



Analysis of Soil Content from Roadside at Urban Area in Kathmandu Valley, Nepal

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Abstract

Contamination of metals from different activities, sources is in roadside soil at urban environment. The dust, smokes, vehicles, and developmental structure are also affected in the soil and plant. It is aimed to determine the effects of air pollution to contaminate in the content at different roadside soil. The study is aim to cover different sites which are heavily polluted, moderately polluted and less polluted sites within different seasons. The soil was collected from study sites. The methods for extraction and digestion of soil samples, bulk elemental analysis were applied. The digested samples were prepared for further elemental analysis and analyzed on ICP-OES equipment. ICP-OES was used to analyze the samples and following elements as Al, Cd, Co, Cr, Cu, Fe, Mg, Ni, Pb, V and Zn were determined. It concluded that Aluminium values are in the first order at all 3 sites and in 2 seasons. In contrast, Cadmium value at the last at all 3 sites and in 2 seasons. Iron and Manganese are in the second and third of the elements series. Due to air pollution, urban soils can be contaminated from different pollutants. The nitrogen and pH values are also determined which is suitable for the environment. These resources can also accumulate in plants, human health and in environment.

Keywords: Elements, ICP-OES, pH, Pollutants, Seasons, Soil.

Introduction

Kathmandu district is located in Kathmandu valley. Kathmandu is the largest municipality. Urban soil is an important component of the urban ecosystem and can be considered as a surface of pollutants and a source of capacity to water, plants and to the environment. Thus, urban soils are used as an indicator of urban environmental quality¹. The valley is especially affected from air pollution due to construction, urbanization, valley centric industrialization, increased vehicles and its topography. Climatic zones are subtropical and temperate.

The temperature between 32°C in summer to - 2°C in winter. Population of Kathmandu valley is 2.5 million with annual population growth rate of 4.2%². Kathmandu valley was chosen as the study site owing to its high population density, vehicles roads and roadsides plants. In addition, the bowl shaped topography of Kathmandu valley contributes to air pollution retention³.

Heavy metals are naturally occurring elements that have a high atomic weight and a density. Their industrial, domestic, agricultural, medical and multiple technological applications is wide in the nature⁴. It was aimed to compare the research results of different sites which are categorized as heavily polluted, moderately polluted and less polluted sites. Research sites were selected in roadsides soil.

Research Objectives: i. Determine the effects of air pollution to contaminate the elements in different roadside soil. ii. Analyze the content of heavy metal elements, nitrogen in soil from different sites and seasons.

Materials and Methods

Soil Samples, Sample Collection and Processing: Soil samples were collected from different study sites in the years 2016 and 2017 systematically. Sample preparation is in powder form. Soil of all selected sites and of different seasons has used for analysis. A total of 30 sampling points were selected for sample collection and collected after physical inspection of the sampling site. The study was carried out during two season i.e. in Summer 2016 / 2017 and Winter 2017. Seasonal impact of air pollution is present on different road site's soil at urban and sub urban areas of Kathmandu valley.

A sufficient amount of soil from 5cm-10cm depth was collected from each sampling site. The collected sample was initially shade-dried followed by oven drying at 105⁰ for 2 hrs. Afterwards the dried samples as 2 mm mesh size were sealed in zipped polythene bags and carried to the laboratory further analysis.

Study Sites: Ambient air quality (AAQ) monitoring analysis was in different sites for its characterization. The parameters

are; particulate matter; PM₁₀, PM_{2.5}, TSPM, SO₂, NO_x, CO, benzene, O₃, Pb.

The study is in three sites:

A: *Heavily polluted sites*: Koteshwor (Figure-1), Ratna Park, Kalanki area.

B: *Moderately polluted sites*: Bhudhanilkantha area

C: *Less polluted sites*: Tribhuvan University, Kirtipur Campus area, (Figure-2).



Figure-1: Study Site, Koteshwor (Polluted Site).



Figure-2: Less Polluted Study Site, Tribhuvan University, Kirtipur.

Methods: Nitrogen Determination from Soil: The determination of Nitrogen from the soil samples are in three steps which are as follows.

The method Kjeldahl⁵ is used for the nitrogen determination from soils.

Digestion: The Kjeldahl method procedure involves three steps: Digestion, Distillation and Titration. The digestion procedure is also in three steps (Figure-5).

