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作品名稱 **USING IRON-STEEL INDUSTRIAL WASTE SLAGS AS A FERTILIZER**

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ABSTRACT OF EXHIBIT
TAIWAN INTERNATIONAL SCIENCE FAIR

Steel slag, is received from iron and steel production facilities in Turkey, and is up to 25-30% from steel production. These couldn’ t have been reclamation for any field of use and free stored in nature. When the structure of this slag examined, it was contained metallic formation (Fe_2O_3, Al_2O_3, MnO_2, MgO_2 etc.) and oxide compositions (SiO_2, CaO_2 etc.). The aim of this project is investigate metallic content of steel slag used as fertilizer in plants. For this purpose, slag is used to determine the physical and chemical characterization. Then, it is separated frommetallic content by using shaking table and multi gravity separative (MGS) method. After these procedures, there are determinate 6 groups with different densities and different grit size. Element analysis was made of these groups by atomic absorption spectrophotometer (AAS) and ICP-OES system. In addition, mineral analysis was determined by XRD device. Thus, within each group minerals have been identified. Slag-soil mixture was prepared for determination the highest yield of using six different slag groups as fertilizer in the plant. Thus, corn crops were grown in different combinations. Then harvested corn plants and done soil analysis of the plants. As a result of experiments, percentage of the most effective slag-soil composition for corn was determined. The highest yield in the slag pot was determined the rate of %12.5 and coarse-grained. Ideally, the slag content found to be chinerals such as merwinite ($3CaO-MgO-2SiO_2$), akermanite ($2CaO-MgO-2SiO_2$), gehlenite ($2CaO-Al_2O_3-SiO_2$). Thus, it was detected the steel slags can be used as feed material for plants. Hence by maintaining the ecological balance economic contribution to the country was achieved.

1. Purpose of the research:

Today, with the world population increases, the growth rate of technology is increasing. Besides developing technology people's needs are also varied and also for these needs can be met the development of industrial enterprises is quite accelerate. Industrial wastes also affect adversely the environment. Researches for industrial waste to be recycled are not done efficient today. It is aimed that providing the slag as iron-steel industry waste in different way for contribute to the national economy and protect the ecological balance.

- Becoming widespread the recycled waste formed by industrial organization tothe nature.
- Investigating areas of use of the iron-seel slag
- Determination of the content of slag,
- Finding rcycling methods by looking content of the slag
- Making decision valuable minerals in the content of the slag samples the potential for use as fertilizer in plants
- Classification according to various grain sizes to be used as a fertilizer separation slag samples classified according to grain size by their density
- Carrying out chemical analysis of slag samples seperated by spesific groups
- Determination of samples with high mineral content and used for planting slag samples by chemical analysis results
- Planting the determinated samples to the soil mixed with different percenteges of slag for finding the most efficient combination of slag-soil
- It is aimed that observing the growth ofplants and determinating the most efficient cobination of slag-soil mixture

