Impact of steel industry waste on Physico-Chemical property of soil

Rajbala Soni¹, Bhaskar. R²
1- Department of Environment Science, Vaish College of Engg., Rohtak
2- Department of Environment Science, G.J.University of S & T, Hisar
rajenv2009@gmail.com
doi:10.6088/tjes.00202030003

ABSTRACT

Industrialization, urbanization and modern civilization have lead to fast degradation of our natural resources like water, soil and air mainly. Soil resource is the important natural resource. Without it survival of life is not possible because it completes our daily indeed and supports our life. But after industrialization soil nutrient quality has been affected. There are so major and minor industries in our country that causing pollution and deteriorating our life. Steel plant is also included in the list of major industry and our paper entitle on study of effect of steel industry waste on physic chemical property of soil. Steel production at an integrated steel plant involves three basic steps. In first step, the heat source used to melt iron and ore is produced. Next the iron ore is melted in a furnace and finally, the molten iron is processed to produce steel. The iron and steel industry involves a myriad of operations which generate vast volumes of air emissions, liquid effluents and solid wastes. This article presents an overview of impact of steel industry on soil nutrient quality. 20 Samples were collected from different places of JSL(Jindal Strips Limited) steel plant of Hisar district(Haryana). The quality analysis has been made through physical parameter (WHC, Bulk density, Colour, pH) and chemical parameter (Sulphates, Phosphate, Na+, K+, Org.C, Chloride ion, Ca²⁺, Mg²⁺). A systematic calculation of the correlation coefficient has also been carried out between different analyzed parameters. Comparative studies of samples were conducted and it was found that soil is not acidic in nature, it is alkaline soil which have pH in range of 8.1 to 11.6. Value of calcium and magnesium is very high of sample no.11 & 17-20(wall of industry & slag dumping side) and these are the major nutrient for plant growth.

Keywords: EC, pH, Bulk density, Org.C, Sodium.

1. Introduction

In India the production of iron ore was merely 3 million tones but it has reached 75million whereas steel production has jumped from mere 1.04 million tones in 1950-51 to 25.1 million tones in 1997-98.Governemnet of India vide press note no. 9(1984 series ) dated 21st June, 1984 has published a list of 20 industries causing high pollution. The list includes iron and steel industry also. In view of this, it is felt necessary to go into the aspects of the environment impact assessment of steel industry. Soil has complex function which are beneficial to human & other living organism. It act as a filter, buffer storage, transformation system and thus protects the global ecosystem against the adverse effects of environmental pollutants.

Plants absorb metals from soil, water and air. The chief source of metal absorption is soil. Uptake from it depends not only on total content of metal but also on its accessibility to roots and transfer across the soil –root. The total amount of metal in soil, affected by the inherent
natural resources of particular areas in addition to agricultural and industrial activities. Metals present in ionic state in soil solution are available, while those which are bound to rock material are least available. Accessibility of Co, Mn and Ni increases with decrease in pH, while that of Mo and Si increase with rise in pH.

In metal uptake are observed in different plant species. Some plants are known to have special affinity for accumulating certain metals e.g. Astritalics sp. (Se), Crotaitalics cobalaticola (Co), Phaseolus vulgaris roots (Zn), Alga Chlorculla vulgaris (Au) and Sebertia accuminata (Ni) etc. Sebertia accuminata is Caledonia Site of world’s largest Ni deposits. Its leaves and latex may contain up to 10g and 250g per kg of Ni compounds on a dry weight basis. Aquatic plants accumulate several hundred fold amount of Ag as compared to other plants.

2. Material and methods

Samples are selected nearby side JSL (Jindal Strips Limited) of Hisar city. This industry is engaged in production of stainless steel and iron and steel bars. This industry responsible for emission of small amount of heavy metal as part of fly ash and sludge. Dumping site at back of industry which adjoins the fields and fly ash as well as sludge gets dispersed with wind to fields. There are some evidences of impact of industrial waste on physico-chemical property of soil. The present study was concern with this.

