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Study on the application of iron and steelmaking slag in agriculture

Sagram Hembrom
Assistant Professor
Department of Metallurgical Engineering ,B.I.T. Sindri, Dhanbad,Jharkhand.
Correspondence: Dr.S. Hembrom, Email.: hembromsangram@gmail.com

Abstract:

To analyse the impacts of Iron and Steel slag and ,L.D. Converter slag in crop cultivation and also different aspects by summarizing its use as fertiliser and as liming agent, it's perspective use as amending material for soils, and by paying attention also to different technologies and methodologies aiming to improve the quality of the slag, in order to increase and its use in agriculture. Steelmaking slag may directly be used as fertilizer, it can be mixed with animal waste materials .Steelmaking slag contains Si, Fe, P, Mn, Ca, and various other elements required in fertilizers. The impact of solid waste materials for crop cultivation depends on the availability and quantity of different constituents such as Chemical Oxygen Demand, PH, Ammonia Nitrites, Nitrates, Permanganate Value Biochemical Oxygen Demand Total Dissolved Solids etc. present in the solid waste. The use of steel slag in agriculture produces not only economic but also ecological advantages. The application of silicon on rice has been observed when soil soluble Si is low and also the use of Si fertiliser has beneficial effects on both rice and sugarcane field.

Key words: L.D. Converter, Iron and Steel slag, silicon etc.

INTRODUCTION

In recent years new technologies have been expanded, and some of them are still under developing, in order to improve the recovery rates of slags. On this subject material separation technologies and carbon sequestration could dramatically reduce CO_2 emissions from steelmaking processes. On the other hand, the increase of slags recovery and use in different fields of application, such as in agriculture, allowed to reduce landfill slags and to preserve natural resources. In addition to the environmental achievements, these practices produced economic benefits, by providing sustainable solutions that can allow the steel industry to achieve its ambitious target of “zero-waste” in the incoming years[1].

Steel is produced by Iron ore and Scrap based :

(1) The iron ore based steelmaking, which represents about 62-70% of the world steel production. The main raw materials are iron ore, coal, limestone and recycled steel scrap. The main production routes are iron making iron ore based on Blast Furnace (BF) followed by steelmaking in the Basic Oxygen Furnace (BOF), and the iron making based on Direct Reduction of Iron ore (DRI), followed by steelmaking in the Electric Arc Furnace (EAF). In the BF coke is the reducing agent of iron ore. Limestone or dolomites (fluxes) are added into the blast furnace where they react with iron ore impurities, such as silica. Steel is produced from pig iron, scrap and lime in the BOF, where oxygen is blown to burn off the carbon.

(2) The scrap-based steelmaking, which represents about 25-30% of the world steel production. This route is based on the scrap recycling in the EAF, where the main input are steel scrap and electrical energy that is needed to melt the scrap into steel. In both BOF and EAF the reactions between oxygen, carbon (carbon as gaseous carbon monoxide), silicon, manganese, phosphorus and some iron as liquid oxides produce oxidized compounds that react with lime or dolomite lime to form slag. At the end of the refining operation, after steel pouring into a ladle, the slag is poured into a vessel and is subsequently tapped into a slag pot. The main by-products resulting by iron making and steelmaking are slags that represent about 85-90% of the total by-products, dusts and sludges. On the average about 190-200 kg of by products per ton of steel result from the steel production through electric arc furnace, while about 380-400 kg of by-products per ton of steel production through BF/BOF [2]. Slag comes from both BF and

steelmaking processes are consumed at steel works, used in fertiliser cement, roadbed material, ground improvement material and as industrial waste in landfills.

This chapter intends to review the state of the art related to the use in agriculture of steel slag, mainly coming from BOF process using basically Linz-Donawitz (LD) converter, in different worldwide contexts. The review covers different aspects by summarizing its use as fertiliser and as liming agent, its potential use as amending material for soils, and by paying attention also to different technologies and methodologies aiming to improve the quality of the slag, in order to increase and make progress in its use in agriculture. On one hand, studies based on the use of slag in agriculture will be considered, which treat the use of steel slags for amending acid soils and as source of important factors and growing agents (not only calcium and magnesium compounds, but also other elements such as silicon, providing important beneficial effects for some crops and increasing the plant yields) and its use as Fe source for reducing Fe chlorosis in different crops. Moreover, investigations will be described concerning the heavy metals contained into the slags and their behaviour on the soil, in order to evaluate possible harmful effects after slag application for agricultural purposes and to avoid their possible negative environmental impacts, as well as the use of steel slags for metal stabilisation in contaminated soils. On the other hand, investigations focused on the obtaining a slag with high phosphorus content to be used as fertiliser (together with other slags with a low content in phosphorus to be recycled inside the steelmaking process will be discussed.

