acceptable limit of sulphate is 500 mg/L. The range of sulphate in varies from 24.8 to 390 mg/L minimum range at Ambala and maximum at Karnal and Chandigarh at 313 mg/L.

Comparison of pollutants with standard

Table 2 shows the comparison of various contaminants present in the effluent with standards prescribed by the government agency. One can observe that pH, TDS, TSS, oil and grease, COD, BOD and phosphate was found to higher than prescribed standards. However, heavy metals like Cu, Cr, Ni, Pb, Zn and Cd were also present in higher concentration and these metals are very much toxic for our environment. Thus, the electroplating effluents are very much polluting and require proper treatment before disposal into environment. The major objectives of pollutant removal of metals from aqueous solutions are (a) toxicity removal, which entails an environmental aspect and (b) recovery of valuable metals, which involves a technological aspect. Various methods including the conventional ones are available for heavy metal waste management. The commonly used conventional

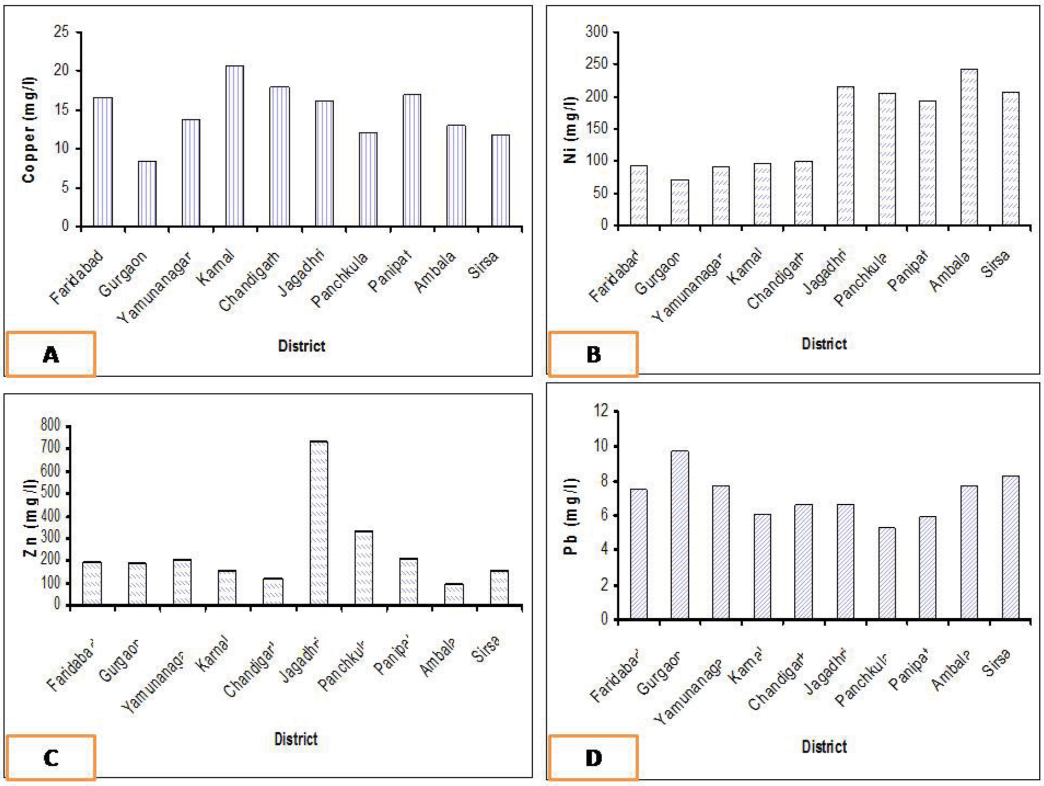

Figure 4: Heavy metals concentration in different parts of Haryana and Chandigarh (A). Copper (B). Nickel (C). Zinc (D). Lead.