Twenty samples (A1 to A20) from JSL Hisar were collected by removing the top layer of about 1-2 inches (given in below mentioned table). The soil so collected were put in thick quality polythene bags and immediately brought to laboratory. Some of physical parameters were analyzed with in 6 hrs. Samples were dried in shade & then sieved through 0.3 mm mesh size sieve.

The soil sample so collected were put in thick quality polythene bags and immediately brought to laboratory. Some of parameter such as pH, EC were analyzed with in 6 hrs. of sampling. The samples were dried in shade before chemical analysis (Avoid direct sunlight). The dried samples were finally sieved through 0.3 mm mesh sized sieve.

Table 1: Number of Samples Selected for Observation Near Steel Industry

| Sr. No. | Sample | Location Site                                      |
|---------|--------|---------------------------------------------------|
| 1       | A1     | 5 mts. away from back side (wall of industry)     |
| 2       | A2     | 10 mts. away from back side (wall of industry)    |
| 3       | A3     | 25 away from back side (wall of industry)         |
| 4       | A4     | 40 away from back side (wall of industry)         |
| 5       | A5     | 60 away from back side (wall of industry)         |
| 6       | A6     | 70 away from back side (wall of industry)         |
| 7       | A7     | 75 away from back side (wall of industry)         |
| 8       | A8     | 85 away from back side (wall of industry)         |
| 9       | A9     | 90 away from back side (wall of industry)         |
| 10      | A10    | 95 away from back side (wall of industry)         |
| 11      | A11    | 110 away from back side (wall of industry)        |
| 12      | A12    | 125 away from back side (wall of industry)        |
| 13      | A13    | 20 mtr. Away from side wall of industry            |
| 14      | A14    | 30 mtr. (construction work side)                   |
| 15      | A15    | 40 mtr. (construction work side)                   |
| 16      | A16    | 45 mtr. (construction work side)                   |
Impact of Steel Industry Waste on Physico-Chemical Property of Soil

Rajbala Soni, Bhaskar. R
International Journal of Environmental Sciences Volume 2 No.3, 2012

|   |   |   |
|---|---|---|
| 17 | A17 | 1 km away from industry (Slag dumping on road side) |
| 18 | A18 | 1.5 km away from industry (Slag dumping on road side) |
| 19 | A19 | Fresh slag (on road side 2km away from industry) |
| 20 | A20 | Fresh slag (on road side 2km. away from industry) |

2.1 Physical Parameters

2.1.1 pH

To 10 gm of air dried soil 50 ml. of distilled water was added to prepare a suspension (1:5 w/v). The suspension was kept over a shaker for 30 minutes. The shaking period was not allowed to exceed 30 minutes otherwise various illogical processes may start in the suspension which may change the actual pH of the suspension. The pH of the suspension was estimated using “Eutech Cybernetics” made pH scan meter. The pH meter was calibrated with buffer solution of pH 4, 7 and 9.2 prior to its use.

2.1.2 Color of Soil

Colour of soil sample merely observed by seeing the colour of soil sample. Colour of soil sample was brown with either blackish/grey tinge.

2.1.3 Bulk Density

Weigh 100 gm of soil from each sample. For determine the bulk density soil samples were kept in sun light for 4-5 hours. After this volume of soil samples were noted & determined the bulk density in g/cm3.

2.1.4 Water holding Capacity

To determine the water holding capacity 100 ml of distilled water added to 10 gm of soil. Soil sample was kept in a glass funnel whose neck was fitted with wool glass. After addition of water samples were kept for 2-3 hours. In this duration soil absorbs the water & we determine the water holding capacity.

2.2 Chemical Parameter

2.2.1 Electrical Conductivity

To prepare a soil suspension, 10 g of air dried soil sample was added to 50 ml of double glass distilled water (1:5 w/v). The suspension so obtained was kept over shaker for ½ H. The EC (in millimho/cm⁻¹) of the suspension was estimated using “Eutech cybernetics” made TDS scan-meter. The EC meter was calibrated.

