

Physical Sciences

- Dissolution of Chalcopyrite with Hydrogen Peroxide in Sulphuric Acid**
A. O. Adebayo, K. O. Ipinmoroti and O. O. Ajayi 65
- A Method for the Determination of Relative Crystallinity of Minerals by X-Ray Diffraction**
Abdul Mannan, K. R. Kazmi, Muhammad Shafiq Khan and I. H. Khan 72
- Development of Nanoparticles of Alumina by Sol-Gel Method Using Inorganic Aluminum Salts as Precursors**
Fadia Shaheen, Wajid Ali Shah, Pervez Iqbal Qazi and Muhammad Latif Mirza 77
- Evaluation of Paint Industry Effluents for Irrigation Purposes**
Y. N. Jolly, A. Islam, S. B. Quraishi and A. I. Mustafa 82
- Trace Metals in Water and Sediments from Ologe Lagoon, Southwestern Nigeria**
K. A. Yusuf and O. Osibanjo 88
- Studies on Zinc(II)-Biosorption Capability of a Filamentous Green Algal Species (*Mougeotia viridis*) Isolated from Electroplating Wastewater**
Asma Saeed, Asia Aslam and Muhammed Iqbal 97

Short Communication

- Development and Applications of Animal Amylases for Enzymatic Desizing of Woven Fabric**
A. Farhan Khan and Shoib Arif 103

Biological Sciences

- Population Structure of the Juvenile Penaeid Shrimps Occurring in the Sandspit Backwaters of Karachi Coast, Pakistan**
Razia Sultana and Javed Mustaqim 106
- Biomass Production of *Pleurotus sajor-caju* by Submerged Culture Fermentation**
Tasnim Kausar, Zahida Nasreen, M. Nadeem and Shahjahan Baig 116
- Prevalence of Mycotoxins in Poultry Rations**
Nafeesa Qudsia Hanif, Muhammad Naseem, Salma Khatoon and Najma Malik 120
- Yield and Chemical Composition of Tobacco Leaves of Different Cultivars as Affected by Four Levels of Potassium Chloride**
Hamid Gul, Riaz A. Khattak and Dost Muhammad 125

Genetic Architecture of Yield in Eggplant (<i>Solanum melongena</i>) A. K. M. Quamruzzaman, M. Nazim Uddin, M. Mashiur Rahman, M. A. Salam and M. K. Jamil	134
---	------------

Short Communication

Location of Seed-borne Inoculum of <i>Lasiodiplodia theobromae</i> and its Transmission in Seedlings of Pumpkin (<i>Cucurbita pepo</i>) Nasreen Sultana	140
--	------------

Technology

Control of Chrome Pollution in Tannery Wastewaters with Humic Acids Surriaya Mir, Zakiuddin Ahmed and Arif Kazmi	143
---	------------

Dissolution of Chalcopyrite with Hydrogen Peroxide in Sulphuric Acid

A. O. Adebayo*, K. O. Ipinmoroti and O. O. Ajayi

Department of Chemistry, Federal University of Technology, P.M.B. 704, Akure, Ondo State, Nigeria

(received November 23, 2002; revised January 28, 2006; accepted February 17, 2006)

Abstract. The dissolution of chalcopyrite with hydrogen peroxide in sulphuric acid solution was investigated. The influence of temperature, stirring speed, concentrations of hydrogen peroxide and sulphuric acid, as well as the particle size of chalcopyrite were studied. Increase in the concentration of sulphuric acid had a positive effect on the dissolution of the chalcopyrite. Stirring speed had a negative effect on the dissolution of chalcopyrite as it enhanced the decomposition of hydrogen peroxide. The dissolution process was found to follow a shrinking-core model, with surface chemical reaction as the rate determining step. This is in agreement with the activation energy of 39 kJ/mol, and a linear relationship between the rate constant and the reciprocal of the particle size. The dissolution process was postulated to be electrochemical in nature.