2. Procedures:

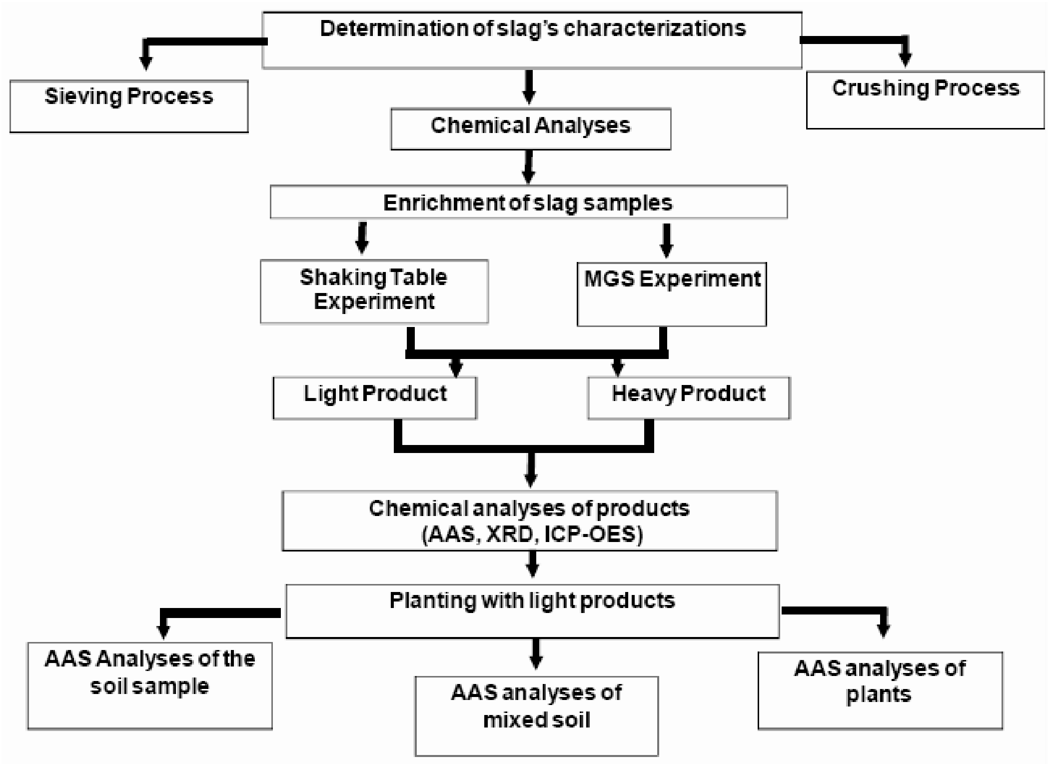

Figure1

3. Data:

<u>Steel Slag</u>

To identify the ares of evaluation of steel slags, it is required for determine the physical and chemical properties of steel slag.

<u>Physical Characteristics of Slag</u>

The table below shows overall physical content of iron and steel slag.

Table 1. Physical characteristics of slag

Characteristic	Value
Density	3,2 – 3,6
Water absorption capacity	< % 3

<u>Chemical Characteristics of Slag</u>

Chemical content of the slag (composition) indicated simple metal oxides that determined by elemental x-ray analysis method. It is required that having information about the content of the slag should be determined areas for the use of slag. The following table provides information about the content of the slag.

Table 2. Chemical characteristics of slag

Compound	Composition (%)
CaO	40-52
SiO_2	10-19
FeO	10-40 (70-80 % FeO, 20-30 % Fe_2O_3)
MnO	5-8
MgO	5-10
Al_2O_3	1-3
P_2O_5	0.5-1
S	< 0.1
Metallic Fe	0.5-10

Because of the needs of chemical analyses, physical analyses were done first. For the first step sieving analyses was performed by sieve shaking device to see normal grain sizes of slag.

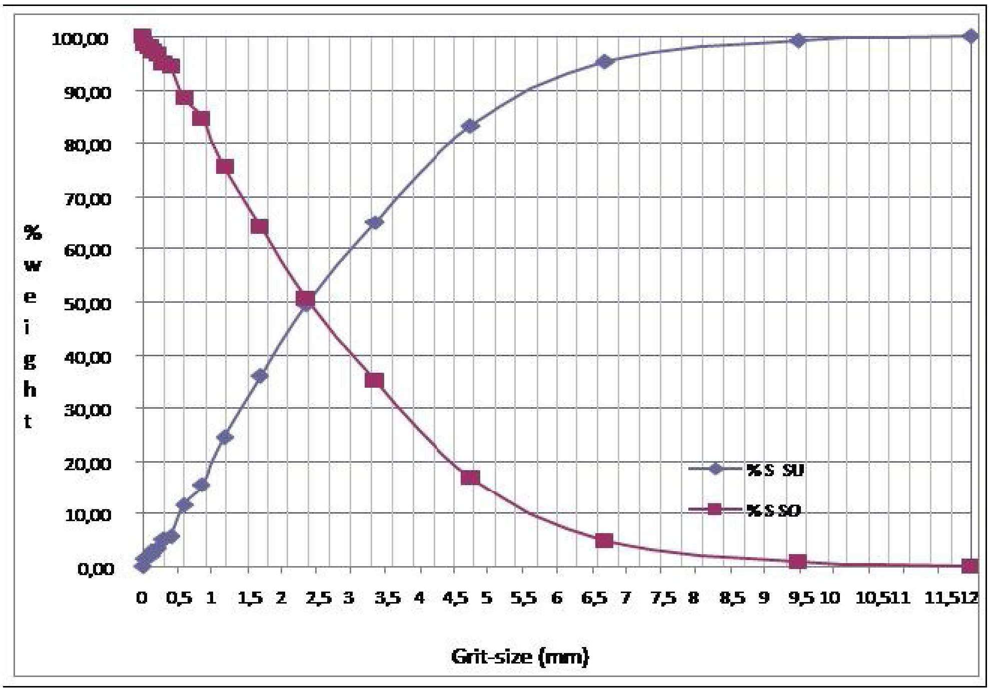

Figure 2. Graphics of the samples under and above sieves.

