International Journal of Engineering Innovation & Research
Volume 4, Issue 4, ISSN: 2277 – 5668

Bioremediation of Iron and Steel Industrial Waste: A Review

Jayapriya. D
Ph.D. Scholar, Department of Environmental and Herbal Science, Tamil University, Thanjavur-613010.

P. Senthil Kumar
Ph.D. Scholar, Department of Environmental and Herbal Science, Tamil University, Thanjavur-613010.

K. K. Kavitha
Assistant Professor, Department of Environmental and Herbal Science. Tamil University, Thanjavur-613010.

***Abstract* – Steel is one of the most basic materials essential for industrialization and plays a vital role in the country's economic development. India is gifted with natural resources required for a healthy and vigorous iron and steel industry. India is at present producing nearly 8.4 million tones of saleable finished steel per year. India is exporting steel products to the tune of nearly on tones. With the liberalization of import tariff on finished steel items the Indian steel manufacturers are able to cut down the cost of production and is competing in the world market. Private industrialists are ready to invest new steel projects. This paper reviews current knowledge of waste management through bioremediation in Indian Steel Industry, approaches to environmental improvement and examines various options to environmental management plan keeping in view of the importance of sustainable endurance of environment and other natural resources.**

Iron and steel industry which comprises, mining of ores, preparation of raw materials, agglomeration of fines in sinter plant, feeding of burden to blast furnace, manufacturing of coke in coke ovens, conversion of pig iron to steel, making and shaping of steel goods, granulation of slag for its use in cement plant, recovery of chemicals from Benzyl and tar products etc. etc. All the above mentioned operations add to air, water, land and noise pollution.

***Keywords* – Steel Industry, Waste Management, Bioremediation.**

I. Introduction

Indian steel plants should recognize that if they are to remain competitive they must innovate to minimize waste pollution arising from their production processes and supporting activities [1] they have found on current knowledge of waste management in Indian steel industry approaches to environmental improvement and examines in the view of the various options to environmental management plan keeping in the view of the importance of sustainable endurance of environment and other natural resources.

Many research papers have been reported on waste water pollution studies and removal of liquid waste but fewer papers are published on wastewater treatment in reference to steel industries using different technologies for control of different pollutants. This suggested that various global and local environmental issues that steel industry presents before the mankind, is a major cause of concern to environmentalists. Some of the important methods have been briefly discussed to reduce these emissions through major energy conservation programs and implementation of energy efficient processes; among local issues are the problems of air, water and noise pollution along with the generation of large quantity of solid waste. Under each area some of the programs have been identified which could provide major research directions towards making the steel industry increasingly more environment friendly [1]-[4] and [16-17] specific environmental clean-up operations.

Iron and steel Industries in India priorities on segregation and disposal waste. In the fields few waste products like metallurgical slag, dust/sludge, considerable research work has been done while some other waste like acetylene sludge and palm oil sludge have received scant to no attention in current research.

Environmental degradation can be protected by using bioremediation methods. Bioremediation is a treatment processes that uses naturally occurring microorganisms as well as plants to breakdown, or degrade hazardous substances into less toxic or non toxic substances. Bioremediation can be applied on site (in-situ) or off site (ex-situ), mediated by mixed microbial consortia and or pure microbial strains. There are many mechanical and chemical methods for treatment of Iron and steel industrial effluents are also available.

II. Bioremediation of Solid Wastes of Steel Industry

Substantial quantities of solid by product and wastes are generated from different processes of iron and steel making in integrated steel plants which are termed as "Solid wastes". Solid wastes in steel plants are essentially by products generated during various processing steps involved in the production of iron and steel. A recent estimate puts it around 1.2 tonnes of wastes for each tone of steel produced. The quantities of such wastes are enormous and their nature quite varied and diverse

In this review paper; with the purpose of evaluating hazardous waste generation from iron and steel industry and the best practices for their management, a site investigation coupled with literature survey was performed. Firstly; a complete material flow analysis was carried out to assess the generation of hazardous wastes from iron and steel industry. Then, types and amounts of hazardous wastes that arise from each process step in steel production were evaluated and hazardous waste generation factors (HWGF) for these wastes were determined. It was found out that there are five different types of hazardous wastes form steel manufacturing are sludge from coke oven containing tar, other slags from coke oven, stack gas treatment sludge, mill scale and flue dust. Some wastes like Blast Furnace (BF) and Steel Melting (SM) Slags as

Copyright © 2015 IJEIR, All right reserved

International Journal of Engineering Innovation & Research
Volume 4, Issue 4, ISSN: 2277 – 5668

well as fly ash, constitute a major fraction of the total generation, whereas mill scale and flue dust contribute comparatively smaller fraction [5].

