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ANALYSIS OF ELECTROPLATING INDUSTRIAL EFFLUENT WITH REFERENCE TO CHROMIUM COMPOSITION

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ABSTRACT

Heavy metal pollution of soil and wastewater is an important environmental issue. The industries like tannery and electroplating are the main source of chromium pollution in India. They are required to comply with the regulations of the Central Pollution Control Boards and concerned State Pollution Control Boards. Thus, our present study contributes towards physicochemical studies and analysis of chromium content using Atomic Absorption Spectrophotometry (AAS) in the effluent released by electroplating industries in 4 different seasons specified by met office of a year to help in the understanding of pollution effects. Study reveals that the effluents from these industries contain Cr (VI) at concentrations ranging from tens to hundreds to thousands of mg/l and unfavorable levels of TSS, TDS, BOD and COD. There are standard values set by Pollution control Board for industrial effluent to be discharged on different types of land. Industrial effluent quality exceeding these specifications is thus harmful. It may cause biochemical effects, such as inhibition of enzymes, metabolic disorders, genetic damage, hypertension and cancer. Microbial load was also studied by enrichment technique which can further be applied for study of potential remediation of chromium.

Key words: Atomic Absorption Spectrophotometry, chromium, Electroplating Industries, Industrial effluent, Pollution.

INTRODUCTION

Heavy metal chromium is one among the top metal pollutant. The sources of chromium pollution include effluents from leather tanning, chromium electroplating industries. These industries in India are required to comply with the regulations of the Central Pollution Control Boards and concerned State Pollution Control Boards. Using government subsidies, the industries have built numerous Common Effluent Treatment Plants (CETPs) to treat the toxic wastewater or effluent. Despite this effort, many of the pollution problems are still exist. Several analyses studies have revealed high concentrations of chromium even in so called treated effluents. The majority of chemicals discharged eventually end up in sediments that may act as major source of pollution. Sediments are ecologically important components of the aquatic habitat.

The other major issue being, entering into ground water there after contaminating the drinking water. As the world progress with industries, the pollution of the environment with toxic heavy metals is spreading all way through. Petrochemical industries, mining activities, agricultural run off, industrial and domestic effluents are mainly responsible for the increase of the xenobiotic especially metallic species released into the environment. Improper disposal of hazardous and toxic wastes can cause serious damage to both health and environment. Recalcitrant or Xenobiotics are man made compounds that are of major concern. In contrast to toxic organics, that can be degraded, the metallic species released into the environment tend to persist indefinitely, thereby accumulating in living tissues throughout the food chain. Heavy metal pollution of soil and wastewater is a an important environmental issue (Cheng, 2003).Wastewaters from the industries and sewage sludge applications have permanent toxic effects to human aswell the environment (Rehman et al., 2008).The effluent released from electroplating industries contains higher concentration of total dissolved solids, phenols, chlorides, chromium and other heavy metals, etc. Heavy metal chromium is one among the top 5 metal pollutant. Heavy metal chromium is the second most common contaminant of ground water at hazardous waste sites. Major sources of chromium pollution include effluents from leather tanning, chromium electroplating, wood preservation, alloy preparation and nuclear wastes due to its use as a corrosion inhibitor in nuclear power plants (Thacker, U, et.al, 2006). Chromium can exist in multiple valence states, Hexavalent chromium Cr (VI) and trivalent chromium Cr (III) are the most prevalent species of chromium in the natural environment (Cantle, J. E, 1982). Trivalent Cr is ubiquitous in the environment and occurs naturally, while almost all known sources of Cr (VI) are derived from human activities. Trivalent Cr found in the environment is typically found as insoluble crystalline or para crystalline compounds such as $Cr(OH)_3$, and Cr_2O_3 .In contrast, Cr (VI) is highly mobile and is considered acutely toxic, although its occurrence is rare in nature. Chromium has been recognized as an essential microelement for animals and humans, potentiating the action of insulin and therefore being effective in carbohydrate and lipid metabolism (Ducros, 1997). On the other hand, recent works point to the severe toxicity of Cr (VI), with respect to human health. Indeed, hexavalent chromium is known to be a skin irritant and to induce allergic contact dermatitis and is considered a class 'A' human carcinogen by inhalation (James et al., 1997). The reduced form, Cr (III), is considered to have low acute and chronic toxicity, mostly because of the demonstrated low capacity to penetrate animal cells.

Many metals accumulate to high concentration in the surface layer of soils irrigated with sewage sludge of sewage/industrial effluents. World health organization recommended the maximum allowable concentration of 0.05mg/L in drinking water for chromium VI. It is same with Indian Standard Institution. With reference to Central pollution control board, the allowable chromium concentration in effluents is 2.0-5.0 mg/L.

