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Comparisionof Lime and Rail Wheel Factory Slag as an Amendment in Acid Soils of Karnataka

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Abstract: *Amelioration of acid soils with liming materials is a common practice. Steel industry basic slag is one such lime source. In this study the possibility of using RWF (Rail Wheel Factory) slag, as an amendment along with other sources. Different sources of liming material $CaCO_3$,CaO and RWF slag were used @ 50,100 and 150% equivalent of exchangeable acidity. The changes in pH, EC and exchangeable calcium and magnesium were determined after 30 and 60 days. Liming material @150% equivalent of exchangeable acidity performed better in increasing soil pH, EC and exchangeable calcium and magnesium.*

Keywords: *Acid soil, Amelioration, Lime, Rail wheel factory slag*

1. INTRODUCTION

In India, more than 45 million hectares of land is acidic and Karnataka is one among the several states where the acidic soils are spread over a large area. Out of the 19.2 m ha of geographical area in Karnataka, nearly 9.6 m ha (50 per cent of the total area). [3] reported that in Karnataka, acid soils were found in the districts of Dakshina Kannada (72%), Uttara Kannada (65%), Kodagu (40%), Chickmagalur (39%), Shimoga (33%), Hassan (20%), Mysore (15%), Mandya (12%), Bangalore (10%) and Belgaum (10%).

Under acidic condition, beneficial nutrient supply in respect of Ca, Mg, N, P and S gets reduced and hence plant growth. The low yields of crops in acid soils are because of poor nutrient supplying power of soils. To meet the calcium demands as well as to create favorable pH conditions for better uptake of other essential nutrients, liming is an important management practice in the acid soils.

Rail wheel factory (RWF) at Yelahanka, Bangalore is a premier rail wheel manufacturing unit. The cast steel technology used in the manufacture of rail wheels results in production of slag which has high pH, Ca and other nutrients and is a potential liming material. The use of alkaline slag for amending acid soil and improving plant growth was analyzed in a study carried out in Iran [2]. With increasing application of slag, the soil pH proportionally increased. [8]reported that liming of acid soils of hill zone of Karnataka increased exchangeable Ca from 3.82 ± 0.30 to 4.51 ± 0.27 Cmol kg^{-1} compared to unlimed soils.

Liming followed by additions of secondary and micro nutrients helped raise base saturation of the soil and inactivation of iron, aluminium and manganese in the soil solution and minimize phosphate fixation by iron and aluminium and improve fertility and productivity of the soil. [1]conductedgreenhouse studies and results showed that the slag application (1% and 2% (w/w)) in tea garden soil and (0.5, 1 and 2%) in rice field soil resulted in increased yield, P and Mn uptake. An increase in Fe and K uptake was also detected in rice field. K uptake in tea garden decreased, while Fe uptake remained the same.

An attempt was made to compare Rail Wheel Factory Slag and agricultural lime as liming material in an acid soil to study the efficacy of lime and industrial slag in neutralizing soil acidity

2. MATERIAL AND METHODS

A major byproduct of the rail wheel manufacture is the slag obtained by steel melting. Slag is basic in reaction and a good source of calcium and other nutrients. Hence used as an amendment and a nutrient source in acid soils. Rail wheel factory slag was powdered and sieved through 0.2 mm sieve to increase reactivity and was predigested by using 5 ml of concentrated nitric acid and was kept overnight. The sample was digested with 10 ml of di-acid mixture (HNO_3: Perchloric acid in 10: 4 ratio) until white residue was obtained. The residue was cooled and diluted to a known volume using distilled water, filtered and used for further analysis. The details of physic chemical properties are provided in Table.1

An incubation study was conducted in a greenhouse to determine the efficacy of lime, calcium oxide and industrial slag as a liming agent in four acid soils of Brahmavara, Shimoga, Mangalore and Mudigere. The chemical properties of soils of four agroclimatic zones are provided in Table.2. The treatments were included addition of $CaCO_3$, CaO and RWF slag@ 50,100 and 150% equivalent of exchangeable acidity to the soils which were maintained at field capacity. The changes in the pH, EC, Ca and Mg contents were monitored at 30 and 60 days of incubation at field capacity and submergence and analyzed for acidity neutralizing capacity