The environmental impact due to steel production was studied [1]. Flow chart linking pollutants and principal operations in integrated steel plants is shown in Figure-1.
A large number of literatures are available on total management of waste generated from a Steel plant focusing on different aspects of pollution measures, safe disposal and recirculation etc. Major noteworthy contributions on overall waste management are by [6]-[8] etc.

Blast furnace flu dust is usually found to be contaminated with Zn and lead or contain alkali elements that make them unsuitable for reuse. However, recovery of Zn and Pb values from BF Flu Dust has been successfully attempted by [9]-[12] studied the effect of alkalies on operation of blast furnace. [8] discussed the utilization of slag, the granulated slag from Bhilai Steel Plant, India in particular for the production of slag cement.

In regards to the metallurgical slag, reports are available on utilization of (Blast Furnaces) BF Slag while slag from steel melting shop is not fully discussed because of inherent problems. Linz-Donawitz (LD) converter process is suitable for recycling steel waste to produce a high-tech steel product and it is ecologically superior over some other steel melting processes [13]. The physico-chemical characteristics of LD slag studied [14]. The major phases that are being found in LD slag include Dicalcium ferrite Calcium aluminate and Wustite. Steel slag also contains some reactive mineral phases such as $2CaO.SiO_2$, $3CaO.SiO_2$ and free CaO and MgO [15]. [16],[45] worked on the recycling of steel plant waste through sinter plant and some industrial applications of biosurfactants.

[18] Summarized the work done at various steel plants of the country in the area of utilization of waste which includes use of LD slag as soil conditioner, recycling of LD slag through sinter routes, manufacture of fly-ash bricks & light weight aggregates, agglomeration& recycling of lime fines. Technology for the treatment of steel plant dusts is also described by [19].

Major hazardous wastes from iron and steel manufacturing are; stack gas treatment sludge that may originate from sintering, blast furnace, basic oxygen furnace and flue gas dust from blast furnace. However, other hazardous waste streams; mill scale from rolling and sludge from coke oven cannot be overlooked as these two wastes are also produced at large quantities [20].

The amenability of the waste materials from metallurgical furnace to upgrade and further utilization was found out [21]. The cost effective and ecofriendly newer biotechnological processes viz. bioremediation and bio beneficiation through microbial metal reabsorption have been widely accepted. Bioleaching / biosolubilization of metal sulphide ores is an ideal alternative for the mitigation of pollution even at mining sites. It has been found that maximum rates and yields of metal extraction can be enhanced at elevated temperatures [22].

