Environmental effects and aspects of LD slag

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Abstract- It is important regarding environmental consideration to reuse the waste generated in steel plants. LD slag is mainly composed of calcium, silicon, iron and phosphorus but also contains trace amounts of potential toxic elements, specifically Cr and V which can be released. Although if directly discharged LD slag has negative impact on environment but it can be utilized judiciously to impart benefit to the environment by different ways mentioned in the paper. Moreover LD slag can be used as the base material or by material for the civil purposes, fertilizers etc. reducing environmental impacts.

Index Terms- effect on soil, effect on water bodies, future aspects.

I. INTRODUCTION

Integrated steel plants generate many types of wastes at different stages of the processing. Utilization of waste is an environment friendly cost saving technique. Generation rate of LD-slag is 150-180 kg per ton of crude steel. CaO is an important oxide present in the slag which can be utilized in other metallurgical processes as flux material instead of lime or lime stone. The phosphorus of BOF or LD slag is too high to be reused in iron making and steel making. Blast furnace slag has a long term market in cement fertilizer and construction industries, whereas LD slag is not suitable due to its high phosphorous content. The most economic, environment friendly and efficient option for metallurgical waste utilization is through proper recycling. Efficient utilization of large quantity of waste slag is very important not only from economic point of view but environmental aspect also.

II. LITERATURE REVIEW

The lands occupied by landfills loses its fertility and are considered degraded and cannot be used for the agriculture. The industrial waste landfills are sometimes placed in the inappropriate place[1].Slag mountains are formed by dumping which not only harms the acquired space but also blocks the space for its use, as the population is increasing day by day so space is also a matter of fact in the upcoming time. It's the responsibility of industries to mitigate the harmful effects of dumping of the slag.

Effect on soil quality and its improvement purpose:

Although researchers are working to utilize the LD-slag as base material for bolder, road making, cement etc [1]. It can directly be utilized for the environment conditioning only if used in a proper way. Dumping of LDSlag directly to an area will increases the metallic,lime and phosphorus content in the soil harming its quality.The composition of LD slag is shown in the table below:

TABLE 1: Composition of several phases in LD slag[2]

	Composition (wt%)								
Mineral phase	CaO	SiO_2	FeO	Mn	MgO	P_2O_5	Al_2O_3	TiO_2	Cr_2O_3
Dicalciumsilicate	58.00	33.84	0.54	-	0.01	3.62	0.67	0.50	0.04
Tricalcium silicate	68.20	25.70	2.15	1.55	0.08	1.10	0.30	0.37	-
Dicalcium ferrite	49.64	1.48	48.11	0.36	4.24	0.02	-	-	-
Dicalciumferritetitanate	52.70	2.55	33.31	0.88	0.43	0.32	3.25	8.53	0.39
MagnesioWustite	2.12	2.08	61.80	17.50	5.68	-	-	-	-

Process for removal of metallic content,so that the amount of the metallic value of soil do not increase[3] :

Different authors have gone through physical processes like magnetic separation, floatation, dual phase separation etc. Particles with high magnetic susceptibility will be separated by a light magnetic field and weaker magnetic particles will be separated by a strong magnetic field. Therefore, the heterogeneous magnetic field of different intensities can separate different particles. However, this is not a very effective way of dephosphorisation.

We can use LD Slag for soil conditioning by the recovery of the phosphorus in the following ways:

Physical process[4]

Scientist studied the removal of phosphorus from LD slag by floating separation of Dicalcium Silicate during solidification. On slow cooling from high temperature the slag is separated in two layers, CaO, SiO_2 and P_2O_5 are segregated in the top layer and FeO, Fe_2O_3 and MnO in the bottom layer.

Chemical process[5]

Pyro metallurgical treatment of LD-slag was done by different investigators. Scientist proposed a method in which phosphorus is removed through evaporation by adding silicon to a Fe-P-C alloy obtained because of reduction of slag with carbon. The overall reaction can be represented by:

$3CaO.P_2O_5(s) + 5C + 3SiO_2 = 3(CaO.SiO_2) + 5CO + P_2(g)$

Physico-chemical method[6-9]

LD-converter slag produced in a 170-t LD-converter at Nippon Steel's Sakai works under various blowing conditions were used for the experiments. Samples were prepared by crushing 10kg of lump slag to below 3mm pulverising to less than 100mesh. Different components of samples were estimated by fluorescent X-ray analysis. The slag has been superheated to 1923K and slowly cooled to lower temperature then at room temperature, the mineral phases were identified by microscopic and EPMA examination. As a result of slow cooling, CaO, SiO, and P_2O_5 are enriched in top and FeO, Fe_2O and Mn0 in bottom. Analysis of top and bottom layer of slag is shown in Table below. They went to the conclusion that dicalcium silicate is apt to separate more efficiently with higher total iron content in slag and at higher start temperature of cooling, close to liquidus temperature. Blowing oxygen into the molten slag before cooling can improve the efficiency of separation.

