Impact of Anthropogenic Air Pollutants on Soil Nutrients in Bengaluru

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Abstract: Human activities pose an impact on the environment, which can be monitored by the mineral content in the soil. Four different locations based on specific environmental characteristics was selected for the study which included residential area, commercial area, an industrial area and a control site. Soil micro and macro nutrients have been investigated in the control and study sites in this study. All the nutrients were seen in low concentration in the control site, when compared to other study sites and their concentrations varied with the increasing depth. In this study, the highly polluted site (Industrial area) had the highest content of nutrients. The macro and microelement contents depend on the type of plant and its environment (the level of industrial development of the region, air pollution and soil and climate conditions) (Voutsa et al., 1996; Ngole and Ekosse, 2009). Macro and micro elements released from anthropogenic sources that have entered the environment is the main focus of this study.

Keywords: Anthropogenic, micro nutrients, macro nutrients, Electrical conductivity, Organic carbon

1. Introduction

The essential elements required for plant growth have been grouped as macro and micronutrients. The deficiency or excess presence of micronutrients such as iron, zinc and copper may produce synergetic and antagonistic effects in the plants. The influence of anthropogenic activities industrial and motor vehicles, on the environment is reflected in the amount of macro and micro - elements deposited in the soil and hence absorbed by plants. Extensive industrial production is usually connected with the emission of various pollutants to the environment (Kalandadze, 2003). Nutrients are essential for plant growth and plant health. Macronutrients occur in substantial levels in plant materials, whereas micronutrients like B, Cu, Zn, Mn, Fe, Mo etc. are required by plants at very low level. These nutrients regulate the functioning of essential enzymes in plant body (Agrawal et al., 2002). The presence of heavy metals and residues from town and industrial wastes is also found to cause soil pollution. Soil is a natural dynamic body developed by natural force acting on natural material. Soil pollution usually originates from the industries, chemical fertilizers, sewage, sludge, city compost, other industrial wastes, its effluents and water drainage. Once pollutants enter the soil, their concentration in soil continuously increases and accumulates which is toxic to all forms of life in biosphere. Due to industrial contaminants, the amount of macro and micro - elements in soil affects plant qualities. The physiochemical characteristics of urban soil have significantly changed due to anthropogenic activities. Urban soil is thus characterized by large fluctuations of physiochemical properties. Soil fertility depends on the presence of essential nutrients in adequate amount and its availability, along with factors such as: physical condition of soil and environmental conditions (Rai, 2002).

2. The Habitat

2.1 Location

Bengaluru is located on the Deccan Plateau, in the southeastern part of Karnataka, It is India's third most populous city and fifth-most populous urban agglomeration. It is situated at an elevation of 900 m. It is located at $12.97^{\circ}N$ 77.56°E and covers an area of 741 km2.

2.2 Soil

The soil is generally red loamy to red sandy in nature, suitable for plant growth. The pH is usually in the alkaline range and poor in organic content, hence low in fertility.

2.3 Climate

The city enjoys a very moderate climate. Bengaluru experiences a tropical savanna climate with distinct wet and dry seasons. The coolest month is December and the hottest month is April.

2.4 Vegetation

Vegetation in the city is primarily in the form of large deciduouscanopy. The climatic feature of the city favors the growth of herbs, shrubs and trees. During monsoon the ground vegetation becomes dominant. Most of the plants flower till late January.

2.5 Vehicular data

Bengaluruharbours 41.71 lakh vehicles, of which 28.81 lakh are two wheelers, 7.92 lakh cars, 1.62 lakh most polluting autos and 3.36 lakh other vehicles.

2.6 Ambient air quality

The rapid increase in the number of vehicles is bound to have an adverse impact on the air quality of Bengaluru. Karnataka State Pollution Control Board has installed and commissioned two Continuous Ambient Air Quality monitoring stations i.e., one at City Railway Station, Bengaluru and another at NisargaBhavan, Saneguruvanahalli, Bengaluru. The concentration of pollutants in Bengaluru is as follows, SO2(8 µgm-3), NOX(29.5 µgm-3), SPM (362 µgm-3) and CO(12 µgm-3).

3. Materials and Methods

3.1 Experimental Sites

The sites selected for the present study include a residential area (BTM layout), a commercial area (Rajajinagar), an industrial area (Peenya industrial estate) and a control site in Bengaluru.