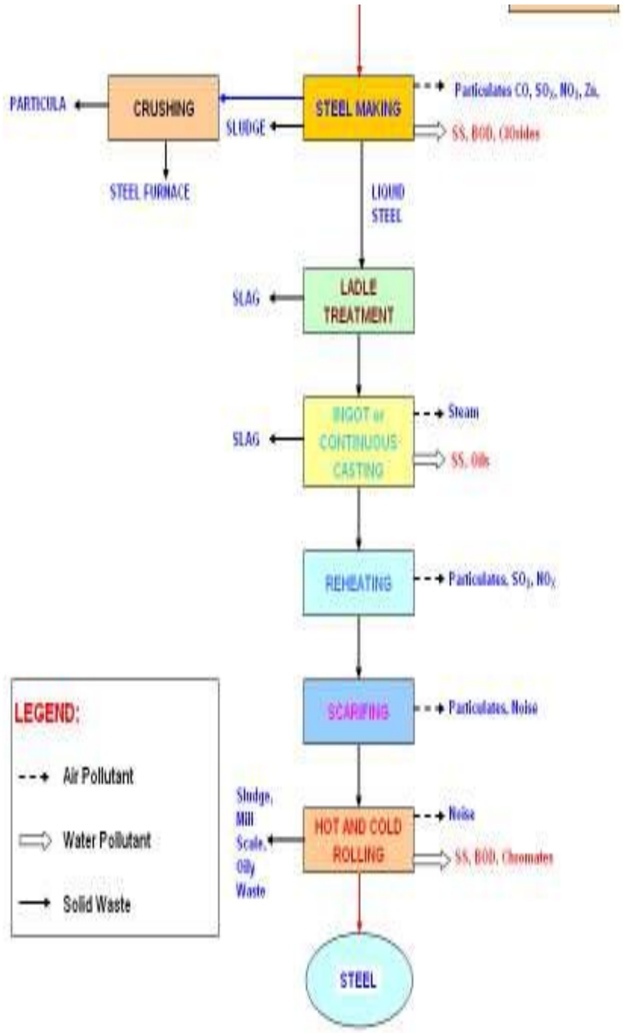

Fig.1. Schematic flow diagram linking pollution and principal operations
(Source: COINDS/27/1998 – CPCB, New Delhi) [45]

Ultimately there is a need to search such metal tolerant, metal absorbent as well as moderate thermophillic, acidophilic organisms for biogeotechnological applications. It has been shown that bacteria and fungi isolated from polluted environment are frequently tolerant to higher levels of metals than those isolated from unpolluted areas and that tolerant microorganisms are found at higher frequencies in polluted habitats [23]-[25]. Potentially, any microorganism or cell fraction that exposes negatively charged groups on its surface should have an affinity for metal cations [26].

Biological methods by using various micro organisms and membrane filters were used in the removal of hazardous waste generation from iron and steel industry and the best practices for their management; a site investigation coupled with literature survey was performed. [27] Revealed primary and secondary screening of various 72 acidothermophilic, autotrophic microbes which were isolated and adapted for metal tolerance and bio absorption potentiality. The multi metal tolerance was developed with higher gradient of concentrations Ag, As, Bi, Cd, Cr, Co, Cu, Hg, Li, Mo,

Copyright © 2015 IJEIR, All right reserved

Pb, Sn, and Zn. The selected highly potential isolate (Ath-14) showed maximum adsorption Ag 73% followed by Pb 35%, Zn 34%, As 19%, Ni 15% and Cr 9% in chalcopyrite.

[28] premeditated both *Pseudomonas aeruginosa* and *pseudomonas sp* H1-G1 could reduce 90% of mercury from the medium after 40 hours of incubation at 37ºC ,both bacterial strains have shown remarkable ability to uptake metal ions from the culture medium.

[29] discovered an iron –oxidation bacterium has been isolated from the iron scraps of a steel industry .It is an aerobic obligate chemolithotroph. Growth occurs optimally at pH 4 and 45 to 50 degree in a mineral medium containing 9%Feso4 but lacking organic carbon. The isolate is morphologically distinct from other well characterized iron –oxidizing bacteria.

The effect of Al, Fe (II) and Mn ions on growth accumulation and sorption potential of tolerant fungi from polluted environment was studied [30]. Isolates were screened for metal resistance by plate diffusion method and tolerance ability observed in Sabourd Dextrose broth. Tolerant fungi were pre-treated for increased accumulation and sorption capacity *Aspergillus oryzae, Trichoderma longibrachiatum, A. fumigatus, A. niger, T.viride, penecillium sp* and *Rhizopus sp were isolated. A.oryzae and T.longibrachiatum* molecularly characterized as *Aspergillus sp* Tu-Gm14 and *T.asperllum*. BHU216 were tolerant to 300 mg. L^{-1} of metals, while other strains showed significant inhibition zones and no growth of tolerant fungi was optimum at 24-48h with increased cell mass while *Aspergillus sp*Tu-Gm14 showed Iron (II) oxidation expressed by color change in medium. Results therefore *Aspergillus sp. TU-GM14* and *Trichoderma asperellum BHU216* biomass exhibited high metal tolerance with resultant oxidative properties. Pre-treatment of the tolerant strains also resulted in increased accumulation capacity and biosorption potential, indicating that they can become useful biosorbents for the removal of Al (III), Fe (II) and Mn (II) from metal-contaminated solutions [30].