With reference to the updated official list of registered factories of 2008 under Karnataka state factories act obtained from the office of dept of boilers and factories, Karmika Bhavana, Bangalore, Industries such as electroplating and tanneries in India are required to comply with the regulations of the Central Pollution Control Boards and concerned State Pollution Control Boards. Using government subsidies, the industries have built numerous Common Effluent Treatment Plants (CETPs) to treat the toxic wastewater or effluent. Despite this initiative, many of the pollution problems are still unresolved. The major components of the electroplating effluents are the toxic trace metal that is chromium. Several analyses reveal high concentrations of chromium even in so called treated effluents. The majority of chemicals discharged through the effluent into aquatic system eventually end up in sediments that may act as major source of pollution. Thus, study of effluent released by industries and the sediment helps in the understanding of pollution effects.

MATERIALS AND METHODS

Sampling location

Sampling area is in Bangalore which is located at a lat. of 12 º 58´ N and longitude of 77 º 35´ E at an altitude of 921 m above mean sea level (Shivashankara, 1999). Sampling area identified is the Peenya industrial complex established in early 1970's is the biggest and one of the oldest industrial estates in the whole of Southeast Asia, located at the northern part of the Bangalore city, Karnataka, India **(Fig 1)**. The area spread over 40 sq kms comprising about 4000 small scale industries and few medium scale industries is one of the biggest industrial areas in the country as well as in Southeast Asia. Peenya industrial area hosts maximum industries, majority of them are electroplating industries. 52 registered factories of electroplating industries are considered for study.

Sample collection

Based on the number of employees, they have been categorized into 3 groups <50, >50 and >100. 10% of each category will all together make up to 5 no's. Hence 5 factories are selected. With respect to 4 seasons of a year 2010 obtained from met office, Bangalore [Winter season (Jan-Feb), Pre monsoon (Mar-May), Southwest monsoon (June-Sep), Northwest monsoon (Oct-Dec)], Sampling was carried out for one year that is in Jan, April, July and Nov 2010, covering all the four seasons. Hence a total of 4 seasonal samples from 5 industries i.e. 20 samples in triplicates were collected and analyzed for chromium concentration using Atomic absorption Spectrophotometry.

The effluent samples of around 1000ml volume from outlets of electroplating industries were collected in autoclaved linear polyethylene containers of 1L capacity with polyethylene cap, labeled properly. 100ml of the samples were preserved immediately by acidifying with conc. Nitric acid (1.5ml Conc. /L sample) and stored at 4˚ C for further analysis.

Sample analysis

Physico-chemical analysis of effluents:

The physiochemical characteristics of effluents like color, odor, pH, Total Suspended Solids, Total Dissolved Solids, BOD and COD values were immediately measured in the laboratory (Standard methods for the examination of water and waste water, APHA, 2005).

Chromium analysis

The other analysis is heavy metal chromium analysis by AAS for which digestion with nitric acid is the preliminary step. Around 50 ml volumes of the effluent samples in evaporating dishes were taken and acidified with conc. Nitric acid. Further 5 ml of conc. Nitric acid was added and evaporated to 10 ml. Then it was transferred to a 125ml conical flask. 5ml of conc. nitric acid and 10ml $HClO_4$ (70%), per chloric acid (70%) were added and heated gently till white dense fumes of $HClO_4$ appear. The digested samples were cooled at room temp, filtered through whatman no.41 or sintered glass crucible and finally the volume was made upto 100ml with distilled water. Then this solution was further boiled to remove oxides of N and Cl. The solution was then used for the analysis of chromium heavy metal using AAS by flame using air acetylene gas (Cantle, J. E., 1982). The next step is Analysis of chromium by Atomic Absorption Spectrophotometry**;** Atomic absorption spectrophotometer provides accurate quantitative analyses for metals in water, sediments, soils or rocks. Atomic absorption units have 4 basic parts: Interchangeable lamps that emit light with element, specific wavelengths, sample aspirators, aflame or furnace apparatus for volatizing the sample and a photon detector. In order to analyze any metal, a halo cathode lamp is chosen that produces a wavelength of light that is absorbed by the element. Sample solutions are aspirated into the flame. If any ions of the given element are present in the flame, they will absorb light produced by the lamp and then reaches the detector. The amount of light absorbed depends on the concentration of the element or metal present in the sample. Absorbance values for unknown samples are compared to calibration curves prepared by analyzing known samples. The atomic absorption spectrophotometer (chemito AA201), with glass flow meters with the operating parameters and working range is given in **Table 1**.