Keywords: hydrogen peroxide, chalcopyrite dissolution, chalcopyrite, electrochemical dissolution, shrinking-core model

A Method for the Determination of Relative Crystallinity of Minerals by X-Ray Diffraction

Abdul Mannan^{a*}, K. R. Kazmi^a, Muhammad Shafiq Khan^b and I. H. Khan^a

^aPCSIR Laboratories Complex, Ferozepur Road, Lahore-54600, Pakistan

^bPharmacy Department, Islamia University, Bahawalpur, Pakistan

(received January 14, 2004; revised December 28, 2005; accepted December 29, 2005)

Abstract. X-ray diffraction spectra of smithsonite, fluorite, zircon, gibbsite, quartz, aragonite, albite, calcite, dolomite, anatase, barite, wollastonite and siderite have been recorded. The relative percentage crystallinity of these were calculated with the help of two programmes, namely, PowderX and WinPlotr. These two programmes have simplified the calculation of relative percentage crystallinity of various materials. Most of the X-ray spectra were very good and without noise. The noise of the spectra, when present, was removed with the programme PowderX and the spectrum was also levelled before the calculation of percentage crystallinity. The spectra of highly crystalline materials showed sharp high intensity peaks with small base. The degree of crystallinity has been determined by WinPlotr using integration method and by PowderX programme using area of the triangle method. Both of these programmes showed similar results, with the exception of a few spectra where the specimens were paracrystalline and amorphous.

Keywords: relative crystallinity, minerals, x-ray diffraction, software WinPlotr, software PowderX, percentage crystallinity

Development of Nanoparticles of Alumina by Sol-Gel Method Using Inorganic Aluminum Salts as Precursors

Fadia Shaheen ^{a*}, Wajid Ali Shah^a, Pervez Iqbal Qazi^a and Muhammad Latif Mirza^b

^a Glass and Ceramics Research Centre, PCSIR Laboratories Complex, Lahore-54600, Pakistan

^b Department of Chemistry, Islamia University, Bahawalpur, Pakistan

(received January 3, 2005; revised December 27, 2005; accepted December 30, 2005)

Abstract. Alumina nanoparticles were synthesized by homogeneous precipitation method from inorganic aluminum salt solutions using urea followed by calcination. The nanoparticles so produced were spherical and acicular with uniform particle size distribution. The process describes synthesis of aluminum hydroxide $\text{Al}(\text{OH})_3$ and boehmite AlOOH , and their thermal decomposition into alumina (Al_2O_3). The structural and morphological properties of the prepared aluminum hydroxide and nanocrystalline powders were characterized by scanning electron microscopy, differential thermal analysis and thermogravimetric analysis.

Keywords: nanoparticles, alumina, aluminum salts, sol-gel, homogeneous precipitation, aluminum hydroxide, nanocrystalline powder

Evaluation of Paint Industry Effluents for Irrigation Purposes

Y. N. Jolly^a, A. Islam^{a*}, S. B. Quraishi^a and A. I. Mustafa^b

^aChemistry Division, Atomic Energy Centre, P.O. Box 164, 4-Kazi Nazrul Islam Avenue, Ramna, Dhaka-1000, Bangladesh

^bDepartment of Applied Chemistry and Chemical Technology, University of Dhaka, Bangladesh

(received June 28, 2005; revised April 2, 2006; accepted April 4, 2006)

Abstract. Effluent samples collected from a paints factory for a period of seven months were analyzed for pH, electrical conductivity (EC), soluble cations and anions, nitrogen, phosphorus, and trace elements (Cd, B, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Pb). Compared with the natural groundwater used for washing paint wastes, the paint industry effluents were found to contain elevated concentrations of cations with the exception of Ca and moderately high concentrations of trace elements. Evaluation of the effluents was made, based on the integration of EC and both the sodium absorption ratio (SAR) and soluble sodium percent (SSP), BOD and COD values, and maximum permissible limits of heavy metals in the irrigation water. From the overall assessment, the effluents were considered suitable for use as supplement irrigation water. However, it is essential that the heavy metals in the effluents, as well as their accumulation in plants and soils, are monitored regularly.