III. Bioremediation of Liquid Waste of Steel Industry

An integrated steel plant requires large quantities of water for direct and indirect cooling, for scrubbing of air pollutants and for process reagents. Depending on local conditions 100 to 200m^3 of circulating water is required to produce one tonne of crude steel (Water Pollution Control Review in Env. Control in the Steel Industry). The actual consumption and discharge can be reduced to 3-6 m^3/t of crude steel depending upon the level of recycling and reuse. The actual quantity of water required per tonne of steel produced is a function of product mix, steel making technology, pollution control technology, recycling opportunities, water availability and relative cost.

Japan has reported a circulation rate of over 90% [31], In the Indian Steel Industry specific water consumption varies in the range 10-50 m^3/t of crude steel as against the norm of 16m^3/t of crude steel [2]. Discharge of effluents generated in steel industry into contiguous water bodies viz rivers has resulted in high pollution load on many Indian rivers rendering their water unsafe for human beings as well as domestic animals. Several instances of concentration of nonbiodegradable toxic constituents like heavy metals (e.g. Lead or Mercury) have been reported in the aquatic life. Several places like Salem have high fluoride level in the ground water and this places a severe restraint on the fluoride content of effluents discharged. Research / Investigation / Survey are urgently required to be conducted to assess the extent of pollution caused to rivers by industry and identify suitable remedial measures. Waste water treatment begins at the point of generation and ends with the ultimate disposal. Waste water treatment can be divided into Primary, Secondary, Tertiary and final polishing stages. Coke oven effluents are regarded as the most toxic and complex waste water generated in steel plants and its treatment methodology is still an area of active research through bioremediation.

Aerobic systems along with packed bed-attached growth (trickling filters) systems have been used in random, the efficiency of the BOD plants to reduce CH- and NH to desired levels is not very satisfactory. An anaerobic system in combination with the other two seems to be a probable solution and needs to be examined [32].

[4] studied on biological degradation of steel plant effluent using a mixed consortium of soil bacteria *(Bacillus, Pseudomonas, Arthrobacter* and *Micrococcus* species) reduced 95% of BOD and COD industrial effluents.

Waste Water Treatment Technology for Steel Industry using Membrane Bioreactor (MBR): Membrane Bioreactor (MBR) is the latest technology for biological degradation of soluble organic impurities was studied [33]. MBR technology has been in extensive usage for treatment of domestic sewage, but for industrial waste treatment applications, its use has been somewhat limited or selective.

Reviewed the common treatment technologies practiced for steel industry in India and ETP performance evaluation of a major steel plant has also been done [34]. In integrated iron and steel industry waste water generated from coke oven by product plant is considered to be the most polluting stream. Ammonia at the inlet of the BOD plant is converted into nitrate in biological treatment. Therefore the quantity of ammonia at the inlet is reduced and should be as far as possible from the source. Similarly, cyanide also interferes in biological treatment.

Biosorbtion is a process, which represents a biotechnological innovation as well as cost effective excellent tool for removing heavy metal from aqueous solutions [3]. This article provide a selective overview of past achievements and present scenario of biosorption studies carried out on some promoting natural biosorbent (algae, fungi, bacteria, yeast) and some waste materials which could serve as an economical means of treating effluents charged with toxic metal ions.

Copyright © 2015 IJEIR, All right reserved

IV. Bioremediation of Air Pollutant of Steel Industry

[35] Studied environmental aspects of direct reduction and applied remedial measures which recommended that atmospheric pollution control standards should be established to ensure the daily average atmospheric concentration of oxides of nitrogen (NO_x) should be within or below the range of 0.04-0.06 percent. Improved combustion methods including fluidized bed combustion should be applied the increase of water recycling rates and installation of various water treatment facilities in steel industry should be promoted to reduce the water pollution.

Captive thermal power plants (CCP I & II) in Bhilai Steel Plant generate huge quantity of ash (fly-ash and bottom ash) during combustion process for generation of electricity. The fly-ash is very fine and contains mostly aluminous rich (mullite) and siliceous (quartz) phases with minor magnetite and hematite minerals. A typical fly-ash sample mainly contains 51% SiO_2, 1.2% CaO, 30% Al_2O_3, and 3% Fe_2O_3. The use of fly-ash in brick-making, as pozzolanic material for cement, synthetic aggregates, mine stowing material etc. is well known. The fly-ash of BSP along with neutralization plant and acetylene plant sludge can be used in brick manufacturing. The iron rich phases from fly-ash can be effectively be separated through wet magnetic separation and be recycled to blast furnace via sinter plant [21].