3.2 Sampling of Soil Samples

Excess plant residues were removed from the top layer of the soil, using a shovel a V - shaped hole was created and 2 -3 cm thick layer was sliced down one side to a depth 40 cm. The slice was trimmed on either side to form a 2 - 3 cm wide core and placed in the sample bucket. This procedure was repeated at all the sampling sites. The samples were broken down and air dried by spreading it out on clean paper under shade. After drying 500 g of soil samples were packed in suitable bags, labeled with appropriate codes and used for further analysis.

Sampling depths

- 0-2 cm
- 2-5 cm
- $5-10\ cm$
- $10-15\ cm$
- $15-20\ cm$
- $20-25\ cm$
- $25-30\ cm$
- $30-35\ cm$
- $35-40\ cm$

3.3 Analytical methods of Soil Analysis

pH of the soil

About 20 g of soil was taken in a 50 mL beaker, dissolved in 25 mL of distilled water and kept aside for 30 minutes with constant stirring. Then the soil suspension was stirred and the electrode of the calibrated pH meter was immersed into the solution and the reading was noted.

Electrical conductivity

Soil water suspension in the ratio 1:5 was prepared, to which 50 mL of deionised water was added to dissolve soluble salts. Reading was recorded using a calibrated conductivity meter.

Macronutrients

Organic carbon

To 1 g of soil, 10 mL of Potassium dichromate solution was added in an Erlenmeyer flask and mixed. Then 20 mL Sulphuric acid was added and allowed to stand for 30 minutes, followed by the addition of 100 mL water and 10 mL Phosphoric acid, allowed to cool. About 10 drops of Barium diphenylamine sulphonate indicator was added and titrated against 0.5 N Ferrous ammonium sulphate solution till the colour changed from violet to bright green. Blank titration was carried out in a similar manner without soil (Walkley and Black, 1934).

% of organic carbon in soil = $\frac{M(V_1 - V_2)}{S \times 0.39 \times mef}$

Where, M = molarity of ferrous sulphate solution

 $\mathrm{V1}$ =volume of ferrous ammonium sulphate used for blank in mL

V2 = volume of ferrous sulphate used to oxidize soil organic C in mL

S = weight of air dried sample in g

mcf = moisture correction factor

Phosphorous

In a 250 mL conical flask, 5 g of soil was taken and a pinch of charcoal and 50 mL of 0.5 N NaHCO3 solution was added, mixed, kept aside for 30 minutes and filtered using Whatman no. 40 filter paper. Filtrate of 5 mL was taken in a 25 mL volumetric flask to which 5 mL of 1.5 % Ammonium molybdate was added and mixed well followed by the addition of 10 mL of distilled water and 1 mL Stannous chloride solution and the volume was made up to the mark and reading was taken at 660 nm. Similarly a blank was prepared with all the reagents without soil. The standard curve was used for quantification of P (Olsen's method, 1954).

Available P2O5=
$$\frac{\text{Graph ppm}}{10^6} \times \frac{\text{Volume of extractant}}{\text{Weight of soil}} \times \frac{\text{Volume made}}{\text{Aliquot}} \times 2 \times 10^6 \times 2.29$$

Potassium

To 5 g soil in a flask, 25 mL ammonium acetate solution was added and was shaken for 5 minutes, filtered and fed into an atomizer of the flame photometer and the reading was noted. Using the standard, the concentration of Potassium was determined (Merwin and Peech, 1951).

Micronutrients

Determination of Lead, Copper, Cadmium and Zinc

The sample preparation was performed according to the guidelines of EPA 3050b. About 0.2 - 0.3 g of sample was weighed in a 250 mL Erlenmeyer flask and 5 mL of 1 : 1 HNO3 was added. The solution was heated on a hot plate to 95 °C, refluxed for 15 minutes without boiling. After cooling, 2.5 mL of concentrated HNO3 was added and the sample was refluxed for 30 minutes at 95 °C without boiling. This step was repeated. Thereafter, the sample was evaporated to 5 mL without boiling. After cooling, 2 mL of double distilled water was added to the sample followed by the slow addition of 3 mL of 30 % H2O2. The solution was then heated until effervescence subsided. Later, 6 mL of 30 % H2O2 in 1 mL aliquots was added and the solution was refluxed. After cooling, 2.5 mL of concentrated HCl was added and the sample was refluxed for 15 minutes without boiling. After cooling to room temperature, the sample was filtered using Whatman No. 1 filter paper and diluted to 50 mL with double distilled water. All samples were analyzed in triplicates by Inductively Coupled Plasma - Optical Emission Spectrometer. The measurements were performed using the Perkin ElmerOptima ICP - OES instrument, ICP version 4.0 software for simultaneous measurement of all analyte wavelengths of interest.