Bacteriological analysis

Luria Bertani broth and agar supplemented with chromium concentration of 100 ppm using potassium dichromate was used for enrichment of the microbes, samples were inoculated into broth first and incubated at 30 deg C overnight and then spread plated on to LB agar plates which were further incubated at 30 deg C for 48 hours and the colonies were counted .The pure cultures of isolated strains were preserved by refrigerating LB agar slants as well glycerol stocks at 4 deg C and coded as PES 1- PES 10 for further use.

RESULTS AND DISCUSSION

Physico-chemical analysis of effluents

In Effluent analysis, the Physico-chemical characterization of effluents was done and is presented in **Table 2**. Effluent color is white to grades of yellow and odorless. pH is between 3-9, these values are compared to ISI (Indian Standard Institution) standards recommended for disposal of effluent on land and are found not suitable to irrigation purpose. Total suspended solids ranged between 20-200, Total dissolved solids values being 520-5800, BOD (Biological Oxygen Demand) value is between 16-90; COD (Chemical Oxygen Demand) value lies between 91-831.

Chromium analysis

Heavy metal chromium analysis by AAS was performed. In the present study, chromium concentration was analyzed in the industrial effluent season wise using Atomic absorption Spectrophotometry (Chemito AA201) and is plotted in **graph 1**. It was found that there is considerably low or BDL (Below detection level) in industry B, while the chromium concentration was high in Industry A, C, E and D with reference to all the 4 seasons. The concentration of chromium was quite high which varied between 239 to 3156 ppm in industry D and C and moderate in Industry A and E which varied between 50.5 to 585.6 ppm. It is interesting to note that the Cr concentration is all time high during winter season and low during southwest monsoon among the five industries.

Bacteriological analysis

Ten different forms of the colonies were identified based on colony characterization from 20 effluent samples. 7 of them were Gram positive and 3 of them are Gram negative. Gram positive were mostly of the form bacilli and few were cocci, where as all Gram negative were bacilli. The same is recorded in **graph 2**.

CONCLUSION

Industrialization means more effluent release into the environment. It becomes mandatory on part of the industry to release the effluent treated by Physical, chemical or biological treatment. However, such treatment systems are not effective for removal of color, dissolved solids; trace elements etc. and thus the effluents are directly discharged into drains, public sewers, rivers, etc. Thus effluents containing heavy metals when released into the agricultural land for irrigation purpose, the heavy metal gets accumulated in soil and it in turn is available to plants and gets into plant material and then the food chain follows then to humans and thus become hazardous to human health. Overall findings indicated that industrial effluents of the major industrial areas of Bangalore city have elevated levels of chromium and the data also reveals that most of these industries are discharging heavy metals above specified limit. The result indicates that effluents contain toxic metals in a relatively high composition, thereby polluting nearby soil and groundwater. Hence it is suggested that the industries should give importance to release of effluent with prior treatment with reference to the standards. The microbial load can further be applied for study of potential remediation of chromium.