Because of the high results, slags were taken for crushing process. In this process 2 different device were used which were Jaw Crusher and Roller Crusher.

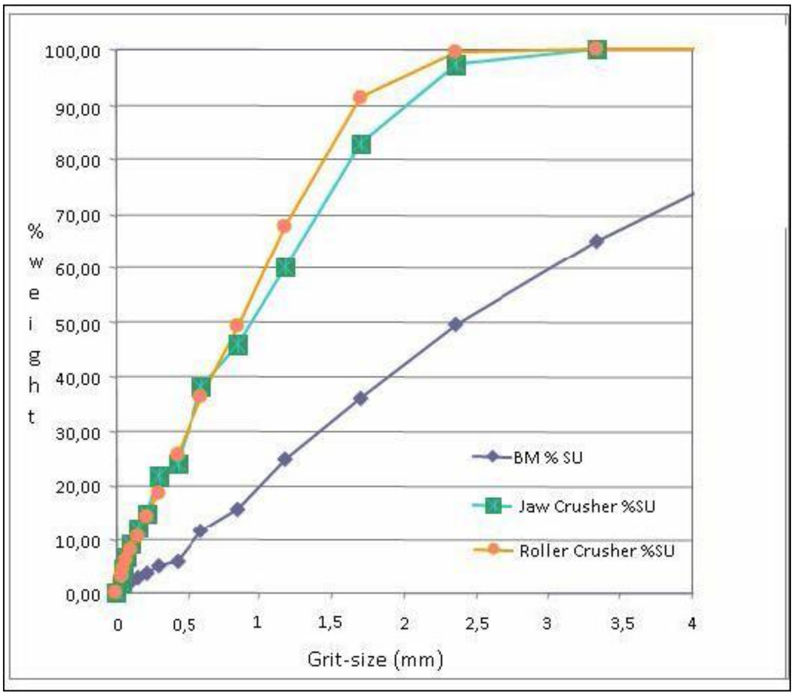

Figure 3. Comparison of Sieve Analysis Result

Table 4. Mineral Values in Atomic Absorption spectrophotometer

Samples / Minerals	Fe_2O_3	Al_2O_3	MnO_2	CaO	MgO
SM_1 A	28,90	7,85	3,47	36,53	8,19
SM_1 B	28,05	8,07	3,67	35,51	8,33
SM_1 C	26,26	8,36	3,65	36,19	8,66
SM_2 A	29,01	7,96	3,65	35,85	8,66
SM_2 B	26,88	8,19	3,49	33,46	8,46
SM_3 A	33,25	6,93	3,39	32,78	8,60
SM_3 E	25,82	6,61	3,76	36,53	8,13
SM_4 A	34,57	6,88	3,42	34,82	8,40
SM_4 C_1	27,11	6,62	3,37	36,19	8,06
SM_4 E_1	27,26	7,76	3,42	35,17	8,40
MGS_1 Consentry	33,10	4,45	3,71	29,70	8,66
MGS_1 Waste	24,76	6,93	2,73	33,46	8,33
MGS_2 Consanty	31,23	7,30	3,86	32,09	9,20
MGS_2 Waste	29,23	6,96	3,42	35,51	8,53
Slag feed sample	29,13	8,15	3,62	37,56	8,46

It is intended to determinate of particle size can be freed the valuable minerals within the slag samples which is separated for crushing analysis.

After the crushing process, Enrichment process began. For this experiment two other devices were used which shaking table and multi gravator separator also known as MGS. With the successful separation of heavy and light products, chemical analyses began.

For chemical analyses, first used instrument was Atomic Absorption Spectrophotometer, also known as AAS. After the confirmed of theory, for more detailed results samples were given for ICP-OES analyses which was also a conformation. For the mineral content of products XRD analyses were performed by X-Ray Diffraction instrument.

Graphic given below for comparison samples of slag by content values of minerals.

Table 5. Minerals and formulas

Minerals	**Formulas**
Akermanite	2CaO-MgO-2SiO2
Gehlenite	2CaO-Al2O3-SiO2
Wollastonite silicate	CaO-SiO2
Merwinite	2CaO-SiO2
Anorthite	3CaO-MgO-2SiO2
Monticellite	CaO-Al2O3-2SiO2

Table 6. Results of ICP-OES.