Blast furnace flu dust is usually found to be contaminated with Zn and lead or contain alkali elements that make them unsuitable for reuse. However, recovery of Zn and Pb values from Blast furnace Flu Dust has been successfully attempted by [9]-[11].

[12] Studied the effect of alkalies on operation of blast furnace. [8] Discussed the utilization of slag, the granulated slag from Bhilai Steel Plant, India in particular for the production of slag cement.

A volume of literature is available on study of Fly-Ash generated from a thermal plant. [51], detailed the characteristics of ash in general. [29] Discussed the strategies to tackle the fly-Ash problems against the backdrop of present state of generation. [38] and the utilization of fly-ash in agricultural sector.

[39] Attempted high resolution micropetrographic study of coarse-grained agglomerated MSN fly-ash [40] discussed the use of fly-ash in Western United States and [41] have determined the usefulness of fly-ash to control bacterial growth in diary bedding.

[37b] Constructed the potential of returns in dollars following various utilization avenues of Indian fly-ashs: like fly-ash cement, fly-ash based wood substitute, fly-ash based tiles, paints &enamels, reclamation of low lying areas, in the construction of road and fly over, embankments and so on. [21] Reported the preparation of fly-ash bricks, aggregates etc. However, characterization of flyash generated from BSP is not available in the literature.

The processing of metallurgical waste and recovery of metal values has been reported by several researchers. They [42] focused attention to reaping the value from dust & slag and [43] discussed the recycling of residues with high Fe content & low Zn and Pb contents. The process permits utilization of carbon content from the waste as a reductant. Study carried by [44] indicated the probability of recovery of 60% carbon values from flu dust through conventional flotation technique.

V. Conclusion

It may be summarized from the review of some of the important literature that basic characterization study of all types of waste generated from Steel Plant has been either reported to a limited extent. From this above review it is clear that researches preferred bioremediation technique for the treatment of solid, liquid and gaseous wastes from steel and Iron industry.

References

[1] P V Viswanathan, and T.K Gangadharan, "Environmental and waste management in iron and steel industry," *NML*, Jamsedpur, 1996, pp. 199-207.

[2] H D Pandey, S Bhattacharya, G D Magaeshwari, S R Om prakash and Madiratta, "Research needs I environmental and waste management In iron and steel industries," *J.nml*, Jamshedpur.1996, pp.1-27

[3] Nilanjana Das, R Vimala and P Karthika, "Biosorption of heavy metal-overview; *Indian journel of biotechnology*,"vol7, 2008, pp. 159-169

[4] R Krishinaveni, Y Pramila Devi, S Ramgopal and Rao, "Bioremediation of industrial effluents using soil microorganisms; *International journel of advanced biotechnology* and research,"Vol. 4, 2013, pp. 51-56

[5] T K Chakravarty, SK Panigrahi, "Strategies for solid waste management in SAIL steel plants," *Nml*, Jamsshedpur, 1996, pp. 52-62

[6] J G Leonard, "Port Phillip Region Groundwater Resources - Future Use and Management," Water Victoria, Melbourne, 1992, *VIC*: pp. 294

[7] G S Basu, P K Sarkar, R P Sharma, A Ahemad and A S Dhillon "Recycling & reuse of solid waste at Tata Steel," Tata Search, 1997, pp.118-120

[8] Murthy and Gangopahyay, "Environmental and waste management in iron and steel industries," *TCDC* International work shop., Jamshedpur., Indian institute of metals Jamshedpur,1999, pp. 111-122

[9] N Piret, D Muller, "Criteria for the selection of a recycling process for low zinc containing residuals and effluents processing and Environmental considerations," Ed.1992, pp. 613-614

[10] I Imris, "Zinc and lead extraction from steel making flue dust," Mining and Mineral Process. Inst. of Japan, 1995, pp. 472-481

[11] L N Lehner, PL Dufton, W R J Rolleston, F P Keenan, "Observations of the Interstellar Medium in the Magellanic Bridge," *The Astrophysical Journal*, 551 : 781È793, 2001 April 20.The American Astronomical Society. All rights reserved. Printed in U.S.A. Observations of the interstellar medium in the magellanic bridge In. K. R Lehner. Sembach, P. L. Dufton, W. R. J. Rolleston, and f. P.Keenan Received 2000 June 20; accepted 2000 December 20.