2.2.2 Total Alkalinity

100 ml. distilled water was added to 10g of air-dried soil sample in a 250 ml. capacity flask to prepare a suspension (1:10 w/v). The suspension was shaken for ½ h over a shaker. Filtered the suspension through a filter paper (Whatman No. 44) and determine the alkalinity using the filtrate 25 ml. of filtrate was taken in a flask and added 2 drops of phenolphthalein indicator, if pink colour appeared, titrated it against standard sulfuric acid solution until extract became colourless. Noted the volume of the acid used as “A” ml. To the same solution, added 2-3 drops of methylorange indicator and titrated it further with standard


Impact of Steel Industry Waste on Physico-Chemical Property of Soil

H\textsubscript{2}SO\textsubscript{4} solution until colour changed from light yellow to red. Again noted the volume of acid consumed as “B” ml.

**Calculation**

Total alkalinity of the soil extract (mg/1) (as CaCO\textsubscript{3})

\[
F = \frac{N_2 \times V_2 \times 50 \times 1000}{V}
\]

Where:

- \(F\) = Normality of standard H\textsubscript{2}SO\textsubscript{4}
- \(V\) = Total volume of suspension (ml)
- \(W\) = Weight of soil taken to prepare suspension (g)
- \(M\) = Moisture content of soil (%)

**2.2.3 Carbonate and**

**2.2.4 Bicarbonate**

Carbonate content and bicarbonate content of the soil samples was determined indirectly making the use of total alkalinity of the soil extract as determined above.

**2.2.5 Magnesium** content of soil samples was determined making the use of calcium parameter as par standard methods.

**2.2.6 Sodium** Soil extract was prepared as described for calcium.

**Determination of sodium content of soil extract**

Sodium was estimated using ELICO CL-220 Flamephotometer.

**Requirements:**

Standard stock solution of sodium (1000ppm)

**Procedure**

Prepare the calibration standards. The sodium content of the soil extract was determined by comparing the instrumental readings with standard curve. The results were obtained in mg/l.

**Calculation**

\[
\text{Sodium content of soil (\%)} = \frac{A \times V}{W \times 100}
\]

Where

- \(A\) = Sodium content of soil extract (mg/l)
- \(V\) = Total volume of soil extract (ml)
- \(W\) = Weight of air dried soil (g)

**2.2.7 Potassium**
Soil extract was prepared as described for calcium.

**Determination of potassium of soil extract**

Potassium was estimated using ELICO CL-22- flamephotometer.

**Requirements**

Standard stock solution of Potassium (1000 ppm). (0.191 g of KCl (AR grade) was dissolved in distilled water and made the final volume of 100 ml.

**Procedure**

Procedure is same as for the determination of sodium content.

**Calculation**

\[
\text{Potassium content of soil} (\%) = \frac{A \times V}{W \times 100}
\]

Where
- \(A\) = Potassium content of soil extract (mg/l)
- \(V\) = Total volume of soil extract (ml.)
- \(W\) = Weight of air dried soil (g)

**2.2.8 Phosphate**

**Preparation of soil extract:**

100 ml. Sulfuric acid (0.002) was added to 1 g air-dried soil sample. The suspension was shaken for about half an hour and then filtered through a filter paper (Whatman No. 44) and phosphate content was determined using the filtrate.

**Determination of phosphate content**

Phosphate content of the soil extract was determined using spectrometric method.

**Requirements**

1. Ammonium molybdate solution.
2. Stannous chloride solution.

**Procedure**

50 ml of soil extract was taken in a flask. 2 ml ammonium molybdate and 5 drops of stannous chloride solution were added to it. A blue color appeared which was measured spectrophotometrically at 690 nm. Within 10 minutes.

The standard phosphate solutions of different strengths were prepared and a calibration curve between absorbance and concentrations were prepared. The phosphate content of the samples was determined by comparing its absorbance with standard curve.

The results were expressed in mg/l
Calculation

Phosphate content of soil (%) = \( \frac{P \times V}{W \times 100} \)

Where

- \( A \) = Phosphate content of soil extract (mg/l)
- \( V \) = Total volume of soil extract (ml.)
- \( W \) = Weight of air dried soil (g)

2.2.9 Total Organic Carbon

Take 1gm of soil in a digestion flask and add 10 ml of 1 N \( \text{K}_2\text{Cr}_2\text{O}_7 \) solution. Then, add 20 ml. of conc. \( \text{H}_2\text{SO}_4 \) gently and kept he solution for \( \frac{1}{2} \) hr. Now, add 100 ml. of distilled water and 10 ml of orthophosphoric acid to it. Add 1 ml of diphenylamine indicator. Now, titrate it again 0.25 N of freshly prepared Ferrous Ammonium sulphate till the color changes to green. Note the volume of FAS used in titration.