Table 1: Physical and chemical properties of rail wheel factory slag

Sl No	Parameters	Content
Physical properties		
1	Bulk density (g cc-1)	0.52
2	Particle density (g cc-1)	2.35
3	Water holding capacity %	31.00
Chemical properties		
4	pH (1:2.5)	10.28
5	EC(dSm-1) (1:2.5)	0.43
6	N %	0.000098
7	P %	0.0068
8	K %	0.000075
9	Ca %	30.00
10	Mg %	10.8
11	S %	0.042
12	Fe %	11.8
13	Cu %	0.40
14	Mn %	1.80
15	Zn %	0.06
16	Na %	0.000131
17	Cr %	0.018
18	Cd %	ND
19	Ni %	ND
20	Pb %	ND

* ND- Not detected

Table 2: Chemical properties of soils of different agroclimatic zones.

Soil	pH	EC (dSm-1)	Ca (cmol [p+] kg-1)	Mg (cmol [p+] kg-1)
Brahmavara TypicKandiustults	4.65	0.08	1.10	0.4
Shimoga UlticHaplustalfs	5.12	0.06	1.15	0.9
Mangalore TypicKandiustults	5.90	0.10	3.11	1.60
Mudigere Paleustulfs	4.93	0.04	1.42	0.50

3. RESULT AND DISCUSSION

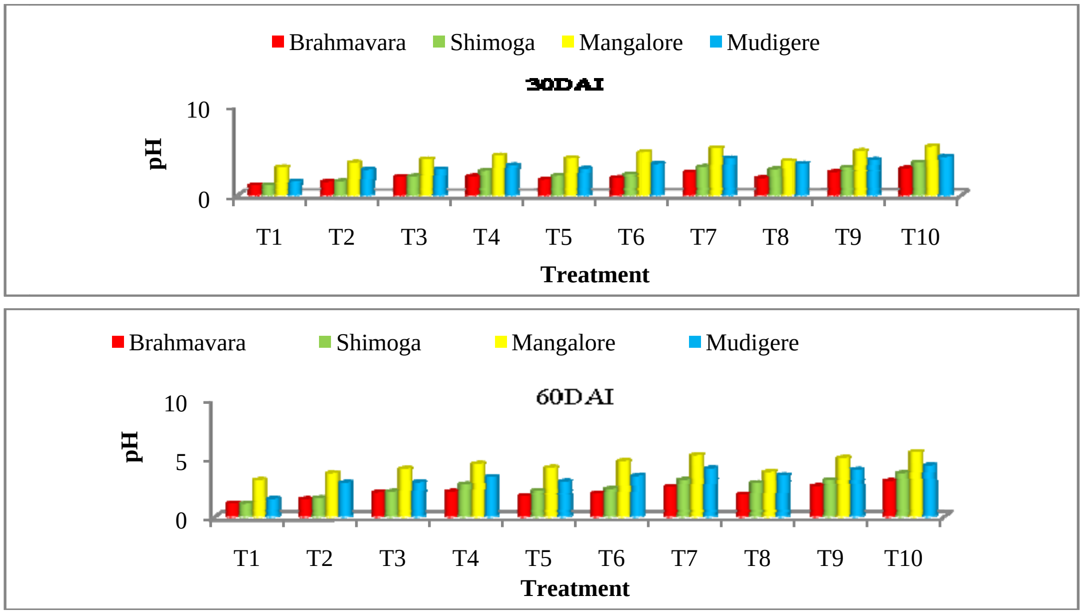
The chemical composition of rail wheel factory slag presented in table 1 recorded bulk density, particle density and maximum water holding capacity of $0.52gcc^{-1}$, 2.35 g cc^{-1} and 31 per cent respectively. The pH of slag was 10.28 with electrical conductivity of $0.45dSm^{-1}$. The concentration of total nitrogen and potassium were considerably less where as phosphorus was 0.0068 per cent. The calcium, magnesium and sulphur contents were 30, 10.8 and 0.042 per cent respectively. The concentration of iron, copper, manganese and zinc were 11.8, 0.40, 1.8 and 0.06 per cent respectively. Heavy metals nickel, cadmium and lead were not detected and the content of chromium was 0.018 per cent.