Keywords: industry effluents, irrigation water, physicochemical properties, ICP-AES, paint industry

Trace Metals in Water and Sediments from Ologe Lagoon, Southwestern Nigeria

K. A. Yusuf^{a*} and O. Osibanjo^b

^aDepartment of Chemistry, Lagos State University Ojo, P.M.B. 1087, Apapa, Lagos, Nigeria

^aDepartment of Chemistry, University of Ibadan, Ibadan, Nigeria

(received June 30, 2004; revised February 16, 2006; accepted March 11, 2006)

Abstract. The concentrations of trace metals in water and sediment samples from Ologe lagoon located in southwestern Nigeria were investigated. The lagoon is a source of water for domestic, transportation and fishing activities. The water quality characteristics for a period of two years (January, 1997 - November, 1998), and the speciation of metals in the lagoon sediments were evaluated. The lagoon water quality characteristics, with respect to heavy metal contamination, were compared with global averages for freshwater and international water quality standards for drinking water. All elements except iron, were well within the safety limits. Sequential extraction techniques were used to establish the association of the total concentrations of Zn, Cu, Pb, Cd and Mn in the sediment samples with their contents as exchangeables, carbonates, Fe/Mn oxides, and organic and residual fractions. The concentrations of trace metals in the whole sediments were generally below the world-wide background levels. When compared to a number of sediment quality guidelines, the concentrations of trace metals were found to be below the level considered to have the potential to cause biological effects. Pb and Cd were extracted from the residual fraction at values greater than 50%. The metals that were most easily extractable in the samples analysed were Mn and Zn, which posed the highest risk to water contamination. The low level of industrialization in the study area has kept the lagoon relatively free from heavy metal contamination.

Keywords: lagoon sediments, trace metals, water quality, lagoon, sequential extraction, Ologe lagoon, metal speciation

Studies on Zinc(II)-Biosorption Capability of a Filamentous Green Algal Species (*Mougeotia viridis*) Isolated from Electroplating Wastewater

Asma Saeed*, Asia Aslam and Muhammed Iqbal

Environmental Biotechnology Group, Biotechnology and Food Research Centre, PCSIR Laboratories Complex,
Ferozepur Road, Lahore-54600, Pakistan

(received December 8, 2005; revised March 27, 2006; accepted March 30, 2006)

Abstract. The biosorption capacity of zinc(II) by a filamentous green alga *Mougeotia viridis*, isolated from the wastewater discharged by electroplating industry was tested under laboratory conditions as a function of contact time, pH, and initial metal ion and biomass concentrations. Optimum pH value for zinc(II) biosorption was determined as 5.0. At 10 mg l⁻¹ zinc(II), the biosorption equilibrium with 1 g l⁻¹ algal biomass was reached in 10 min showing a relative efficiency of 59.24% metal removal. When the biosorbent biomass was increased to 2 g l⁻¹, the metal removal capacity was enhanced to 81.4%. At optimum conditions, zinc(II) uptake increased with the increase in initial metal ion concentration from 5-300 mg l⁻¹. Langmuir isotherm model was found to be suitable for describing the biosorption of zinc(II) by *Mougeotia viridis*. The q_{\max} obtained experimentally and theoretically calculated from the Langmuir isotherm model at the regression coefficient value of 0.9975, respectively, were 27.7 mg and 26.71 mg zinc(II) g⁻¹ algal biomass, at the initial metal concentration of 200 mg l⁻¹. In five repeated biosorption-desorption cycles, the zinc(II) desorption from the metal-loaded algal biomass remained around 99%. The observations reported in the present study indicate that the alga can be used as an efficient biosorbent for the removal of zinc(II) from aqueous solution.

Keywords: filamentous microalga, metal biosorption, zinc(II) adsorption, heavy metals, wastewater treatment, *Mougeotia viridis*

Short Communication

Development and Applications of Animal Amylases for Enzymatic Desizing of Woven Fabric

A. Farhan Khan* and Shoib Arif

Textile Institute of Pakistan, PQA Campus: EZ/1/p-8 Eastern Zone, Bin Qasim, Karachi, Pakistan

(received July 11, 2005; revised March 16, 2006; accepted April 1, 2006)

Abstract. Investigations have been carried out on the development of stabilized crude animal amylases for enzymatic desizing of woven fabric. Animal amylases from pancreas were extracted and stabilized for industrial use. The extracted pancreatic amylases took 1 h in exhaust process and 6 h in pad batch process for the desizing of woven fabric. The desizing performance of these amylases was also compared with commercially available enzymes. The present studies have yielded highly active and stabilized amylases from animal pancreas. The method used for the enzyme recovery was also noted to give good yield of the enzyme from animal origin.