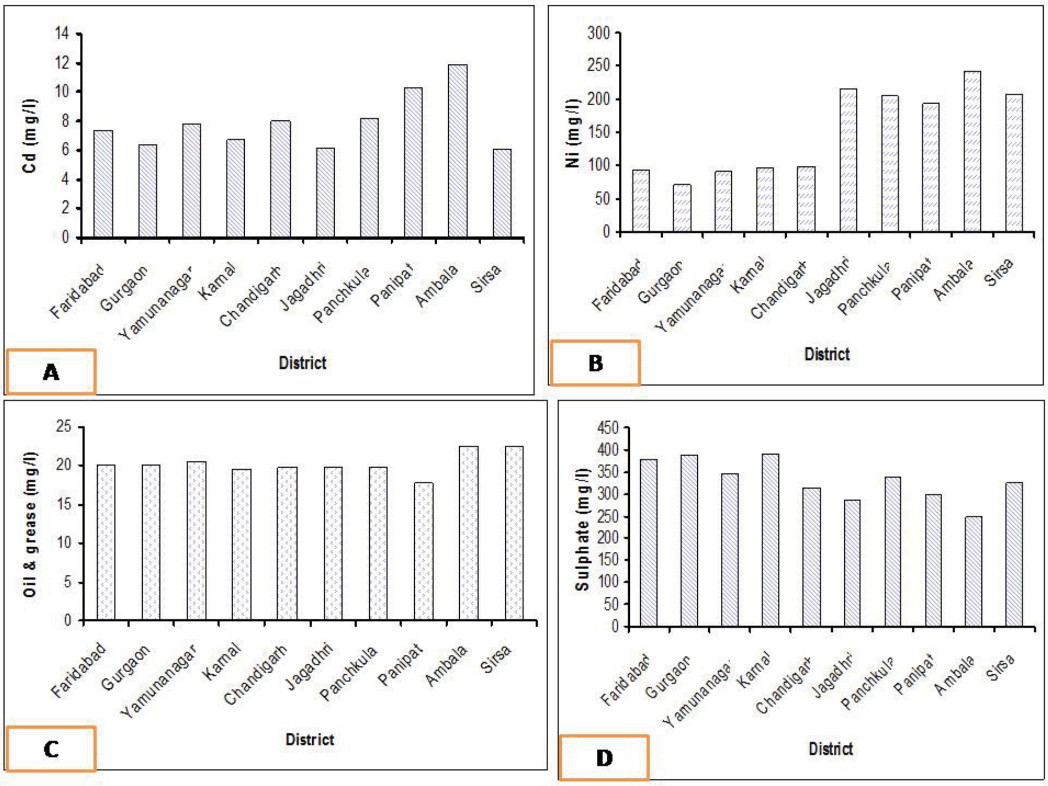

Figure 5: The estimation of various parameters of electroplating effluents from different district of Haryana and Chandigarh (A). Cadmium (B). Nickel (C).Oil and Grease (D). Sulphate.

S. No.	Parameters	Range	Standard
1.	pH	2.2 -3.8	6.5-8.5
2.	Temperature	18-26	<40
3.	TSS	675-1495	20
4.	TDS	316-623	500
5	COD	371-571	250
6.	BOD	64-102	30
7.	Oil & Grease	17-23	10
8.	Sulphate	248-390	500
9.	Phosphate	0.6-3.5	5
10.	Chromium	21-47	0.05
11.	Copper	8-21	0.5
12.	Zinc	100-200	5
13.	Nickel	72-243	2
14.	Lead	10-May	0.2
15.	Cadmium	12-Jun	0.1
All values expressed in mg/L, except pH, temperature (°C)			

Table 2: Comparison of various pollutants with the standard.

methods include precipitation, ion exchange, adsorption, reverse osmosis, electrodialysis, evaporation, foam floatation, liquid membrane techniques, solvent extraction and crystallization etc. for heavy metal removal. Various techniques used for metal removal recovery are listed. However, the major shortcoming of the conventional treatment includes (a) Low efficiency at low concentration of heavy metals and, (b) Expensive handling and safe disposal of toxic sludge.

Conclusion

The conditions based on detailed analysis of effluent characteristics from Haryana region and Chandigarh electroplating industries has been studied. The various parameters present in effluents have been correlated with the prescribed standards. It was observed that maximum parameters have been found higher concentrations than the limits prescribed as per government standards. The wastes generated from electroplating industries are identified as hazardous solid and toxic waste. On comparison of heavy metals with standards it was reported that the concentration is very high and is these are very toxic even at low concentration. Since, the leachability of heavy metals such as chromium, nickel, cobalt, iron and copper in effluent also requires proper management including waste minimization, metal recovery, bioremediation using the suitable biosorbants and safe disposal.

Care should be taken for handling such type of effluents in electroplating and metal pickling industries for avoiding contamination of soil and groundwater nearby industry.

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