The samples (1 gram of soil) were mixed with 10 ml concentrated sulfuric acid in digestion tube. Potassium sulfate is added in order to increase the boiling point of sulfuric acid and catalysts are added in order to increase the speed and efficiency of the digestion procedure. Copper Sulphate and Potassium Sulphate (Digestion mixture: CuSO₄ and K₂SO₄ in ratio of 1:5) need to keep 1 spoon as a catalyst. The digestion of samples kept at temperatures between 320 and 350°C in the equipment (KEL PLUS KES 12 L model) in laboratory of School of Environmental Science (SES); JNU, Delhi. The higher the temperature used, the faster digestion can be obtained.

All these mixture were kept in the digestion tubes, prepare in the iron tube stand and set in the digestion machine at around 4 hours. After digestion was completed the cool sample was diluted with 25ml of distilled water and transferred to the distillation unit. In this process the organic material carbonizes. During the digestion, decomposes processes and finally a clear liquid indicates the completion of the chemical reaction. Organic carbon and hydrogen form carbon dioxide and water.

Distillation: The receiving vessel (250ml Conical Flask) for the distillate was filled with an absorbing solution in order to capture the dissolved ammonia gas. Organic nitrogen is converted into NH₄⁺ NH₃ was distilled and retained in a receiver vessel, Nitrogen is determined.

In each conical flask added 25ml of 4% boric acid. The ammonia is quantitatively captured by the boric acid solution forming solvated ammonium ions. During the distillation step, the NH₄⁺ are converted into NH₃ auto from distillation machine (KEL PLUS-DISTYL EM-VA). A distillation tube gives black color. After this, distillation machine should run 9 minutes. The NH₃ is transferred into the receiver vessel. From digested samples N₂ fumes come to mixed in the titration flask and red color solution converted into green color solution.

Titration: The titration flask from distillation step used for titration from Burette containing 0.05N HCl. After titration the green color solution dissolved and becomes colorless to pink color solution in titration flask. The volume of HCl used to change the color of solution in titration methods should be taken for the calculation of Nitrogen in the given soil samples.

Total Nitrogen (N) Estimation in Soil

Calculation:

$$\text{N Content in Soil (\%)} = \frac{R (\text{Sample } (m_1) - \text{blank } (m_2)) \times \text{N-Acid} \times \text{Atomic Wt. of Nitrogen}}{\text{Sample Wt. (gm)} \times 1000} \times 100$$
$$\text{N (\%)} = \frac{R \times 0.05 \times 14 \times 100}{\text{Soil (1 gm)} \times 1000}$$

Where, R= Reading of Burette in Samples titration (Final-Initial), Blank= Reading of Burette in Blank Samples, N-Acid= HCl Concentration in Burette.

Soil pH Determination: Soil pH of samples was measured using a digital pH meter having an accuracy of ± 1 . The pH-meter is calibrating with buffer solution of pH 4 and 9. Soil and water suspension of 1:2.5 ratios were made⁶ by mixing 10 grams of soil with 25 ml distilled water. This prepared solution was stirred for 5 minutes and kept for half an hour. Then the digital pH meter was dipped in the mixture and pH reading was recorded.

Digestion of Samples and Extraction of Elements: The soil samples were digested metal determination. The chemical methods were applied (Figure-3 and Figure-4).

Bulk Elemental Analysis: For the assessment of total metal concentration, bulk digestion of samples was carried out following the procedure given by Shapiro and Brannock⁷, Pruseth⁸, SES, JNU Lab. In soil sample acid digestion method, mineral acids, conc. HNO_3 , conc. HCl and HClO_4 was used (Figure-6).



Figure-3: Preparation of Powder Soil Sample from Different sites.



Figure-4: Preparation of Soil Samples for the Digestion and Element Analysis.



Figure-5: The Digestion of Samples and Nitrogen.



Figure-6: Digestion of Soil Sample for Elements Determination; SES, JNU.

In the *first step* of this method, 0.2 gm. soil sample was digested with a 10 ml conc. HF, 5 ml conc. HNO_3 and 1-2 ml HClO_4 in the 60 ml capacity Teflon crucible (Teflon crucibles from high class Teflon rods were used for acid digestion) on a hot plate at a temperature $85^\circ - 90^\circ$ for four hours. After four hours, open lids and the crucibles were heated until complete dryness. In the *second step*, 5ml HF, 10ml HNO_3 and 1-2ml HClO_4 were added and the crucibles were again heated at 90° to complete dryness.. In the *third step*, 5ml conc. HNO_3 was added and heated again to complete dryness to remove the trace of the remaining fluoride from the solution. After drying the solution, around 20 ml of 1 N HCl was added and crucibles were gently heated at 85° with regular swirling of solution for few minutes. The clear solution was, then, transferred into 100 ml volumetric flask, Figure-7. The Teflon crucible was rinsed several times with 1 N HCl followed by Milli-Q water and poured it to 100 ml volumetric flask. After filtration, the final solutions were stored in the 120 ml wide mouth bottle for elemental analysis on ICP-OES (Inductively coupled plasma - optical emission spectrometry) (Figure-8).