NO	Sample	Fe_2O_3 (%)	Al2O3 (%)	MnO (%)	CaO (%)	MgO (%)	SiO2 (%)
1	SM1B	23,84	8,07	3,67	33,95	5,32	19,64
2	SM4E1	22,53	7,76	3,42	32,89	4,99	18,22
3	MGS waste	19,65	6,93	2,71	31,22	5,02	18,47
4	SM3A	32,92	6,93	3,39	30,73	4,95	15,42
5	SM1C	21,01	8,36	3,65	33,94	5,29	16,54
6	Cüruf BM	24,84	8,15	3,62	33,87	5,04	15,00
7	SM4A	30,03	6,88	3,41	29,88	5,04	14,57
8	SM2A	25,70	7,96	3,65	34,12	5,49	15,27
9	SM3E	22,96	6,61	3,76	32,38	4,76	20,47
10	MGS consanty	30,23	4,45	3,71	28,46	4,66	15,53

NO	Sample	TiO2 (%)	Na2O (%)	K2O (%)	P2O5 (%)	Cu (ppm)	Zn (ppm)
1	SM1B	0,44	0,16	0,03	0,07	227,8	<0,1
2	SM4E1	0,44	0,33	0,07	0,05	241,8	<0,1
3	MGS waste	0,38	0,30	0,13	0,01	303,1	582,8
4	SM3A	0,40	0,17	0,03	0,00	576,4	<0,1
5	SM1C	0,44	0,17	0,06	0,05	199,7	<0,1
6	Cüruf BM	0,46	0,16	0,03	0,07	260,2	<0,1
7	SM4A	0,40	0,14	0,04	0,00	457,2	<0,1
8	SM2A	0,43	0,19	0,04	0,03	453,8	<0,1
9	SM3E	0,48	0,66	0,49	0,32	1134	<0,1
10	MGS consantry	0,41	0,73	0,53	0,31	728,5	<0,1

NO	Sample	Ni (ppm)	Cd (ppm)	Pb (ppm)	Cr (ppm)	Co (ppm)	Mo (ppm)
1	SM1B	14,40	<0,1	6,53	5198	1,12	<0,1
2	SM4E1	21,55	<0,1	175,10	4745	6,76	<0,1
3	MGS waste	41,94	1,27	536,70	3802	9,94	<0,1
4	SM3A	82,76	<0,1	92,90	4504	8,63	<0,1
5	SM1C	12,15	<0,1	26,93	5679	4,05	<0,1
6	Cüruf BM	23,60	<0,1	46,15	4840	62,47	<0,1
7	SM4A	61,37	<0,1	157,60	4670	7,39	<0,1
8	SM2A	31,71	<0,1	27,33	4556	5,29	<0,1
9	SM3E	278,60	<0,1	291,90	14570	16,02	<0,1
10	MGS consanty	74,52	<0,1	266,90	10630	7,55	<0,1

Table 7.

Groups	Slag Samples
1. group	SM_1 B + SM_1 C
2. group	SM_2 B + SM_2 C
3. group	SM_3 E + SM_3 D_1 + SM_3 E_1
4. group	SM_4 E + SM_4 B_1 + SM_4 C_1 + SM_4 E_1
5. group	MGS_2 waste product
6. group	MGS_1 waste product

For planting process similar products were matched into groups and every pot contained different percentage of slag which was %25,%50,%75 %100 slag and %100 soil as an control group.

Nutrient is absolutely necessary or plants. Nutrients have to provide 3 main conditions.

These are;

1- If the element is missing, it can not complete the period of plant life,

2- Element, have a special effect, with the entire plant,

3- Elements have a direct effect of the plant.

For the planting process, corn was chosen to be the plant because of it’s adaptation to almost every climate in different regions also it’s a 1 year old plant which grows fast enough for experiments.

Figure 3.46 (a) while harvesting the plant (b) harvested plants

When examined chemical analysis of growing plants and the physical observations, that the content of the slag is useful for plant and suitable for using as fertilizer.

According to the information obtained from the literature when comparison of steel slags that we used and in generally, contains of used steel slags have;

- Below average amount of CaO
- Lower lever amount of MgO
- Normal level amount of SiO_2
- Normal level amount of Fe_2O_3
- Below average amount of MnO
- Above average amount of Al_2O_3
- Normal level amount of P_2O_5

As a result of shaky table experiments of the enrichment gravimetric analysis; low density of the slag samples by slag feed samples, content of the trace element (Fe, Zn, Cu Mn) ratios were seen close, heavy metals were low ratio, the proportion of mineral nutrient were seen high ratio.

Plants trace elements and heavy met contents are measured with atomicspectrophotometer. The values of plant that got the best results from of plant grown in pure soil are given the table below.