	FeO	CaO	SiO_2	MnO	MgO	P_2O_5
Top	14.0	47.6	18.5	3.0	4.1	3.14
Bottom	29.2	34.9	7.1	5.9	5.6	0.96

While,

%P = %P2O5 * 0.44

Now the recovered phosphorus canbe used in fertilizer industries. According to the conventional fertilizer standards a 100 pound bag of 10-10-10 fertilizer contains 10% P_2O_5. In the year 2016-2017 production of Tata Steel is 10.5MTPAas per its yearbook.Generation rate of LD Slag is 150 – 180 kg per ton of steel .While P_2O_5 is 1 -3% of slag. It means for the production of 1 ton of steel we will get 1.5 – 5.4 kg of P2O5.

By the simple calculation above it can be seen that a huge amount of P_2O_5 can be produced and used in the fertilizer formation.

As per the report based on P fertility status of soils in India and 9.6 million soil test summaries, 49.3%of district are in low phosphorus category while 48.80% are medium and 1.9% is high in P category. It is shown by the Table2 .

STATE/UNION TERRITORY	No. of districts for which soil tests were obtained	fertility classes		
		low	medium	high
ANDHRA PRADESH	21	17	4	-
ARUNACHAL PRADESH	5	-	5	-
ASSAM	9	1	6	2
BIHAR	26	12	14	-
CHANDIGARH	1	1	-	-
DADAR AND NAGAR HILLS	1	-	1	-
DELHI	1	1	-	-
GOA	1	1	-	-
GUJARAT	19	14	5	-
HARYANA	11	2	9	-
HIMACHAL PRADESH	11	2	7	2
JAMMU AND KASHMIR	10	1	9	-
KARNATAKA	19	16	3	-
KERELA	10	3	7	-
MADHYA PRADESH	45	15	30	-
MAHARASHTRA	25	17	8	-
MANIPUR	1	1	-	-
MEGHALAYA	2	2	-	-
MIZORAM	1	1	-	-
NAGALAND	6	6	-	-
ORISSA	13	5	8	-
PONDICHERRY	1	1	-	-
PUNJAB	12	2	10	-
RAJASTHAN	26	2	21	3
TAMIL NADU	13	8	5	-
UTTAR PRADESH	55	41	14	-
WEST BENGAL	15	4	11	-
TRIPURA	3	3	-	-
TOTAL	363	179	177	7
PERCENT OF TOTAL	-	49.3	48.8	1.9

TABLE2: Distribution of districts and Union territories according to the available P in soil.[10]

As the major part of Indian economy is based on agriculture so to promote the Indian agriculture we can use LD Slag, phosphorus plays vital role in crop growth such as rice,corn,wheat, tobacco etc. Phosphorus is an essentialrequirement in rice farming as it promotes rapid tillering, root development and early flowering.If P is deficient damage occurs to the plant.

FIG. 01 a. Crop devoid of Phosphorus b. Crop having sufficient amount of phosphorus

After the removal of the phosphorus content to a lower amount the LD Slag can be used to increases the basicity due to high CaO content to manage acidity of the soil.

Effect on aquatic life:

Direct discharge to the area near to the water bodies can cause contamination.Minerals are the essential component required for the growth of the aquatic life. "Oligotrophication"[11],characterized by a low accumulation of dissolved nutrient owing to a high oxygen content, as a result of which there is a little to no plant life. As the phosphorus content of LD slag is high it can be used for the growth of the aquatic floras resulting in the improvement of the aquatic ecosystem.

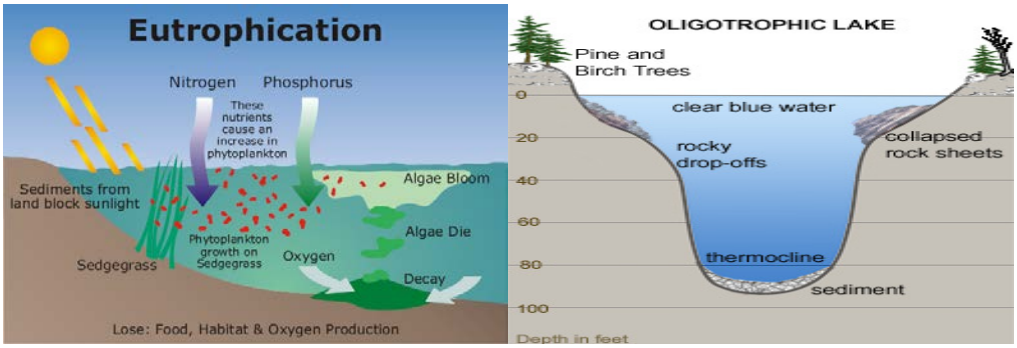

FIG. 02

Eutrophication also called Hypertrophication is the depletion of oxygen in water bodies which kills aquatic animals. It is a result to the addition of excess nutrients mainly phosphates which induces excessive growth of plant and algae. After the death of such organisms bacterial degradation occurs which consumes oxygen,depleting it from the aquatic body[12].As phosphorus plays a vital role for the growth of plants and it is a major component of LD Slag it can be used to support the environment in a better way. LD slag can also be used as sand-capping material so that nutrient from the soil can be prevented to flow into the water bodies.