Calculation

\( \% \) Carbon = \( \frac{\text{(Vol. of FAS used for K}_2\text{Cr}_2\text{O}_7 – \text{Vol. of FAS used for sample}) \times 0.0003 \times 100}{\text{Weight of the soil}} \)

2.2.10 Total Kjeldahl’s Nitrogen (TKN)

Take 10gm. of soil into a 300 ml. Kjeldahl’s flask. Add 25 ml. distilled water to moisten the soil. Add 20 gm. Of catalyst mixture and 35ml. concentrated \( \text{H}_2\text{SO}_4 \) Mix by gentle swirling. Heat initially at low heat for first 10 to 30 minutes until frothing stops and then raise the heat. Continue the digestion, keep rotating the flask at intervals until the contents become light yellow. Flame should not e allowed to touch the upper part of the flask above the level of the contents, to avoid any undue loss of ammonia by decomposition of ammonium sulphate at higher temperature. Heat further for 1 \( \frac{1}{2} \) hr. Cool the digest and add 100ml. of distilled water. Mix & stand. Transfer the supernatant. Now, add a few drops of Phenolphthalein indicator to it. Then add, 40% of NaOH, slowly, till the colour becomes pink. Now, transfer the solution to distillation flask. Distill it into the receiver solution of boric acid (25 ml.) taken in another flask collect about 150 ml. of condensate into the flask and then titrate it against 0.1 N HCL solution until the colour changes from green to red.

Calculation

\( \% \) of N = \( \frac{T \times N \times 0.14 \times 100}{W} \)

Where

- \( T \) = Vol. of HCl (0.1 N) used in titration (ml.)
- \( N \) = Normality of acid
- 0.14M = Equivalent weight of N
- \( W \) = Weight of soil taken

2.2.11 Sulphate
Sulphate content of the soil extract was determined by spectrophotometer method.

Reagents
   a. Buffer solution : HgCl$_2$ + Sodium Acetate + HNO$_3$ acid
   b. BaCl$_2$ crystals
   c. Standard Sulphate Solution

Procedure
Preparation of Soil Extract
1. Prepare 1:5 (w/v soil suspension) by adding 100 ml of distilled water to 20 gm of soil. Stir mechanically for about one hour at regular intervals.
2. Filter the suspension through Whatman no. 50 filter paper.

50 ml of soil extract and 5ml of buffer solution. Mix well and add a pinch of BaCl$_2$ crystals. Continue stirring for 1 minute after addition of BaCl$_2$. Measure the BaCl$_2$ turbidity after stirring period has been ended. Run a blank and absorbance at 420 nm within 4 minute. Standard sulphate solution of different strengths were prepared and the calibration curve between absorbance and concentration was prepared. The sulphate content of the sample was determined by comparing its absorbance with standard curve. The results were expressed in mg/l.

Calculation
Sulphate content in soil extract % = \( \frac{SO_4 \text{ mg/l Soil solution}}{2000} \)

3. Results and Discussion

India is in list of developing countries. But with industrialization and urbanization we are inviting many problems like air pollution, water pollution and noise and soil pollution. Paper, textile, tannery, distillery, Metal plating, Iron and steel industry continuously increasing the pollution problem. Effluents of these industries polluting the water bodies and soil fertility. Now pollutants causing the serious health problems. So, for identification of adverse effect of these pollutants we were collected soil samples from various spots of Jindal Steel Industry, Hisar. Physical parameters and chemical parameters are studied here. p$_H$-pH vary from 7.92 to 11.6. Maximum value of Ph noted from sample 19. It means soil is alkaline in nature.