Keywords: animal amylases, desizing enzyme, enzyme stabilization, woven fabric desizing

Population Structure of the Juvenile Penaeid Shrimps Occurring in the Sandspit Backwaters of Karachi Coast, Pakistan

Razia Sultana^{a*} and Javed Mustaqim^b

PCSIR Laboratories Complex, Shahrah-e-Dr. Salimuzzaman Siddiqui, Karachi-75280, Pakistan

Centre of Excellence in Marine Biology, University of Karachi, Karachi-75270, Pakistan

(received February 11, 2004; revised April 10, 2006; accepted April 15, 2006)

Abstract. Ten species of juvenile penaeid shrimps were collected from Sandspit backwaters, Karachi coast, Pakistan. The genus *Penaeus* was represented by *P. penicillatus*, *P. merguensis*, *P. indicus*, *P. monodon*, *P. semisulcatus* and *P. japonicus*, the genus *Metapenaeus* was represented by *M. monoceros*, *M. stebbingi* and *M. affinis*, whereas the genus *Parapenaeopsis* was represented by a single species, *P. stylifera*. Population structure, such as the species composition, seasonal abundance, size distribution, sex ratios, and the length frequency distribution were studied for seven species. The remaining three species (*Penaeus semisulcatus*, *P. japonicus* and *Parapenaeopsis stylifera*) were found only once and thus excluded from the above noted studies. The juvenile population in the Sandspit backwaters was dominated by *M. monoceros* (40.97%) and *P. penicillatus* (32.64%), which altogether constituted 73.6% of the population. These were followed in the order of abundance by *M. stebbingi* (10.73%) and *P. merguensis* (9.29%). The three less abundant species were *P. indicus* (3.27%), *M. affinis* (2.14%) and *P. monodon* (0.87%). *P. penicillatus* dominated during July to October, *M. monoceros* dominated during March to June, and *M. stebbingi* dominated during December and January. The average total length of *P. penicillatus* (juveniles) was found to be 57.1 mm with a range from 11 mm to 119 mm. In *P. merguensis*, the total length varied from 11 mm to 123 mm with the average length of 54.3 mm. The total length of *P. indicus* varied from 12 to 117 mm, with the average length of 60 mm. The total length of *P. monodon* (juveniles) ranged from 49 to 163 mm, and the average length was 105 mm. The total length of *M. monoceros* ranged from 11 to 93 mm, with the average size of 46 mm. The size of *M. stebbingi* (juveniles) varied from 10 to 90 mm in its total length and the average size was found to be 31 mm. In *M. affinis*, the total length varied from 18 to 95 mm, with the average length of 55 mm. The overall sex ratios in juveniles of all the species were not found to be significantly different. However, in certain size classes, the sex ratios deviated significantly.

Keywords: shrimp population, penaeid juveniles, Karachi coast, *Panaeus* species, *Metapenaeus* species, *Parapenaeopsis stylifera*

Biomass Production of *Pleurotus sajor-caju* by Submerged Culture Fermentation

Tasnim Kausar*, Zahida Nasreen, M. Nadeem and Shahjahan Baig

Biotechnology and Food Research Centre, PCSIR Laboratories Complex, Lahore-54600, Pakistan

(received March 28, 2005; revised January 9, 2006; accepted January 31, 2006)

Abstract. The effect of different carbon sources, namely, sawdust and powder of agrowastes (as such, or water soluble extracts), and inorganic/natural nitrogen sources on the biomass production of *Pleurotus sajor-caju* by submerged culture fermentation was studied. Supplementation of the fermentation medium with 2% molasses, 2% wheat spike powder, extract of 2% wheat spike powder, and corn gluten meal resulted in 12.85, 10.85, 12.35 and 13.92 g/l biomass production of *P. sajor-caju*, respectively. The fungal hyphae biomass contained 8.28% moisture, 21.18% crude protein, 1.55% fat, 3.59% ash, 2.32% crude fibre, and 63.48% nitrogen free extract.