Sadakata , Professor at the University of Tokyo ,took an interest in LD slag as a means of supplying iron as a nutrient to curb Oligotrophication of seawater. Here a mixture of artificial humus soil, obtained by fermentation of waste wood chips, and LD slag, subjected to the process of carbonization, was used. The mixture was placed in water-permeable coconut bags (Beverly Unit) and uniquely shaped steel cases (Beverly Box), and the bags and cases were settled at suitable points in the experimental sea area[13].

Harmful effect of slag on environment[14]

Most slag contains impurities of toxic elements, such as As,Pb,Cd,Co,Cr or Ni.Since these substances can be leached to some extent from the slags, possible environmental hazards cannot always be excluded.

The gaseous emissions from the salt slag (slurry) that result from contact with water are of great environmental concern. These elements even though not in a large amount affects environment a lot.

III. Results and Discussions

LD slag or steel slag, a by-product of the steel making process is one of the important waste materials generated in steel plants. The presence of phosphorous in it is quite high which restricts its utilisation in iron and steelmaking directly. The amount of phosphorus can, however, be reduced by physical and chemical means. Besides its effective use as road making, cement producing, fertilizers it can very well replace lime addition to the steelmaking route due to its high lime content and can be used for various purposes including calcium oxide based

reformer (ground improvement or soil improvement), source of iron for sea weed beds.

Because many of the uses represents natural substitutes for man-made materials, expansion of the applications of slag is an activity that greatly contributes to the environmental conservation.

At European level, the legal framework acts under which the road builders should provide 20-30% of the necessary material by industrial waste management, slag being an important part in it[15].As the step taken is a good one all countries should focus on steps like this.

Eutrophication is a great problem in the mid-20^{th} century the World Resource Institute got coastal zones in the world with high concentration of minerals covering eastern and southern coast of US,East Asia and mainly Japan.

Developed countries such as Japan is working for the utilization of LD slag in a better way to promote the aqueous life and enhance fisheries by increasing mineral content by providing nutrients required for the growth of coral weeds.

Many of the steel companies of the world are not utilizing LD slag properly and prefer to dump it.So if they start utilizing LD slag like Japan,China etc. then it will act as a great remedy for environmental pollution. By harnessing the deposits we will be able to recover large area for agriculture.

There are so many challenges related with the same such as Health hazard, environment disregard etc. We can use LD slag for creating the favorable condition, essential for environment.

IV. Conclusion

LD slag is a major by-product in steelmaking, if not utilized in a proper way or by dumping in an area can cause harmful effects to the environment.But it can be used to help the environmenti.e.soil, aquatic life etc. It can be utilized not only from economic point of view but also from the environmental viewpoint, if utilized by proper processing and channeling. In future it can contribute to our society, mankind to an extended level if proper incentives will be taken in time, for the advancement of the environment.

References

[1] National Agency for Environment Protection 2006,Regional Development Agency West 2008.

[2] J. Pal, P.N. Chaudhary and M.C. Goswami “Utilisation of LD slag — An overview”April 2003,p.62.

[3] J. Pal, P.N. Chaudhary and M.C. Goswami;Utilisation of LD slag — An overview.

[4] Suito, H.Hayashida. Y and Takahashi, Y., (1977). Minaralogical study of LD converter slags, Tetsu-to-Hagane, 63(8), pp. 1252-1259. Nippon Steel Technical Report No. 104 August 2013

[5] Shiomi, S., Sano, N and Matsushita, Y.. (1977), Removal of phosphorus in BOF slag. Tetsu-toHagane, 63(9), pp. 1520-1528

[6] Ono. Hitoshi.. Inagaki. A., Masui, T., Narita. H., Nosaka, S..Mitsuo, T.andGodha, S., (1981). Transactions-ISIJ, 21(2). pp. 135-144.

[7] Fujita, T and Iwasaki, I., (1988), Phosphorus removal in high gradient magnetic separation from steelmaking slags slow cooled in an air atmosphere. Process Mineralogy VII , Minerals, Metals and Materials Society, pp. 293-308.

[8] Fregeau, E. Wu., et. al., (1990), In-situ grain size determination of slow cooled steelmaking slags. Process Mineralogy IX , Minerals, Metals and Materials Society, pp. 429-439.

[9] NKK-promoting effective utilisation of steel making slag, NKK Monthly, 2000. December. 25. Recycling And Environmental issues of Metallurgical slags and salt fluxes;M.Reuter ,Y.Xiao and U.Boin.

[10] R.Hasan ,Phosohorus Status of Soils in India ,Better Crops International Vol.10 ,No.2 , November 1996.

[11] “Oligotrophication” A Dictionary of Plant Sciences, Encyclopedia .

[12] Schindler ,David and Vallentyne ,John R.(2004) Over Fertilization of the World’s Freshwaters and Estuaries,University of Alberta Press ,p.1.

[13] Nippon steel technical report No. 104 August 2013,p.126

[14] M.Reuter , Y. Xiao and U.Boin ,Recycling and Environmental issues of metallurgical slags and salt fluxes,p.353.

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