Uses of Iron making and steel making Slags:

Slags are generated in all stages of steel production and the following four different kinds of slags from different routes can be identified: BF slag, BOF slag, EAF slag and Secondary Steelmaking Slag. The slagging agents with fluxes, such as limestone, dolomite and silica sand, are added into BF or steelmaking furnaces in order to remove impurities from ore, scrap and other ferrous charges during smelting. The slag formation is the result of a complex series of physical and chemical reactions between the non-metallic charge (lime, dolomite, fluxes), the energy sources (coke, oxygen, etc.) and refractory bricks. Because of the high temperatures (about 1500°C) during their generation, slags do not contain any organic substances. The slags protect the metal bath from oxygen and maintain temperature through a kind of lid formation. Due to the fact that slags are lighter than the liquid metal, they float and may be easily removed. Slag is generated in a parallel route of the main processes of hot metal production in ironmaking and steelmaking and therefore the slag generation process is considered as a part of the whole steel production process [3].

Blast furnace slag can be used also in agriculture because of its high sorption capacity of phosphorus, which remains into the available form for the plants. Negative effects, resulting from steel slags use, could derive from their heavy metal concentrations, but such metals tend to bound to the slag matrix and thus they are not available for plants. All these factors contribute to underline positive effects of using slag as liming materials, that lead to better yield of the crops, soil protection and reduction of natural resources consumption [4]. Free lime, after separation, can be used as fertiliser, in cement and concrete production, for waste water treatment and in coastal marine blocks. In soil conditioning slags are efficient in soil neutralisation. In addition, the siliceous liming materials improve soil structure and reduce fungal infections.

Steelmaking slag deriving from BOF process (using the Linz-Donawitz converter) comes from the pig iron refining process, which converts molten pig iron and steel scraps into high quality steel. Most slags from steel plant derive from this process, with an average of 150-200 kg of slag generated per tonne of steel produced. but it contains some reactive mineral phases, such as $2CaO.SiO2$, $3CaO.SiO2$ and free $CaO.MgO$ [5]. The EAF slag utilisation is quite similar to the one of BOF slag, but, due to its lower lime content, EAF slag is very stable and can be used in asphalt without any problems.

Secondary Steelmaking Slag disintegrates into a powder due to instability of the di-calcium silicate, causing an increase in dust emissions to the environment and to make this slag suitable for use and valuable [6,7].

Table: Typical values of ferriferous solid wastes generated in India per ton of steel .

Sl.No	Sources	Amount
1	Blast furnace Slag	320-400 kg/thm
2	Blast Furnace Sludge	4-10 kg/thm
3	Blast Furnace Dust	9-20 kg/thm
4	BOF Slag	125-155 kg/tcs
5	BOF Sludge	9-15 kg/tcs
6	BOF Dust	11-20 kg/tcs
7	EAF Dust	14-20 kg/tcs
8	EAF Slag	20-120 kg/tcs

Table: Average Chemical composition of different solid wastes under Indian conditions.

Solid Waste	SiO_2	CaO	Al_2O_3	MgO	S	P	Fe
Blast furnace Slag	32.75	33.06	19.33	8.69	1.03	0.002	0.37
BOF Slag	15.02	49.05	2.20	7.8	0.14	1.12	18.31
BF Flue Dust	7.12	3.45	3.14	1.30	0.35	0.15	38.8

METHOD:

Steelmaking Slag as a Silicon Sources :

After oxygen, silicon (Si) is the most abundant element in the earth's crust. Silicon sources for agricultural purposes must display some important features, such as high soluble Si content, low cost, availability for plants, balanced ratios and amounts of Ca and Mg, increase of phosphate mobility, suitable physical properties, easy application, and absence of heavy metals because blast furnace slag contains fertilizer components CaO, SiO_2, and MgO, it is used in rice cultivation as calcium silicate fertilizer. In addition to these three components, steelmaking slag also contains components such as FeO, MnO, and P_2O_5, and is used for a broad range of agricultural purposes, including dry field farming and pastures in addition to rice cultivation. Its alkaline property also remedies soil acidity.