WHC-Water holding capacity of soil is vary in range of 0.6 to 2.2. Sample 6 and Sample 19 have water holding capacity is 2.2 and 1.6 sample 6 have high value of water holding capacity. Bulk density- Bulk density of soil samples lie in between 0.05 to 0.75. Sample 17 have very high bulk density i.e 0.75. Color of Soil Sample- Color of soil sample was brownish/yellowish and few samples have gray color also. There is little ting of reddish color of the sample. Chloride-There have been wide variation in chloride content. It varies from 5103 in most of sample chloride is negligible, maximum value is found in sample no. 19 which is 2Km away from industry. Sulphate- Value of sulphate in different samples varies from 12.3-41.4. Higher value of sulphate in soil samples represented a good quality of soil. Effluent of steel industry are quite reach in sulphate contact and there may be low degradation by microorganism. Carbon-Soil samples collected from different regions of steel industry, they show a high content of carbon. Soil is rich in carbon. The value of carbon vary from 7.56-26.7. Maximum value is in the soil near the residential and agriculture area which are rich in carbon. Alkalinity- of soil as a direct link with p$_H$ f soil. As we have seen sample
Impact of Steel Industry Waste on Physico-Chemical Property of Soil

is slightly alkaline in nature. Calcium- Value of range of 2.4-81.6. This shows a wide variation. Maximum value near dumping site which 2Km away from industry. Magnesium- value of range 31.2-63.4. This shows a wide variation. Thus soil is rich in magnesium and calcium.

These physical and chemical parameters determines that soil is rich in calcium, magnesium and organic carbon. The steel industry has conformed direct and indirect short term and long term effect on physic-chemical properties. Our study was confined to time and resources and further interrogation into the topic can be helpful in establishing the result.

**Table 2(A): Results of Physical Parameter of Soil Sample**

| Sample  | A1   | A2   | A3   | A4   | A5   | A6   | A7   | A8   | A9   | A10  |
|---------|------|------|------|------|------|------|------|------|------|------|
| WHC(mg/l)| .7   | .5   | .8   | .6   | 1.0  | 2.2  | 1.0  | .9   | .8   | 1.0  |
| BULK DENSITY(mg/kg) | .60  | .6-  | .63  | .62  | .60  | .61  | .60  | .62  | .60  | .48  |
| pH      | 9.3  | 8.5  | 9.9  | 9.4  | 8.2  | 8.8  | 9.7  | 7.9  | 7.4  | 9.6  |
| COLOUR  | D.B  | B    | L.B  | S    | G    | D.B  | G    | B    | B    |

**Table 2(B): Results of Physical Parameter of Soil Sample**

| Sample  | A11  | A12  | A13  | A14  | A15  | A16  | A17  | A18  | A19  | A20  |
|---------|------|------|------|------|------|------|------|------|------|------|
| WHC(mg/l) | .6   | 1.4  | .6   | .7   | .5   | .8   | .3   | .8   | .8   | 1.6  |
| BULK DENSITY(mg/kg) | .50  | .70  | .70  | .72  | .72  | .62  | .75  | .62  | .65  | .70  |
| pH      | 8.1  | 9.7  | 5.4  | 8.8  | 9.4  | 9.8  | 11.6 | 11.6 | 10.9 | 11.4 |
| COLOUR  | Y    | B    | B    | Y    | D.B  | G    | G    | G    | G    | G    |

**Figure 1: For Physical Parameter of Soil Sample**

Colour of soil

DB=Dark Brown; B=Brown; LB=Light Brown; S=Sandy; G=Gray; Y=Yellow
**Table 3:** Results Of Chemical Parameter Of Soil Sample