[12] M S Erol and N Sevine, "Control of alkalis in the blast furnace. Union chambers of Turkish Engineers and Architects," Turkey, 1995, pp. 315-322

[13] H Kreulitsch, W Krieger, "The LD process - an ecological optimized process," 1991, pp. 271- 278.

Copyright © 2015 IJEIR, All right reserved

[14] ST Kim, WK Huh, BH Lee and SO Kango, "D-arabinose dehydrogenase and its gene from Saccharomyces cerevisiae." *Biochim Biophys Acta* 1429 (1) 1998, pp. 29-39 Journal Article | Research Support, Non-U.S. Gov't.

[15] D C Goldrig, L M Jukes, "Petrology and stability of steel slag, Iron making and Steel making." vol. 24 (6), 1997, pp. 447-456

[16] B D Das, U S Yadav and D N Jena, "Recycling of steel plant waste through sinter." Proc. Sem. on Recent Techniques in Mineral Processing Waste and Environment Management (*RETMEM*), 2000, pp. 187-192.

[17] Das, P S R Reddy, S Prakash , S K Biswal , R B Rao, BK Mohapatra and S K Bhaumick, "Recovery of carbon values from blast furnace dust by flotation techniques. Int. Sem. Min. Process." Tech. (MPT-2001), Hyderabad, Abstract, 2001, pp. 39

[18] S N Sinha, "Solid Waste Generation in Steel Plants and its Reutilisation," Proceeding of International Workshop on Environment and Waste Management, *N.M.L*, Jamshedpur,1999, pp. 177-192.

[19] NA Braeza, L R Nelson, "Technology for the treatment of steel plant dusts," World Steel Review, 1 (1), Mintek, 1991, pp. 27-35.

[20] N Cakir , G Olmez, T Karanfil, E Alp and U Yetis, "Hazardous waste generation from integrated iron and steel production in turkey– Evaluation of cleaner production options," *International iron and steel symposium*: Vol. 02-04, 2012

[21] Nirlipta priyadarshini nayak, 'Characterization and utilization of solid wastes generated from BHILAI steel plant,"M.Tech Thesis. 2008, National Institute of Technology, Rourkela

[22] P R Norris, "Microbial Mineral Recovery," In: H.L Ehrlich., C.L. Brierley, (Eds.), McGraw-Hill, New York, 1990, pp. 3–27

[23] K Arnebrant, E Baath, A Nordgren, "Copper tolerance of microfungi isolated from polluted forest soil," Mycologia 79, 1987, pp. 890-895.

[24] Baath, Effects of heavy metals in soil on microbial processes and populations (a review) Water, Air, and Soil Pollution. Vol. 47, Issue 3-4, October 1989, pp 335-379

[25] F W Huysman, P Verstraete, "Brookes Effect of manuring practices and increased copper concentrations on soil microbial populations Soil Biol," Biochem. 26, 1994, pp. 103–110

[26] H L Ehrlich: What types of microorganisms are "effective in bioleaching,bioaccumulation of metals,ore beneficiation and desulfurization of fossil fuels," J.Biotecchnol.Symp.16, 1986,pp. 227-237

[27] V Valentina, Umrania: "Bioremediation of toxic heavy metals using acidothermophilic autotrophies," *ElSEVIER*, Biosource technology 97(2006), 2005, pp. 1237-1242

[28] A Rehman, A Ashfaqali and AR Shakoori, "Biosorption of mercury by bacteria, isolated from industrial effluents: potential use in bioremediation of waste water," *J.zool*, vol. 40(2), 2008, pp. 115-122

[29] Suparna Deepak, Ankita patil, and Arti matele, "Isolation of a novel iron scraps of a steel industry," J.Advanced in applied science research , vol. 5(1) 2014,pp. 277-281

[30] Omeike Sunday osaizua, Kareem sarafadeen olateju, Oni-orisan yetunde adeola and Awosolayejide olanike, "Tolerance, Bioaccumulation and Biosorption potential of fungi isolated from metal-finnishing industry waste site," *Journel of applied sciences in environmental anitation*. Vol. 9, 2014, pp. 35-44