In order to have an effective use of Si fertilization in agronomic practices, an adequate knowledge of physical and chemical characteristics of Si sources and of the rates and methodologies for applying them are needed. A number of field and greenhouse studies have demonstrated that the use Si soil amendments increases crop production and quality. The application of Si fertiliser has beneficial effects on both rice and sugarcane. Although the mechanism of response of sugarcane to Si fertilization is not yet well understood, studies have shown that the yield increase of the sugarcane may be associated with different factors, such as Al, Mn and Fe toxicity alleviation, increased P availability, reduced lodging, improved leaf and stalk erectness, freeze resistance and improvement in plant water economy. Furthermore the Si accumulation protects plants from certain diseases, such as a resistance to biotic and a biotic stresses [8]. The use of Si in the plants can help the plants against pathogen attacks [9].The use of silica (SiO2) as a fertiliser increases the rice resistance to diseases and vermin. For this purpose the slag produced in the hot metal de-siliconization process, which contains mainly silica, has been taken into consideration in order to develop a potassium silicate fertiliser. This is an example of a new steelmaking process developed by Nippon Kokan Kabushiki Kaisha and referred as Zero Slag Process,[10] focused on the reduction of the amount of generated slag and also to the stabilization of the composition of slag generated through hot metal pre-treatment[11]. This fertiliser, developed by adding potassium to the de-siliconization slag, dissolves with difficulty in the water and slowly dissolves in the weak citric acid released by plant roots. The potassium contained into this fertiliser is slowly released and is effectively adsorbed by plant. The process consists in the de-siliconisation process of the hot metal and subsequently the potassium carbonate is continuously added into the ladle containing the hot metal and then the uniformly melted slag, which is recovered from the hot metal ladle, is solidified by cooling and crushed into a granular form. This fertilizer has been demonstrated to be as effective as other commercial potassium silicate fertilisers and combined potassium chloride-calcium silicate fertilisers when it was applied to some vegetables, in particular to rice. Its marketing started in December 2001 in Japan. As described above, since the silicon fertilisation has been turned out to be beneficial for plant growth, such as rice and sugar cane, the identification the most promising and potential available Si sources to plant has been studied. In particular, in a greenhouse experiment several Si sources have been evaluated in order to test their ability to supply Si to rice crops. Among different Si-rich materials, metallurgical slags have been evaluated, because the high temperatures used in iron making and steel making processes release Si from crystalline form to reactive and as consequence more soluble forms, with the result to supply it to plants [12]. In the comparative study differences between silicon sources in relation to Si uptake have been observed. Furthermore steel slags (LD, AOD, electric, and stainless steel furnaces) have shown higher Si availability than BF slag, and differences depending on the type of steel produced and on the type of furnace used to produce steel. Phosphate slags provided the highest Si uptake. On the other hand, recent studies have shown that Si concentration is negatively related to as content in straw and polished rice, that is Si in the soil available for plant reduces the uptake of as [13].

Use of steelmaking slags as fertilisers:

A small amount of slag is used as fertiliser in agriculture and this use depends on the market situations due to the low market value of fertilisers, the long distances transportation is a limiting factor. In addition natural lime stone fertilisers are in competition to the slag use. Therefore, the development of new markets for the slag, in order to ensure its utilisation in the future, is required. In this respect the steel industry is committed to minimize the amount of slag which has to be deposited, by improving its use through the increase of its properties [14]**.** The resulting slag containing phosphate has been used as fertiliser for about 70 years. The current steelmaking process is based on the Basic Oxygen Steelmaking process, where a basic slag is produced in the Linz-Donawitz converter. The LD slag contains about 1-3 wt% of P2O5, which is too low to be used as phosphate fertilizer, but, at the same time, it is too high to be used in the BF or recycled in the sinter plants. The LD slag contains high levels of lime (CaO) and MgO that make it a potential liming agent, may improve soil pH and can be used as plant nutrients. Particularly free lime, which is one the main slag constituents, can partially dissolve by reacting with water to produce calcium hydroxide and calcium hydroxide dissolves into Ca^{2+} and OH^-, resulting in a pH increase.