| Sample | SO$_4^{2-}$ (mg/l) | PO$_4^{3-}$ (mg/l) | Na$^+$ (mg/l) | K$^+$ (mg/l) | Org-C (mg/l) | Cl$^-$ (mg/l) | Ca$^{2+}$ (mg/l) | Mg$^{2+}$ (mg/l) |
|--------|---------------------|--------------------|--------------|-------------|-------------|-------------|---------------|----------------|
| A1     | 13.6                | .006               | 1.9          | 7.56        | .01         | 10.4        | 134.6         |                |
| A2     | 9.8                 | .017               | 1.2          | 2.3         | 12.48       | .008        | 4.8           | 31.10          |
| A3     | 2.3                 | .013               | .57          | 1.9         | 8.34        | .009        | 4.8           | 179.3          |
| A4     | 17.4                | .014               | 1.7          | 4.0         | 12.6        | .026        | 6.4           | 202.6          |
| A5     | 8.88                | .011               | 1.0          | 1.2         | 8.94        | .006        | 13.6          | 161.8          |
| A6     | 4.10                | .005               | 1.2          | 0.53        | 11.76       | .009        | 2.4           | 132.1          |
| A7     | 4.47                | .007               | 1.0          | .45         | 12.7        | .009        | 4.0           | 228.4          |
| A8     | 5.08                | .022               | 1.0          | 1.3         | 11.88       | .012        | 2.4           | 229.3          |
| A9     | 6.52                | .017               | 1.4          | 1.3         | 11.76       | .016        | 7.2           | 226.4          |
| A10    | 9.50                | .020               | .82          | 2.5         | 12.5        | .007        | 4.8           | 40.8           |
| A11    | 41.4                | .044               | 5.2          | .12         | 15.2        | .018        | 38.4          | 341.1          |
| A12    | 1.16                | .019               | .63          | .15         | 11.8        | .012        | 5.6           | 59.77          |
| A13    | 4.61                | .012               | 1.3          | .15         | 16.0        | .007        | 3.2           | 56.37          |
| A14    | 3.6                 | .014               | .63          | .22         | 12.5        | .006        | 3.2           | 66.09          |
| A15    | 3.03                | .013               | 1.2          | .3          | 4.56        | .009        | 2.4           | 149.2          |
| A16    | 2.10                | .010               | .76          | .15         | 8.22        | .005        | 7.2           | 199.7          |
| A17    | 1.18                | .0003              | 1.6          | .13         | 26.7        | .007        | 76.0          | 624.5          |
| A18    | 2.00                | .0019              | 1.4          | 5.2         | 8.7         | .054        | 78.4          | 641.1          |
| A19    | 2.68                | .0063              | 1.3          | 4.9         | 22.14       | .066        | 70.4          | 739.6          |
| A20    | 0.467               | .0134              | 1.6          | 3.6         | 11.58       | .025        | 81.6          | 509.3          |

**Figure 2:** For Chemical Property of Soil Samples

4. Conclusion

After the analysis of soil samples taken from different distances from the industrial area a general conclusion that could be reached is that the soil at the dumping site is rich in magnesium and calcium. As we move further away, the soil fertility is increasing steadily but
slowly. The organic content of soil was low in most areas and medium in a few, the available sodium was low to medium and potassium level was very low in soil samples examined. The level of sulphate was high in few areas but the level of phosphate was very low, while all other metals were within non-toxic limit. The physico-chemical properties of both sites under study do not show significant variations. But the values at 1Km away from the industry show better physico-chemical properties when compared to other side.

5. References

1. Agarwal Ranjana., (2009), Study of Physico-Chemical Parameters of Groundwater Quality of Dude Town in Rajasthan Rasayan Journal of Chemical Science. 2(4), pp 969-971

2. Babyshakila.P and Usha K., (2009), Effect of Diluted Effluent on Soil Properties and Plant Growth, Advanced Studies in Biology, 1(8), pp 391 – 398.

3. De. A.K., (2000), Environmental Chemistry, 4th Edn., New Age International Publishers(P) Ltd., New Delhi

4. Panda, S.C and Kar R.N., (1998), Final Report on Environmental Panda, S.C and Kar R.N,(1998): Final Report on Environmental study of Powmex Steel Division,G.k.w Ltd, Titillagarh, Jan

5. Rowell,D.A., (1994), Soil Science Methods and Applications.Harlow,Longman

6. Shaxson,T.F.’Organic materials and soil fertility (1996), Enable 1, pp 2-3 1993- Principles of better bonding, Ebable, 5, pp.4-13.

7. Torkashvand Mohammadi A., (2010), The effect of paper mill sluge on chemical properties, African journal of Agriculture Research, 5(22), pp 3082-3087

8. Van Breemen., (1993), N.Soil’s as biotic constructs favouring net primary productivity, Geoderma, 57, pp 183-211.