[31] Nagaswa and Kanaura , *Ibid*. (1992), pp. 385-397

[32] B E Prater, R Fisher, "In Env. Control in the Steel Industry," Ed. by [IS I, Pub. by Stahl & Eissen, (1992), pp. 398-417

[33] Sinha Sanjeev Kumar, Vikas Kumar Sinha, Kr Samir, Pandey, Anup Tiwari (2014). "A Study on the Waste Water Treatment Technology for Steel Industry: Recycle And Reuse," American Journal of Engineering Research *(AJER)* e-ISSN: 2320-0847 p-ISSN: 2320-0936 Vol. 03, Issue-04, pp. 309-315

[34] Ahmed sirajuddin, Rk Rathi and Chandra umesh, "Waste water treatment technologies commonly practiced in major steel industries in India," 2010, Jamia Millia Islamia (Central University).

[35] B R Nijhawan, "Environmental aspects of the direct reduction route to steez making.Environamental &Waste management," Eds : A Bhandopadhav., N G Goswami , Ramachandra Rao. P, 1999, pp. 1-10

[36] A Tripathy, RK Sahu: "Effect of coal flyash on growth and yoeld of wheat," *J.Environ.Biol*.Vol. 18, no.2, 1997, pp. 131-135

[37a] V Kumar, P Sharma: "Fly ash management in iron and steel industry. Proc. Sem. on Environmental and waste management in iron and steel industries," *NML*, Jamshedpur, 1999, pp. 163-176

[37b] KumarVimal and P Sharma, Mission mode management of flyash. Proc.International conference of "Flyash-Disposal and Utilization,"Vol.1, 1998, page1-1/1-7, held at New Delhi, Jan 20-22.

[38] S Jha, S Chauduri, and V N Sharma, Growth studies of vegetable species in fly ash amended soil. Procd. Sem on "Environmental and waste management in iron and steel industries," *NML*, Jamshedpur, 1999, pp. 163-176

[39] J Dykstra, Jr Eusden and T Taylor, "Petrogenesis, bulk mineralogy and melt structure of MSW fly ash," Fly ash research, 2007, pp. 150

[40] K G Hoffman, "Fly ash usage in Western United States," Western Region Ash group. 2000, pp. 1-3

[41] J Kirk , U C Davis, Studies on the potential use pf fly ash in Bedding on Dairies 1999, Proc. of Int. Conf. on "fly ash Disposal and Utilisation, New Delhi,"

[42] J Schriefer, Reaping the value from dust and slag. New Steel (online), February (1997), Available from http://204.243.31.49/cgiwin/csearch.exe/search.htm.

[43] K Grebe, H J Lehmkuhler, "High residue- free iron and zinc recovery from integrated steel plant waste with less than 2% zinc plus lead. Iron and steel making society," USA, 1991, pp. 113-127

[44] P S.R Reddy, S K Biswal, B Das, and B K Mohapatra, "Recovery of carbon and iron values from blast furnace flue dust by beneficiation techniques. Powder, Handling and Processing," Vol. 8 (2), 1996, pp. 139

[45] Central pollution control board ministry of environment and forest, "Sponge Iron Industry", Comprehensive Industry Documents Series: COINDS/66/2006-2007. Published By: Dr. B. Sengupta, Member Secretary, Central Pollution Control Board, Delhi – 32

[46] K Das, AK Mukherjee, Comparison of lipopeptide biosurfactants production by *Bacillus subtilis* strains in "submerged and solid state fermentation systems using a cheap carbon source" Some industrial applications of biosurfactants Process Biochem. Vol. 42, 2007, pp. 1191–1199

AUTHOR'S PROFILE

Mrs Jayapriya, D.

She as Ph.D. Scholar Department of Environmental and Herbal Science, Tamil University, Thanjavur, Tamil Nadu. Specialization in the field of Environmental Microbiology.

Senthil Kumar, P.

He has Ph.D. Scholar Department of Environmental and Herbal Science, Tamil University, Thanjavur, Tamil Nadu.. Specialization in the field of Environmental Microbiology.

Dr. K. K. Kavitha

She works as an Assistant Professor at Department of Environmental and Herbal Science, Tamil University, Thanjavur. She has published 3 papers in International journals 5 National journals and 5 full papers in conferences proceeding books in addition to published two books in the field of Environmental Science.

Copyright © 2015 IJEIR, All right reserved