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ICP – OES para	Value			
Wavelengths	Lead	220.353 nm		
Wavelengths	Copper	327.393 nm		
Wavelengths	Cadmium	226.502 nm		
Wavelengths	Zinc	213.857 nm		
Power	1450 W			
Plasma Gas F	15 Lmin-1			
Auxiliary Gas	Flow	0.2 Lmin-1		
Nebulizer Pres	sure	140.00 kPa		
Replicate Tir	me	5 s		
Stab Time	10 s			
Sample Upta	22 s			
Rinse Time	10 s			
Pump Rate	2	25 rpm		

Determination of Manganese and Iron

To 10 g of soil, 20 mL of Diethylene Triamine Penta Acetic acid (DPTA) solution was added and shaken continuously for 2 hours, filtered and concentration of Zn, Cu, Mn and Fe was determined using atomic absorption spectrophotometer at wavelengths 279.5 and 248.3 nm respectively.

4. Results

The results of micro and macronutrients are presented in table 1-4 respectively. All the nutrients were seen in low concentration in the control site in comparison to other study sites.

4 (a) Soil pH

The pH of soil varied with different study sites. pH was observed to be high in the highly polluted area (Industrial area) and went on decreasing with moderate (Residential) and less polluted site (commercial). The result also showed that the pH of the soil decreased as the depth of soil increased. The top soil in the all sites showed a higher pH.

4(b) Electrical conductivity

The electrical conductivity ranged from 1.51 to 2.15 in the industrial area which was high compared to control site 0.10 - 0.89. This was followed by residential and commercial area ranging between 1.06 - 1.69 and 0.75 - 1.49 respectively. Electrical conductivity decreased as the depth increased.

4(c) Macro Nutrients

Organic carbon

Organic carbon contents were measured in %, which ranged from 3.29 - 2.92 percentage in industrial site. Top soil showed high organic carbon content and decreased along with the increase in depth. The same pattern was followed in other two study sites as well.

Phosphorous

Phosphorous ranged from 109 to 182 μ gg-1in industrial area which was highest among the all study sites. It was followed by residential and commercial areas. Top soil had less Phosphorus and the concentration increased with depth.

Potassium

The Potassium ranged from $902 - 1010 \mu gg$ -linthe industrial area and followed by commercial area with $707 - 605 \mu gg$ -l and residential with $516 - 409 \mu gg$ -l. The concentration decreased with depth. Top soil of all the sites was high in potassium content.

4 (d) Micro nutrients

The micro nutrients analysis of soil is given in table -1. All the nutrients were in low concentration in the control site in comparison to the other study sites.

Zinc

The Zinc concentration ranged from 53.35 to $205.98 \ \mu gg-1$ in the industrial area which was high compared to control site. This was followed by residential and commercial area ranging 29.43 to $189.34 \ \mu gg-1$, $36.53 \ to \ 192.56 \ \mu gg-1$ respectively. Zinc content increased as the depth decreased.

Cadmium

The Cd concentration ranged from 4.01to18.69 μ gg-1 in the industrial area which was higher compared to control place 0.15 to 1.43 μ gg-1. This was followed by residential and commercial area ranging from 29.43 to 189.34 μ gg-1 and 36.53 to 192.56 μ gg-1 respectively. Cadmium content increased with depth. The Cd concentration in the control site top soil was very less when compared to other nutrients.

Lead

Lead ranged from 99.15 to 317.12µgg-1 in industrial area which was highest among the all study sites. This was followed by residential and commercial areas. Top soil had higher Lead content which decreased with the depth

Iron

The Iron ranged from 954.96 - 1451.98 μ gg-1 in the industrial area and followed by commercial site range of 623.54 - 886.24 μ gg-1 and residential site range of 642.87 - 899.58 μ gg-1. The concentration decreased with depth. The Fe concentration in the top soil in the control site was 112.54 μ gg-1.

Manganese

Manganese ranged from 69.29 to 220.11 μ gg-1 in industrial area, followed by residential and commercial areas. Top soil had less Manganese content which increased with the depth.

Copper

The Cu concentration ranged from 16.49 to37.76 μ gg-1 in the industrial area which was higher compared to control site range of 0.67 to 2.93 μ gg-1. This was followed by residential and commercial areas ranging from 5.09 to 14.93 μ gg-1 and 7.02 to 15.94 μ gg-1 respectively. Cu content increased as the depth decreased.