Preparation of Blank Solution: The sample blank was also prepared following the chemicals used in sample digestion method. It contains without any sample. A sample blank must be prepared for each analytical sample groups.

Elemental Analysis: Digested samples were analyzed on ICP-OES Spectrometer equipment. Calibration of ICP-OES, single elemental standard was used. Standards used in the serial dilution from stock solution of 1000 ppm concentrations.

ICP Operation (Calibration of ICP-OES): i. Calibrate the ICP using a blank. ii. Immediately following calibration, analyze the standard. iii. Analyze the method blank and samples.

Calculations: For the determination of metal concentration in solution, the value is in milligrams per liter (mg/L) or micrograms per liter (µg/L). For aqueous samples as µg/L,

Where, µg/L = mg/L x 1000.

Concentration of Metal in Sample = $X \times 250 / 1000$ (250 = Acid blank in ml)

Where: X = mg/L (µg/L) of metal.



Figure-7: Sample for the Process of Element Analysis.



Figure-8: Samples for the Element Determination from ICP-OES, JNU

Results and Discussion

The elements contents are different and presented in tables.

Nitrogen Estimation: a. Soil Samples, b. Season: Winter 017

Table-1: Nitrogen determination from soil sample.

| Plant | Less Polluted | Moderately Polluted | Heavily Polluted |
|-------|-----------------|---------------------|------------------|
| Soil | 0.0745 ± 0.0022 | 0.0105 ± 0.0043 | 0.047 ± 0.019 |

Nitrogen values high in less polluted sites (Figure-9).

The pH determination of the soil (2016/ 2017) from the different study sites and in different seasons.

Table-2: pH determination of soil from different seasons and sites.

| Study Areas | Summer | Winter | Spring | Autumn |
|--------------------------|----------------------------|-----------|------------|------------|
| Less Polluted Site | 6.53± 0.033 | 6.6±0.033 | 6.7±0 | 6.73±0 |
| Moderately Polluted Site | 6.6±0.057 | 6.6±0.057 | 6.63±0.033 | 6.63±0.033 |
| Heavily Polluted Site | 6.6±0.033 0 0.033333 | 6.7±0.033 | 6.7±0 | 6.6±0.033 |

The values of pH in different seasons and in different sites were not so different. It gives as the normal in different soil in different roadside environment. According to the result of soil pH, road soil environment is suitable for different plants (Figure-10).

Neina, D.¹⁰, in the natural environment, soil pH has an enormous influence on soil biogeochemical processes. Soil pH relates the biological, chemical, physical properties and processes that affect plant growth, biomass yield. The anthropogenic activities induce changes in soil pH.

The elements content in the soil samples with mean values and standard error are presented (Table-3). The soil was collected from different study sites and in seasons. Elements are Aluminium, Cadmium, Cobalt, Chromium, Copper, Iron, Manganese, Nickel, Lead, Vanadium and Zinc (Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, V, and Zn).

The results of determination of metals other than Al and Cd were giving different values in all sites and in seasons (Figure-11). Fe, Mn and Zn concentration were comparatively high than other determined elements.

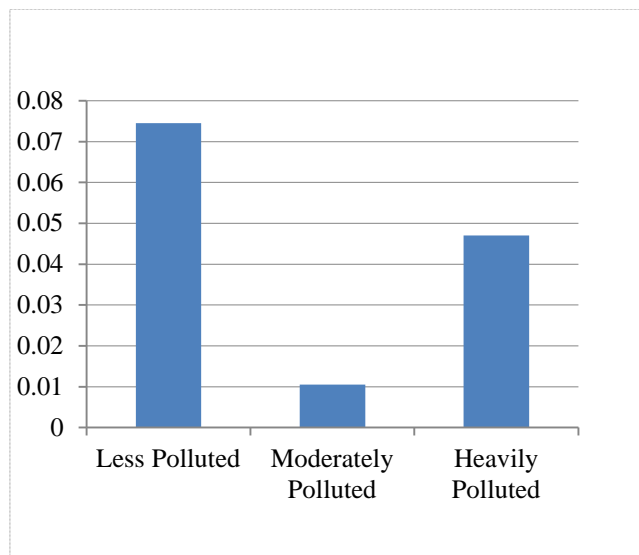


Figure-9: Nitrogen of soil.