These results are similar to those for converter slag a byproduct of steel industry as reported by [2] who reported that converter slag had higher pH (13.2) and less EC. The major components of converter basic slag are Ca and Mg followed by Fe. Higher amount of calcium oxide and magnesium oxide was observed in converter slag (52.8%, 2.28% respectively), MnO (4.46%), SiO_2 (8.92%) and P_2O_5 (4.76%). [2]. [9] reported that the basic slag of steel industry consisted of Ca-20.8%, Mg-9.8%, Fe-11.6%, Mn-0.04%, PO_4-0.03% and pH-9.6. [4]reported that basic slag contained P_2O_5 ranging from 2-6% and some micronutrients and magnesium.

An increase in soil pH was observed with increased liming in soils of different agro climatic zones (Fig.1). The pH rose from 4.65 to 6.67 in Brahmavara soil, 5.12 to 7.10 in Shimoga soil, 5.9 to 7.64 in Mangalore soil and 4.86 to 6.81 in Mudigere soil is presented in fig 1.

A similar trend was followed in case of EC of soil. Which increased from 0.08 to 0.24 in Brahmavara soil, 0.06 to 0.18 in Shimoga soil, 0.10 to 0.24 in Mangalore soil and 0.04 to 0.21 (dSm^{-1})in Mudigere.

Among the treatments T_{10} (CaO @150% equivalent of exchangeable acidity) recorded significantly higher pH and EC compared to all other treatments at 30, 60 days of incubation. Calcium oxide treated soils recorded higher pH and EC compared to other liming materials as it has highest neutralizing value. Other liming material such as calcium carbonate and RWF slag also increased the pH and EC of soils. The pH increased on addition of lime and decline in Al^{3+} activity. The slag neutralizes active acidity by removing free hydrogen ions from the bulk solution, thereby increasing pH and basic cations. The action is similar to the application of basic slag to acid sulphate soil which significantly increased soil pH, Ca and Mg with an associated decrease in Na, Fe and Al concentrations over time [6]. Basic slag had a very high pH of 9.6 and contained 20.8 % Ca, 9.8 % Mg, and 12.8 % SiO_2[7]. Liming of acid soils results in reduction in concentration of exchangeable and soluble aluminum as a result of precipitation of Al as insoluble hydroxyl-Al species [5].



Note: T_1 - Control, T_2 - $CaCO_3$ @ 50% equivalent of exchangeable acidity, T_3 - $CaCO_3$ @ 100% equivalent of exchangeable acidity, T_4 - $CaCO_3$ @ 150% equivalent of exchangeable acidity,T_5 - RWF slag @ 50% equivalent of exchangeable acidity, T_6 - RWF slag @ 100% equivalent of exchangeable acidity,T_7 - RWF slag @ 150% equivalent of exchangeable acidity, T_8 - CaO @ 50% equivalent of exchangeable acidity,T_9 - CaO @ 100% equivalent of exchangeable acidity, T_{10} - CaO @ 150% equivalent of exchangeable acidity.