Keywords: *Pleurotus sajor-caju*, mushrooms, submerged culture fermentation, fungal culture, fungal biomass

Prevalence of Mycotoxins in Poultry Rations

Nafeesa Qudsia Hanif^{a*}, Muhammad Naseem^b, Salma Khatoon^a and Najma Malik^a

^aRomer Laboratories Pakistan, Flat-8, Satellite Plaza, 71-A, 6th Road, Rawalpindi, Pakistan

^bNaseem Traders International, Rawalpindi, Pakistan

(received January 19, 2005; revised March 10, 2006; accepted March 15, 2006)

Abstract. Samples of poultry broiler and layer rations (n = 865) were received at Romer Laboratories Pakistan from different parts of the country over a period of 31 months for the purpose of their mycotoxin analysis. The samples were analyzed by thin layer chromatography and by HPLC. The mycotoxins analysed included aflatoxin-B₁ (AfB₁), zearalenone (Zon), deoxynivalenol (Don), 3-acetyldeoxynivalenol (3ac-Don), 15-acetyldeoxynivalenol (15ac-Don), nivalenol (Niv), fusarenon-x (Fus-x), T-2 toxin (T-2), HT-2 toxin (Ht-2), diacetoscirpenol (Das), neosolaniol (Neos) and ochratoxin-A (OtA). The mycotoxin AfB₁ was noted to be the major contaminant in the feed samples analyzed (84.70% in 182 feeds), followed by OtA (51% in 41 feeds), Zon (49.33% in 150 feeds), Don (38% in 150 feeds), T-2 (34.65% in 101 feeds), 3ac-Don (19.41% in 67 feeds), and 15ac-Don (11.94% in 67 feeds). Mean values with standard deviation for AfB₁, OtA, Zon, Don, T-2 toxin, 3ac-Don and 15ac-Don were 13±16.80 µg/kg, 10±19.63 µg/kg, 213.58±440 µg/kg, 456±1122 µg/kg, 442.56±1191 µg/kg, 41±102 µg/kg, and 38.92±149.58 µg/kg, respectively. All samples were observed to be negative for HT-2 toxin, Das, neosolaniol, nivalenol, and fusarenon-x. This study is the first report on the occurrence of a range of mycotoxins in the Pakistani poultry rations, which shows that AfB₁, OtA, Zon, T-2 toxin, Don, 3ac-Don and 15ac-Don may be present at levels, which adversely affect poultry production.

Keywords: mycotoxins, aflatoxins, toxic metabolites, poultry feed, poultry rations

Yield and Chemical Composition of Tobacco Leaves of Different Cultivars as Affected by Four Levels of Potassium Chloride

Hamid Gul^a, Riaz A. Khattak^{b*} and Dost Muhammad^b

^aPakistan Tobacco Board, Mardan, Pakistan

^bDepartment of Soil and Environmental Sciences, NWFP Agricultural University, Peshawar, Pakistan

(received September 14, 2005; revised March 15, 2006; accepted April 18, 2006)

Abstract. An outdoor pot experiment was conducted to evaluate response of ten tobacco (*Nicotiana tabacum*) cultivars to KCl induced chloride toxicity at the Tobacco Research Station, Mardan, Pakistan, during 2002. The study included four levels of KCl, which were: 0, 4, 8 and 12 mmol kg⁻¹ soil and was arranged according to 4x10 factorial design with three replications. Seedlings of the respective cultivars, Spt-G.28, KHG-14, KHG-15, KHG-18, Coker-371 Gold, Candel, KHG-19, K-399, Coker-48 and Coker-176 were planted in pots containing 5 kg normal soil. After establishment of the seedlings, the respective amount of KCl was applied in one litre of water and then irrigated with normal water for the rest of the growing period. The data showed that all growth parameters increased with the initial dose of 4 mmol kg⁻¹ of KCl, but then decreased with higher levels due to chloride toxicity. When averaged across cultivars, the highest seedling height (17.4 cm), number of leaves per plant (8.7), leaf area (42.0 cm²), and dry weight (10.17 g per pot) were recorded in treatments receiving 4 mmol KCl kg⁻¹ soil. Chloride, reducing sugars, nicotine and K content of leaves showed linear regression with KCl levels ($r^2 > 0.95$), producing 250, 74.33, 18.62 and 14.14% increase at 12 mmol kg⁻¹ soil, respectively, as compared to control. Nitrogen content of leaves also increased with increasing KCl levels in most of the cultivars showing an overall increase of 12.46%, as compared to control. Unlike other growth parameters, ash content increased with increase in KCl level up to the higher dose of 12 mmol kg⁻¹ soil. Cultivars showed differential response to the KCl induced chloride toxicity. KHG-14 was found to be the most sensitive cultivar regarding growth parameters, while KHG-18 and KHG-15 recorded higher changes in chemical composition to KCl application. Considering the overall performance, Spt-G.28 was found to be the most suitable variety producing higher plant height, number of leaves per plant, leaf area, fresh and dry weight, reducing sugars and nicotine, and lower levels of nitrogen and chloride as compared to other cultivars. It is concluded that KCl applications should be avoided or applied very carefully to prevent its adverse effects on yield and quality of tobacco as our soils already contain sufficient amount of chlorides.