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DEPTH	рН	EC	OC (%)	$\begin{array}{c} P_2O_5\\ (\mu gg^{-l})\end{array}$	K_2O (μgg^{-l})	Zn (µgg ⁻¹)	Cd (μgg^{-l})	Pb (μgg^{-l})	Fe (µgg ⁻¹)	Mn (μgg^{-l})	Cu (µgg ⁻¹)
Тор	6.8	0.1	1.76	11	211	7.05	0.15	2.69	112.54	36.05	0.67
2cm	6.7	0.18	1.72	26	205	8.98	0.22	2.25	159.36	42.96	0.89
5cm	6.7	0.22	1.72	29	199	9.11	0.42	1.99	196.77	50.75	1.02
10cm	6.5	0.33	1.66	38	186	10.23	0.59	1.69	224.37	58.69	1.19
15cm	6.3	0.45	1.59	45	172	11.55	0.67	1.42	269.3	65.45	1.32
20cm	6.3	0.56	1.41	52	165	12.69	0.84	1.22	314.64	72.65	1.48
25cm	6.2	0.69	1.32	61	154	13.99	0.99	1.39	344.93	89.57	1.61
30cm	6.2	0.74	1.25	70	139	14.58	1.11	1.56	375.36	101.97	1.86
35cm	6	0.82	1.15	78	122	15.78	1.29	2.10	401.11	117.25	2.06
40cm	5.9	0.89	1.02	84	116	16.6	1.43	2.33	452.47	134.28	2.97

Table 1: Micro and macronutrients in soil sample (Control site)

Tabl	e 2: Mici	ro and	macron	utrients	in soil	l samp	le (I	Resid	lential	site)
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DEPTH J	nH	FC	OC	P_2O_5	K_2O	Zn	Cd	Pb	Fe	Mn	Си
	pm	LC	(%)	$(\mu g g^{-1})$	$(\mu g g^{-1})$	$(\mu g g^{-1})$	$(\mu g g^{-1})$	$(\mu g g^{-l})$	$(\mu g g^{-l})$	$(\mu g g^{-l})$	$(\mu g g^{-1})$
2cm	7.3	1.12	3.31	59	506	39.26	0.98	98.87	643.66	71.69	6.86
5cm	7.1	1.14	3.26	62	492	44.26	1.29	88.65	659.14	82.36	7.26
10cm	7	1.25	3.19	68	486	78.78	2.98	73.89	682.99	96.11	8.98
15cm	6.8	1.34	2.85	74	472	98.64	3.65	60.58	701.25	112.39	9.56
20cm	6.8	1.42	2.55	79	466	108.31	4.91	46.26	729.61	131.69	10.25
25cm	6.6	1.49	2.21	84	451	127.65	5.45	49.36	762.64	149.78	11.69
30cm	6.5	1.54	2.01	89	442	140.11	6.65	52.69	792.87	172.64	12.59
35cm	6.3	1.59	1.82	92	418	165.78	7.82	58.65	836.95	198.35	13.66
40cm	6.3	1.64	1.42	98	409	189.34	8.67	62.87	886.24	211.39	14.93

Table 3: Micro and macronutrients in soil sample (Commercial site)

DEPTH	pН	EC	OC (%)	$\begin{array}{c} P_2O_5\\ (\mu gg^{-l}) \end{array}$	$K_2O \ (\mu gg^{-l})$	Zn (μgg^{-l})	Cd (μgg^{-1})	Pb (μgg^{-l})	Fe (µgg ⁻¹)	$Mn \\ (\mu g g^{-l})$	Cu (μgg^{-1})
2cm	6.9	0.82	2.75	69	692	55.97	1.91	101.25	661.59	81.41	7.96
5cm	6.9	0.89	2.71	71	681	82.41	2.25	89.59	689.67	102.65	8.36
10cm	6.7	0.96	2.51	74	672	101.39	3.54	76.36	706.33	118.73	9.87
15cm	6.6	1.04	2.33	77	654	114.55	4.62	68.51	739.62	136.55	10.65
20cm	6.4	1.16	2.06	79	644	134.27	5.26	52.51	784.39	158.64	11.59
25cm	6.4	1.26	1.87	82	632	154.97	6.78	56.32	806.27	171.99	12.79
30cm	6.2	1.39	1.71	90	629	169.21	7.65	62.85	849.73	192.92	13.46
35cm	6.2	1.42	1.44	95	614	180.11	8.37	69.12	872.11	210.36	14.89
40cm	6	1.49	1.12	101	605	192.56	9.12	73.11	899.58	220.11	15.94