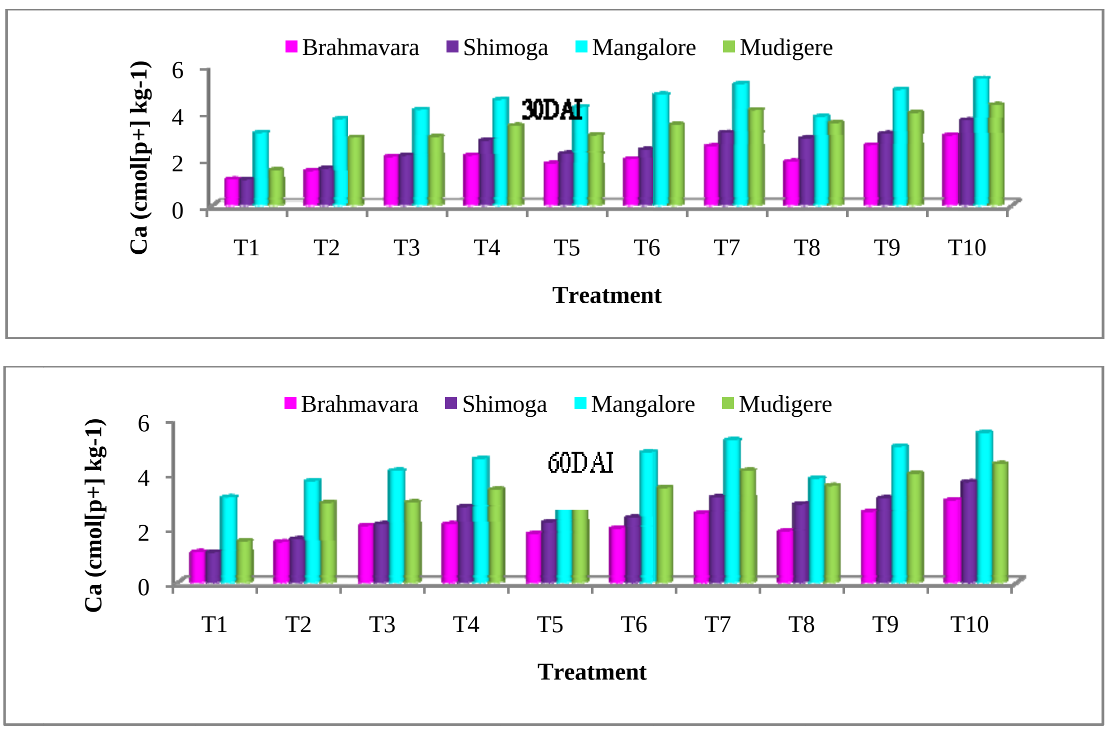


Fig. 2: Effect of liming material on soil reaction (EC) at 30 and 60 days of incubation at field capacity

Note: T_1 - Control, T_2 - $CaCO_3$ @ 50% equivalent of exchangeable acidity, T_3 - $CaCO_3$ @ 100% equivalent of exchangeable acidity, T_4 - $CaCO_3$ @ 150% equivalent of exchangeable acidity,T_5 - RWF slag @ 50% equivalent of exchangeable acidity, T_6 - RWF slag @ 100% equivalent of exchangeable acidity,T_7 - RWF slag @ 150% equivalent of exchangeable acidity, T_8 - CaO @ 50% equivalent of exchangeable acidity,T_9 - CaO @ 100% equivalent of exchangeable acidity, T_{10} - CaO @ 150% equivalent of exchangeable acidity.

Among soils of different agro climatic zones higher calcium content was recorded in Mangalore soil (5.47 kg ha^{-1}) and least in Brahmavara soil 3.00 kg ha^{-1} (Fig 2). Calcium content increased in all soils varying from 1.10 to 3.00 in Brahmavara soil, 1.15 to 3.67 in Shimoga soil, 3.11 to 5.47 in Mangalore soil and 1.42 to 4.33 kg ha^{-1} in Mudigere soil. Maximum magnesium content was noticed in Mudigere soil (3.63 kg ha^{-1}) and least was in Brahmavara soil (2.43 kg ha^{-1}).

Fig. 1. Effect of industrial slag on soil reaction (pH) of soil at 30 and 60 days of incubation at field capacity

Among treatments T_{10} (CaO @150% equivalent of exchangeable acidity) recorded significantly higher Ca and Mg compared to all other treatments at 30, 60 days of incubation in all soils. Significant increase in level of calcium and magnesium were observed at field capacity on application of different source of liming materials. Increase in the quantity of lime added enhanced calcium content of soil.

The increase in charge density due to liming has greater affinity for higher valent ions. Thus Ca being divalent ion and its higher activity in soil solution due to liming increased its concentration on exchange complex. The increase in exchangeable magnesium content of soil upon liming can be explained by the same principle as Ca.

4. CONCLUSION

The results revealed that with application liming material there was significant increase in pH, EC, Ca and Mg with time in soils of four zones. Industrial slag according to this study has shown promising results in terms of amending soils and as nutrient sources, therefore it can be a substitute for lime.

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