Keywords: tobacco leaves, potassium chloride, *Nicotiana tabacum*, chloride toxicity, tobacco cultivation, phytotoxicity, tobacco cultivars, flue-cured cultivars

Genetic Architecture of Yield in Eggplant (*Solanum melongena*)

A. K. M. Quamruzzaman*, M. Nazim Uddin, M. Mashiur Rahman, M. A. Salam and M. K. Jamil
Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, Bangladesh

(received September 13, 2005; revised February 16, 2006; accepted March 31, 2006)

Abstract. The genetic architecture of yield in eggplant was studied in a nine parent half diallel cross. The values of mean square for GCA (general combining ability) and SCA (specific combining ability) were highly significant which suggested the presence of both additive and non-additive genetic variance in the population. The higher magnitude of GCA, as compared with SCA, indicated predominance of additive genetic variance. In most of the cases, the cross between poor and poor parents showed positive SCA effect for yield per plant, which indicated the higher yield. The estimates of better parent heterosis ranged from 3 to 90 percent and the mid-parent heterosis ranged from 30 to 105 percent. Analysis for genetic components of variation suggested that additive components were more important in the inheritance of yield per plant. This character was observed being controlled by two to three pairs of genes or groups of genes. Narrow sense heritability was 21 percent indicating probability of selection in generations. The graphical analysis also indicated wide genetic diversity among the parents.

Keywords: eggplant, combining ability, heterosis, genetic architecture, *Solanum melongena*, additive genetic variance

Short Communication

Location of Seed-borne Inoculum of *Lasiodiplodia theobromae* and its Transmission in Seedlings of Pumpkin (*Cucurbita pepo*)

Nasreen Sultana

Crop Diseases Research Institute, Pakistan Agricultural Research Council, Karachi University Campus,
Karachi-75270, Pakistan

(received October 28, 2004; revised March 21, 2006; accepted April 6, 2006)

Abstract. Using naturally infected seeds of pumpkin, the fungus pathogen *Lasiodiplodia theobromae* (syn. *Botryodiplodia theobromae*) was located on and in the seed coat, including tegmen, and in the tissues of the cotyledons and embryo. Apparently healthy seeds showed incidence of the fungus in seed coat and tegmen. The fungus was transmitted to seedlings and caused pre- and post-emergence damping-off disease, resulting in increase in the inoculum potential of *L. theobromae* in the agricultural fields.

Keywords: pumpkin, seed-borne fungus, *Lasiodiplodia theobromae*, seedling mortality, *Cucurbita pepo*, *Botryodiplodia theobromae*, seedling damping-off

Control of Chrome Pollution in Tannery Wastewaters with Humic Acids

Surriaya Mir^a, Zakiuddin Ahmed^{a*} and Arif Kazmi^b

^aPCSIR Fuel Research Centre, Off Shahrah-e-Dr. Salimuzzaman Siddiqui, Karachi-75280, Pakistan

^bDepartment of Chemistry, University of Karachi, Karachi-75270, Pakistan

(received August 31, 2005; revised April 20, 2006; accepted April 22, 2006)

Abstract. Tannery industry in Pakistan occupies an important place in the national economy. The magnitude of chrome effluent waste generated by the industry has rapidly multiplied during the past decade. This has caused an irreversible damage to the 'flora and fauna', which demands immediate remedial action. An effort has been made to develop indigenous means to combat chromium pollution with humic acids. Humic acids (HA) are polymeric, brown complex of compounds occurring in the aquatic, terrestrial and sedimentary environments. Soft brown coals and leonardite are major sources of humic acids, which contain up to 80% extractable humic acids. These economical, coal-derived humic acids are useful for soil and water remediation. The process reported in the present study for this purpose is simple, economical and avoids the problems associated with the disposal of bulky chromium waste produced using coagulation and other techniques.

Keywords: chrome effluents, tannery wastes, humic acids, lignitic coal, wastewaters treatment