All these factors characterizing this material, can allow to recycle an industrial residue and to improve the fertility of acid soils. Among these a three-years research carried out in the Basque Country of northern Spain, by using LD converter slag on pasture land, has produced significant results [15]. The comparative study analyzed soil modifications produced by LD slag and those produced by traditional liming agents. In particular, the influence on soil pH, soil Ca and Mg content, the percentage of Al saturation and the yields have been taken into consideration in this study. The achieved results concern different aspects that have been considered in it. Firstly, increasing rates of LD slag application have increased the soil pH linearly, that, as a consequence, has led to Al solubility decrease; this has allowed the P absorption, due the changing of insoluble forms to soluble ones. In addition the Ca and Mg soil contents increase, resulting in an increased yield, while the consequence of the PH has reduced the toxic effects of Mn. On the other hand, the Cd, Cr and Ni monitoring has shown that, after LD slag application, there was not heavy metals. A research project that was funded by the Research Fund for Coal and Steel (RFCS) programme [16]**,** led to relevant results about the liming and fertilising effects of fine grained iron and steel slags, such as BF slag, LD slag or ladle slag, compared to other liming materials, such as burnt lime or carbonate limestone, in field trials investigations as well as in greenhouse pot experiments. The research aimed to investigate the fertilising effects on both the soil and the plants. These investigations have been carried out in arable land (Germany, Austria and Spain), in green land meadows (Germany and Spain), and in forestry (Spain). Furthermore the behavior of trace elements, such as Ca, Mg, P, Cr, V, Zn and Pb, in soils and plants has been investigated, in particular, the behavior of heavy metals, especially of Cr and V, their mobility and their bonds in the soil.

Investigations carried out on soil and yield have proven that the yields of experimental crops, in long term experiments by using iron and steel slags, were higher than those achieved after using different liming materials; on the other hand, PH has increased in the same way as a result of the use of both kind of materials. The use of basic slag in soil tests has produced the same fertilising effects, while the results of P content and soil PH has been higher, compared with super phosphate or rock phosphate use.

The comparison between the converter slag and the converter sludge applications to soils and tea plants, conducted in northern Iran, produced effects on soil properties and on the tea plant nutrient concentrations [17]**.** Results have shown that converter slag application increased soil PH more than converter sludge treatment, probably because of the higher original PH of the slag. In addition they have supplied calcium and magnesium to soil and, consequently, their concentrations have increased in tea leaves. The use of alkaline slag for amending acid soil and improving plant growth has been analysed in a recent study carried out in Iran[18]. After the application of increasing amount of slag, the soil PH proportionally increases. Moreover, at PH values between 7.4 and 8.5, the Fe availability decreases, while at higher PH values it increases; on the other hand, the phosphorous and Mn availability proportionally increases. The greenhouse studies have shown that the slag application in tea garden soil and rice field soil leads to the increase of plant yield and the phosphorus and Mn uptake; an increase of iron and potassium uptake has been detected in rice field, a decrease of K uptake in tea garden has been observed, while Fe uptake has not been changed. The same results have been achieved after the application of basic slag in acid sulphate soils in an incubation study. The investigation aimed at assessing the ability of basic slag to neutralize acid and its effectiveness on the solubility of basic cations in the soils, in order to achieve a sustainable use of acid sulphate soils in coastal areas of Bangladesh[19]. A wide range of processes can lead to the addition of acid cations and the removal of basic ones in the soils. The acid water, penetrating into the ground, through the leaching process, tends to increase the acidification of the soil, except if bases are compensated by different sources, such as atmospheric deposition. When acid cations are in soil solution, they tend to replace basic cations. This can also affect the metals and metalloids mobility in the groundwater, with the result that this can be a threat to groundwater and the health of aquatic and terrestrial ecosystems. Incubation experiments showed that basic slag increases soil pH, mainly due to its neutralizing effect that releases basic elements in the acid sulphate solution. This process reaches the highest value after several days of incubation under saturated moisture condition, probably due to slow releasing of basic ions from basic slag. In addition the application of basic slag increases potassium, calcium and magnesium in soils, although, in some cases, over the course of time, a small decrease of this trend has been observed, probably because of the formation of insoluble compounds of calcium and magnesium.

DISCUSSION:

Use of slag as an iron fertilizer:

The problem of iron chlorosis can affect many crops on calcareous soils, resulting in substantial yield losses. Generally it has been corrected through the addition of Fe synthetic chelates, but these have resulted very expensive. Various studies have been focused on applying different Fe sources, in order to reduce the economic burden and to recycle some industrial by-products, such as converter slag [20,21].They are used not only as soil amendment but also as source of important plant nutrients, such as P, K, Mg and Fe oxides. An investigation pursued on 1984 showed that the application of a steel by-product as fertilizer to alkaline soils, with without sulphuric acid, increased dry matter yield of sorghum [22]. A similar treatment, through a mixture of sulphuric acid and iron sulphates, has allowed to correct Fe chlorosis in corn and alfalfa [23]. While converter sludge has been used as Fe fertiliser in calcareous soils with positive results, recently the use of converter slag as source of Fe fertiliser in some calcareous soils incubation studies has led to relevant achievements. On this subject, pot experiments in a greenhouse have been carried out in China[24]. Relevant results of this study have shown that the use of moderate steel slag or acidified slag as Fe fertilizer leads to the increase in Fe uptake and corn dry matter yield. This phenomenon is proportional to the application rate and is enhanced by the acidification of slag, although increasing application rates do not produce further improvements in yield and in Fe uptake. This propounds a possible optimized rate of these applied substances. On the other hand, in experiments conducted with the sandy loam dry matter yield significantly decreased , because the Fe availability decreases with salt levels increase, resulting in a yield decrease and an increase of chlorosis in plants.

The investigate the correct rates of converter slag for different crops and its possible residual environmental impacts to the soil, important results have been achieved by using this by-product as a source of available Fe [25]. In an incubation study, by adding to the soil converter slag (from Isfahan steel factory, Isfahan, Iran), containing about 24% of Fe oxides, along with elemental sulphur and organic matter, the soil pH has increased, due to the alkaline pH of slag. But during the incubation time the pH decreased. According to previous studies, either to the precipitation of the free carbonates as calcium carbonate [26] or to the hydrolysis of $Fe3+$ in the soil [27]. The decrease of soil pH probably results from the decomposition of organic matter applied and subsequent organic acids and CO_2 release as well as the buffering ability of the calcareous soils. The observed yield increase in these soils may be due to the some nutrients availability as a consequence of pH increase.

The converter slag application has increased ammonium bicarbonate diethylene triamine pent acetic acid extractable Fe, although in some incubation soils Fe extractable decreased, maybe due to the temporary fixed of iron by organic matter. Further in the pot experiment converter slag has been shown to be very effective in correction of Fe chlorosis in calcareous soils.

Calcium silicate fertilizer using blast furnace slag.

Sl.No	Characteristic	Advantages	Examples
1.	Boosting dry matter production improving harvest quantities appearance and flavour.	Boosts dry matter production. Improves ripening in later growth stages. Increases harvests by increasing the number of unshelled rice kernels. Improves appearance quality, increasing the ratio of and highest grade rice. Promotes ripening to improve flavour.	Fertilizer using granulated slag
2.	Silicate for healthy rice plants.	Promotes photosynthesis by improving light-receiving healthy rice condition of leaves. Creates strong stems that resist collapse. Silicified cells form on leaf surfaces.	Fertilizer using granulated slag .

Converter lime fertilizer using iron and steel slag:

Sl.No	Application	Advantages	Examples
1	Dry field farming	Creates a general soil fertilizer containing a good balance of various fertilizer components needed by crops, including silicate, iron oxide, lime, magnesia, phosphate, manganese, and boron Helps improve acidic and deteriorated soil, that not only improves alkalinity but also promotes the breakdown of organic substances	Fertilizer using converter slag
2	Wet field farming	Iron oxides and manganese give vitality to roots Silicate, lime, phosphate, and magnesia create healthy rice plants. Effective in improving iron-poor soil (preventing root rot, leaf blight, and autumn paddy degradation)	Fertilizer using converter slag

Use of steel Slags for metal stabilization in contaminated soils:

Some investigations about the addition of steel slag in contaminated soils have been carried out. The stabilization technique is based on the incorporation of amendments, in order to minimize metals and metalloids, such as As, Cr, Cu, Pb, Cd and Zn that can be found in contaminated soils at wood treatment plants. When Pb can be stabilized by using phosphorus-containing amendments, that reduce the Pb mobility, Zn can be immobilized in soil by using phosphorus amendments and clays (Kumpiene et.al.,2008, as cited in Negim et.al.,2009). While the As can be stabilized by sorption on Fe oxides and also by the formation of amorphous Fe (III) arsenates, the Cr immobilization takes place through Cr reduction from Cr (VI), which is mobile and toxic, to Cr (III), which is stable.

When the copper sulphate and chromate copper arsenate are used to protect wood from insects and fungi, they can cause the soil phytotoxicity. The Cu stability in soil is pH dependent, because its mobility increases with decreasing pH. Carbonates, phosphates and clays can reduce the mobility and availability of Cu in soil. The proposed mechanism consists in precipitation of Cu carbonates and oxy-hydroxides, ion exchange and formation of ternary cation–anion complexes on the surface of Fe and Al Oxy-hydroxides. The utilize of alkaline materials, organic matters, phosphates, alumina-silicates and basic slag has been shown to limit the accumulation of Cu in plants cultivated in Cu-contaminated soils.