Table 4: Micro and macronutrients in soil sample (Industrial site)

DEPTH	pН	EC	OC (%)	$\begin{array}{c} P_2O_5\\ (\mu gg^{-l}) \end{array}$	K_2O (μgg^{-l})	Zn (μgg^{-1})	Cd (μgg^{-1})	Pb (μgg^{-1})	$Fe (\mu gg^{-l})$	$Mn \\ (\mu g g^{-1})$	Cu (μgg^{-l})
Тор	7.9	1.51	3.92	109	1010	53.35	4.01	317.12	954.96	70.134	16.49
2cm	7.8	1.56	3.8	116	998	67.25	6.11	286.07	978.36	84.57	17.96
5cm	7.7	1.58	3.72	126	981	89.64	8.62	229.10	996.74	98.72	19.43
10cm	7.5	1.63	3.62	134	976	109.65	10.98	189.54	1067.33	126.79	21.99
15cm	7.5	1.7	3.52	141	962	122.69	11.53	120.15	1145.17	162.29	23.06
20cm	7.3	1.79	3.4	149	951	136.64	12.98	99.15	1220.64	184.36	26.72
25cm	7.2	1.87	3.29	156	946	149.74	14.12	106.54	1308.99	201.97	29.56
30cm	7.2	1.95	3.16	163	932	166.82	15.96	129.1	1379.4	239.51	32.36
35cm	7.1	2.02	3.04	172	919	184.31	17.12	136.07	1401.49	279.66	35.78
40cm	7	2.15	2.92	182	902	205.98	18.69	147.12	1451.98	297.51	37.76

5. Discussion

Soil micro and macro nutrients have been investigated in the control and polluted sites of Bengaluru in the present study, and their concentrations varied with the increasing depth. Macro and micro elements released from anthropogenic sources have entered the environment as indicated by this study. The study also revealed that the soils from the polluted area are enriched with micronutrients like Zn, Mn, Cu and Fe although they show varying range. Soil samples of industrial area is enriched with carbon while soil samples of control sites were deficient in phosphorous. The concentration of Pb, Cu and Cd that are considered to be highly toxic to the plant was observed to be high in this study. Due to industrial contaminants, the amount of macro and micro - elements in soil affects plant qualities.

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6. Conclusion

In this study, the highly polluted site (Industrial area) had highest content of nutrients as maximum industrial activity is seen in this site. This shows that the environment of the industrial area (Peenya) is being contaminated with the heavy metals. Macro and micro elements released from anthropogenic sources have entered the environment and have followed normal biogeochemical cycles. Mainly pollutants have come from the air as suspended particles and deposited in soil and also from effluents and water runoff from contaminated sites. The physiochemical characteristics of urban soil have significantly changed due to anthropogenic activities. There is a need to have some safety measures to overcome this toxic metal contamination of the environment.

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References

- [1] Agrawal, K.M, Sikdar, P.K., Deb, S.C. 2002. A Text book of Environment. Macmillan India Limited, pp. 139 165.
- [2] Kalandadze, B. 2003. Influence of the ore mining and processing enterprise on soil types in adjoining areas. Agron. Res. 1: 131 - 137.
- [3] Merwin, H.D., Peech M. 1951. Exchangeability of soil potassium in the sand, silt and clay fractions as influenced by the nature of the complimentary exchangeable cations. Soil Science Soc. Amer. 15: 125 – 128.
- [4] Ngole, V.M., Ekosse, G.E. 2009. Zinc uptake by vegetables: Effects of soil type and sewage sludge. Afr. J. Biotechnol., 8: 6258 - 6266.
- [5] Olsen, S.R., C.V. Cole, F.S. Watanabe, L.A. Dean. 1954. Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate. U. S. Department of Agriculture Circular No. 939.
- [6] Rai, M.M. 2002. Principles of Soil Science. Fourth Edition, Macmillan India Limited, 218 278.
- [7] Voutsa, D., Grimanis, A., Samara, C. 1996. Trace elements in vegetables grown in an industrial area in relation to soil and air particulate matter. Environ. Pollut, 94: 325 - 335.
- [8] Walkley, A., Black, I.A. 1934.An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science, 37: 29 - 38.