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REFERENCES

1. Athena Linos (2011). Oral ingestion of hexavalent chromium through drinking water and cancer mortality in an industrial area of Greece – An ecological study. p 10- 12
2. Cheng, S. (2003): Heavy metal pollution in China: origin, pattern and control. Environmental Sciences and Pollution Research **10**, 192-198.
3. Clesceri, L.S., A. E. Greenberg , E. W. Rice and A. D. Easton., 21st edition 2005. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Washington, DC. p. 3-59.
4. Cantle, J. E. (ed.). 1982. Atomic Absorption Spectroscopy. Elsevier Scientific Publishing Co., New York. p. 48.
5. Chung, J. Nerenberg, R. and Rittmann, B.E. (2006): Bio-reduction of soluble chromate using a hydrogenbased membrane bioflim reactor. Water Research **40**, 1634-1642
6. Anne spain, 2003, Implications of microbial heavy metal tolerance in the environment. Reviews in undergraduate research (**2**):1-6.
7. E.Nkegbe and I.Koorapetse., 2005. Heavy metal compositions in Gaborone industrial effluent. Journal of applied sciences, Vol **5 (8):**1418-1419.
8. Fendorf, S., B. W. Wielinga and C. M. Hansel. 2000. Chromium transformations in natural environments: The role of biological and abiological processes in chromium (VI) reduction. Int. Geol. Rev**. 42**: 691-701.
9. K.Sundar and N.Chandrasekaran, 2010.Seasonal variations in the chromium concentration and chromium resistant bacterial populations in Vellore district, Research journal of applied sciences, Engineering and technology **2(4);** 378-380.
10. Mallavarapu Megharaj, B Ramakrishnan, Kadiyala Venkateswarlu, Nambrattil Sethunathan, Ravi Naidu, Bioremediation Approaches for Organic Polllutants: A crtitical prospective, Environment International vol. **3**, p 1362- 1364.
11. Metallic Chromium, Health Council of the Netherlands, 2011 p 8 – 13.
12. N.Ahalya, T.V. Ramachandra and R.D.Kanamadi., (2003) Biosorption of heavy metals. Research journal of chemistry and environment.vol **7(4).**
13. O.P.Shukla, U.N.Rai, N.K.Singh, Smita Dubwey and V.S.Baghel (2007). Isolation and characterization of chromate resistant bacteria from tannery effluent. Journal of environmental science, vol **28**(2), 399-403.
14. Rehman, A Zahoor, A. Muneer, B. and Hasnain, S. (2008): Chromium tolerance and reduction potential of a Bacillus sp.ev3 isolated from metal contaminated wastewater. Bulletin of Environmental and Contamination Toxicology **81**, 25-29.
15. R. Cornelis, J. Caruso, H. Crews and K. Heumann (Eds.), Handbook of Elemental speciation: Techniques and Methodology, John Wiley and Sons Ltd, England (2003).
16. Slavin, M. 1978. Atomic Absorption Spectroscopy. John Wiley and Sons, New York. p.9-14.
17. Smith, S.R. Agricultural recycling of sewage sludge and the environment, CAB International, Wallingford, UK (2006), pp 119 – 151.
18. Thompson, K. C. and B. J. Reynolds. 1978. Atomic Absorption, Fluorescence and Flame Emission Spectroscopy, A Practical Approach. John Wiley and Sons, New York. p.33.
19. Tor Norseth (1981).The Carcinogenicity of Chromium, Environmental health Perspectives, vol. **10** p 121 -130

20. Tetsu K.Tokunaga, Jiamin Wan, Mary K.Firestone, Terry C.Hazen, Kieth R.Olson, Donald J.Herman, Stephen R. Sutton, and Antonio Lanzirotti.,(2003) Bioremediation and biodegradation- In situ reduction of chromium (Vl) in heavily contaminated soils through organic carbon amendment, J.Environ.Qual.32:1641-1649.
21. Thacker, U. Parikh, R. Shouche, Y. and Madamwar, D. (2006): Hexavalent chromium reduction by Providencia sp. Process Biochemistry **41**, 1332-1337.
22. Toxicological profile for chromium (draft). US Department of Health and Human Services; Public Health Service; Agency for Toxic Substances and Disease Registry; 2008.
23. Shivashankara, G. P., Ranga, K., Ramalingaiah and Manamohan Rao, Characteristics of bulk precipitation in industrial areas of Bangalore city. Indian J. Environ. Health, 1999, **41**, 229–238.
24. Vijendra Singh and C P Singh Chandel 2006, Analytical Study of Heavy Metals of Industrial Effluents at Jaipur, Rajasthan (India), JOURNAL Of Environmental Science and engg VOL **48** , No. 2, p-103-108.
25. Taher AG (1999). Inland saline lakes of Wadi El Natrun depression. Egypt Inter. J. Salt Lake Res. **8**: 149-169. Thacker U, Parikh R, Shouche Y, Madamwar D (2006). Hexavalent chromium reduction by Providencia sp. Process Biochem. **41**: 1332-1337.
26. WHO (1993). Guidelines for Drinking Water Quality, second ed., vol. **1**, World Health Organization, Geneva, pp. 45-55.