4. Conclusions

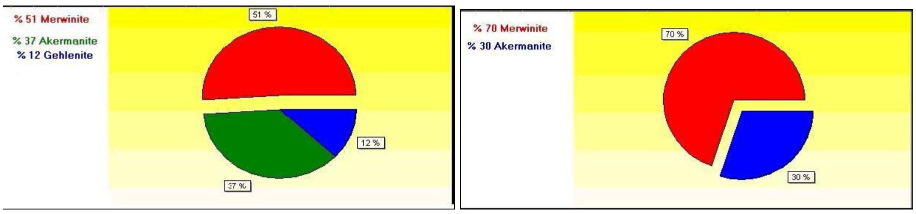

Figure 4. SM_1 B and SM_1 C

- Graph of the mineral content;
- Merwinite: $3CaO\text{-}MgO\text{-}2SiO_2$
- Akermanite: $2CaO\text{-}MgO\text{-}2SiO_2$

- Gehlenite: $2CaO\text{-}Al_2O_3\text{-}SiO_2$

In our study, SM1 B and SM1C sample has the most coarse grain size. As a result coarse grain sized slag samples are blocked the soil be pressed. Thus, plant roots are able to develop more easily in no congested soil. The soil was able to keep more air and water by gaps. By holding water feature soil with slag was yielded by using less water. Percentile values of the best results of the slag-soil composition are given the following table.

Table 8. the best result of the slag-Soil Composition Percentile Values

Group no – Mixture rate	total (%)	total (ppm)							
	Fe	Cu	Zn	Mn	Cd	Co	Cr	Ni	Pb
%100 soil	1,20	5,12	28,26	82,04	0,39	10,37	16,98	7,46	8,92
1- %12,5 slag	1,32	5,62	38,55	132,51	0,45	14,97	22,70	10,45	10,70
2- %12,5 slag	1,57	5,07	50,60	165,26	0,46	12,75	20,57	9,64	10,39
3- %12,5 slag	1,48	6,08	51,15	141,64	0,44	12,93	24,46	8,14	11,22
4- %12,5 slag	1,48	5,68	51,90	117,18	0,48	12,38	20,31	9,44	9,76
5- %12,5 slag	1,76	6,57	52,21	145,22	0,54	12,99	20,12	8,15	10,66
6- %12,5 slag	1,95	5,81	52,47	175,98	0,58	15,53	21,69	9,25	12,28

Plants trace elements and heavy met contents are measured with atomic absorption spectrophotometer. The values of plant that got the best results from these measurements and values of plant grown in pure soil are given the table below.

Table 9. AAS Analysis Results of the plant received best results

Group no – Mixture rate	Total (ppm)								
	Fe	Cu	Zn	Mn	Cd	Co	Cr	Ni	Pb
% 100 soil	69,18	3,27	8,09	21,13	0,08	0,86	0,91	1,52	1,93
1- %12,5 slag	55,64	3,26	10,12	25,64	0,09	1,15	1,10	1,96	2,06
1-%25,0 slag	51,88	3,52	10,60	26,92	0,11	0,98	1,01	1,83	2,53
1-%50,0 slag	51,88	3,80	17,77	28,12	0,13	1,24	1,02	2,01	2,65

Plants trace elements and heavy met contents are measured with atomic absorption spectrophotometer. The values of plant that got the best results from these measurements and values of plant grown in pure soil are given the table below.

Table 10. AAS Analysis Results of the plant received best results

Group no – Mixture rate	Total (%) Fe	Total (ppm)							
		Cu	Zn	Mn	Cd	Co	Cr	Ni	Pb
% 100 soil	1,20	5,12	28,26	82,04	0,39	10,37	16,98	7,46	8,92
1- %12,5 slag	1,32	5,62	38,55	132,51	0,45	14,97	22,70	10,45	10,70
1-%25,0 slag	1,76	6,57	44,21	178,23	0,55	12,34	20,02	9,54	12,62
1-%50,0 slag	1,78	6,31	52,10	190,20	1,06	16,36	20,49	12,83	13,40

The result of trace elements and heavy metals analysis of soil and plant samples taken from the pot samples, there were determined any problems in samples of trace elements and heavy metals.

Depending on the content of increasing slag samples are increased content of trace elements and heavy metal but this increase did not reach toxic levels.

The steel slag was detected supplying the nutrient and enriched the soil by mineral. Space was created for the use of steel slag. In this way, it has been achieved ecological balance preserved and also contributes to the national economy.

評語

This study investigated the usage of iron-steal industrial waste slags as a fertilizer in Turkey. The physical and chemical characteristics of slag, chemical analyses of products and planting with light products were investigated and discussed. By maintaining the ecological balance economic contribution to the country was achieved.