Recent study, the use of slag with basic properties into a Cu-contaminated soil has led to relevant results in soil composition [28], Because of its Ca and P content, the basic slag is a fertiliser, as it improves the physico-chemical properties of the soil and by increasing plant growth and liming materials are use as it increases the precipitation and sorption of metals such as Cu. For this reason, the effects on soil pH, soil conductivity, plant growth and chemical composition of bean plants in pot experiments, by mixing soil with increasing basic slag addition rates, from 0% to 4%, in controlled conditions. This material affects the soil solution composition through acid-base, precipitation and sorption reactions. In particular the soil pH has increased from 5.6 to 9.8, and the soil conductivity has risen from 0.11 to 0.85 mS cm-1 by applying increasing rates of basic slag due to the basic slag composition, particularly to the Calcium content. Furthermore the foliar Cu concentration has probably caused a phytotoxic effect in plants grown in Cu-contaminated soil. When the basic slag addition at 1% rate the bean growth, along with the decrease of foliar Cu concentration, has been observed. Moreover while the Calcium foliar concentration has increased after applying increasing rates of basic slag, the foliar Phosphorous concentration has not been improved. These results suggested that the use of basic slag at 1% addition rate is effective as a liming material but, is not effective as P fertiliser. Furthermore, the basic slag addition in contaminated soil does not increase the foliar concentrations and accumulations for Zinc, Cadmium and Chromium.

Fertilizer and soil improvement:

The pulverized basic oxygen furnace slag was used in acidic soil to grow vegetables and crops. The utilize of basic oxygen furnace slag for lime and phosphate fertilizers as well as special fertilizer containing iron is being practiced in many countries. The basic oxygen furnace slag contains various trace elements such as iron oxides, manganese, and boron in addition to calcium, magnesia, and silica. It also exerts quick alkaline effects due to calcium as well as slow but long-lasting effects due to calcium silicate. Therefore, it is characterized by being able to offer improvement effects for acidic soil lasting longer than those of ordinary fertilizers such as magnesium lime and hydrated lime. NKK Japan has developed a process to produce eco-friendly slow-release potassium silicate fertilizer from the slag that shows less release effect rather than conventional fertilizers and also improves soil quality and productivity.

Utilization of steelmaking slag and converter slag:

Blast furnace slag, there are certain limitations which limit the utilization of BOF slag. It contains significant amounts of FeO, free lime, high magnesia and high phosphorous. As it contains large amounts of FeO, one of the options is to recycle back into the iron-making processes. Unfortunately, the phosphorous content in the BOF slag is so high that only limited amounts can be recycled and if phosphorous content is very low that it cannot be used as fertilizer.

LD slag can be used in different fields of application such as fertilizer, soil conditioners, and recovery of metal values due to its hard characteristics. Steelmaking slag from Basic-Bessemer or Thomas process has been used as a phosphatic fertiliser, but also the current LD slag composition containing SiO_2 CaO, MgO, Mn and other valuable micronutrients, such as zinc, copper, boron and cobalt makes it suitable as liming materials. On one hand, calcium and magnesium compounds, because of their basicity, improve soil pH and also they are plant nutrients and stabilisers for soil aggregates. Physical treatments of slag as well as its mineral composition influence the solubility and plant availability of the nutrients. Silicate has a special bond in the slag minerals and it is useful for plant nutrition and soil quality. In fact silicate provides beneficial effects on plant health and soil structure, increase the phosphate mobility in the soil and the efficiency of phosphate fertilisation [29].

CONCLUSION:

Slag is most effective used in field of farming to conditioning the soil and Steelmaking slag may directly be used as fertilizer and also it can be mixed with animal waste materials. Steelmaking slag contains Si, Fe, P, Mn, Ca, and various other elements required in fertilizers. Since paddy rice consumes a large amount of Si, the slag silicate fertilizer has become widespread, although it is effective in improving acid soil. The application of Si fertiliser has beneficial effects on both rice and sugarcane field, when soil soluble Si is low. Use of slag in tea garden soil and rice field soil leads to the increase of plant yield and also decrease of potassium uptake in tea garden has been observed and phosphorus and manganese uptake and an increase of iron and potassium uptake has been observed in rice field.

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