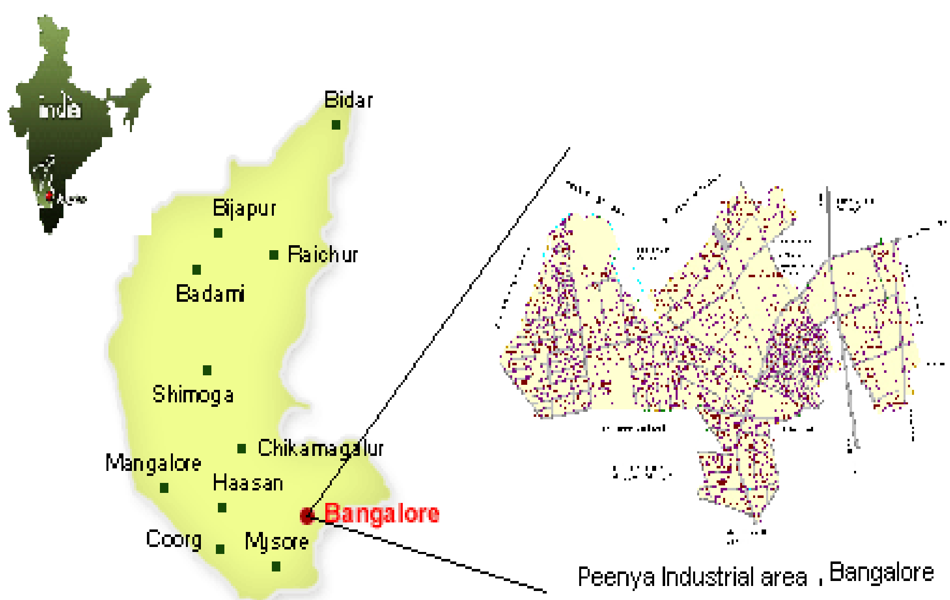


Figure 1. Peenya Industrial area located in Bangalore, Karnataka State, India

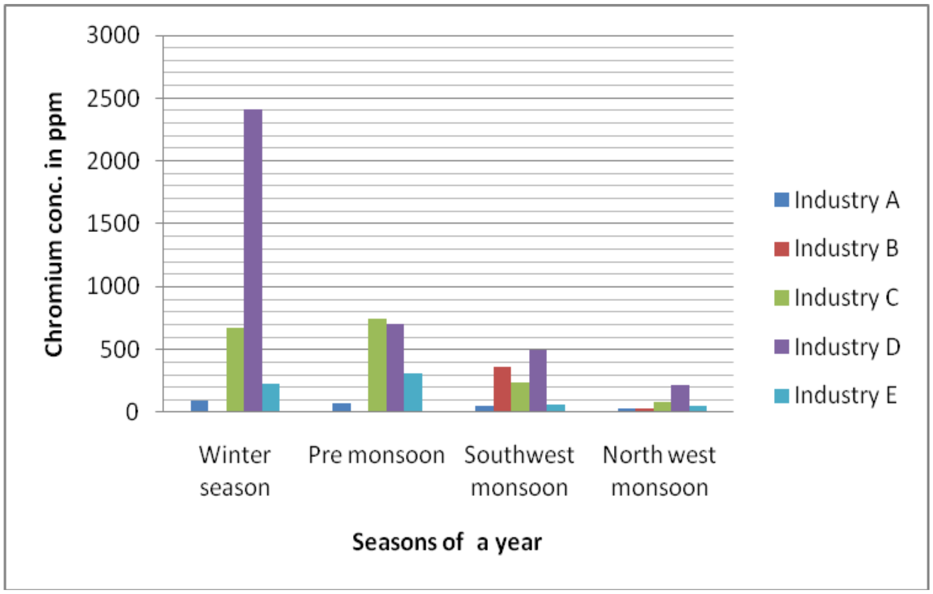
Table 1.Atomic Absorption working conditions

OPERATING PARAMETERS		WORKING RANGE
Instrument	Chemito AA201	
Wavelength	357.9 nm 425.4 nm	2-8 ppm 10-40 ppm
Light source	Hollow cathode lamp	
Flame type	Air –Acetylene flame Reducing (rich yellow)	

Table 2: Physicochemical characteristics of electroplating Industrial effluent (TSS, TDS, BOD and COD Units in mg/L)

Samples	Colour	Odour	pH	TSS	TDS	BOD	COD
A1	Yellow	Odorless	6	60	1200	69	633
A2	Lemon Yellow	Odorless	7	20	1000	56	673
A3	Yellow	Odorless	5	20	1500	56	555
A4	Yellow	Odorless	6	30	1200	64	600
B1	White	Odorless	9	20	1000	60	633
B2	White	Odorless	7	40	1000	64	594
B3	yellow	Odorless	6	20	580	78	600
B4	yellow	Odorless	9	20	600	70	655
C1	Yellow	Odorless	5	60	520	90	632
C2	Orangish Yellow	Odorless	5	60	5740	77	594
C3	Brownish yellow	Odorless	3	80	5500	68	580
C4	Brownish yellow	Odorless	3	70	5000	65	600
D1	Brownish yellow	Odorless	6	200	5800	68	277
D2	Yellow	Odorless	4	60	3800	16	91
D3	Yellow	Odorless	4	60	3500	88	488
D4	Yellow	Odorless	5	40	3200	68	500
E1	Yellow	Odorless	4	40	2400	90	792
E2	Yellow	Odorless	6	40	600	88	831
E3	Yellow	Odorless	7	60	900	85	700
E4	Yellow	Odorless	7	60	1000	68	650

Graph 1: Heavy metal chromium concentration (ppm) vs seasons in industrial effluents of electroplating industries.



Graph 2: Chart with microbial load.