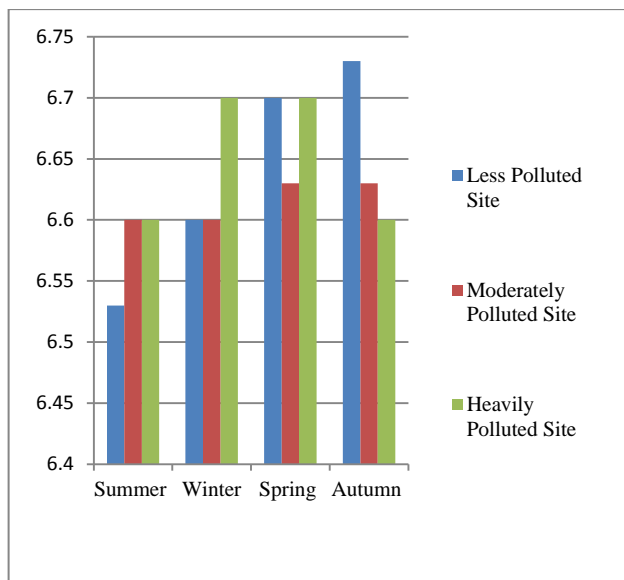


Figure-10: pH of Soil.

Table-3: Season: Summer 2016 / 2017 (Elements content).

| Sites | Al Cd | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | V | Zn |
|---------------------|---------------------|---------------|---------------|----------------|----------------|---------------------|-----------------|----------------|----------------|----------------|------------------|
| Less Polluted | 43846.41 ±327.08 | 1.69± 0.12 | 6.62± 0.1 | 43.37 ±1.12 | 27.71± 0.26 | 25034.38 ±337.56 | 337.2 ±1.54 | 35.86 ±0.16 | 39.45 ±0.12 | 80.78± 0.33 | 105.92± 0.26 |
| Moderately Polluted | 35152.39 ±36.58 | 1.4± 0.01 | 4.41 ±0.07 | 71.72 ±0.37 | 28.52 ±0.33 | 21324.68 ±334.17 | 323.78± 4.37 | 24.5 ±0.46 | 54.66± 0.31 | 55.04± 0.31 | 129.85 ±0.30 |
| Heavily Polluted | 31254.35 ±520.74 | 1.4±0. 03 | 5.35 ±0.18 | 79.58 ±5.42 | 22.63± 3.73 | 17825.99 ±277.56 | 251.39 ±3.50 | 24.42± 1.05 | 44.10 ±2.71 | 54.92± 2.84 | 111.69± 11.48 |

Table-4: Season: Winter 2017 (Elements content).

| Sites | Al | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | V | Zn |
|---------------------|--------------------------|---------------|---------------|------------------|----------------|---------------------|-----------------|----------------|----------------|----------------|-----------------|
| Less Polluted | 47265.87 ±337.14 | 1.63± 0.12 | 6.00 ±0.26 | 81.34 ±0.26 | 26.44 ±0.34 | 19580.48 ±130.59 | 226.64 ±0.62 | 32.29± 0.31 | 35.85± 0.18 | 69.59± 0.48 | 113.91± 0.41 |
| Moderately Polluted | 28992.46 ±348.90 | 1.59 ±0.12 | 5.64 ±0.38 | 36.94 ±0.28 | 12.88± 0.29 | 11243.20± 329.31 | 181.88 ±0.42 | 25.38± 0.31 | 47.78 ±0.16 | 29.87± 0.35 | 125.19 ±0.18 |
| Heavily Polluted | 58731.72 ±2132.9 0 | 1.58 ±0.08 | 12.7 ±2.8 | 124.80 ±28.50 | 37.08 ±1.14 | 32276.14 ±377.35 | 622.3 ±96.92 | 33.24 ±3.05 | 41.20± 1.26 | 76.54 ±5.6 | 112.59 ±4.3 |

The results of determination of the metals indicated that Al concentration was high while Cd has the lowest concentration (Figure-12). Fe, Mn and Zn concentration were comparatively high than other determined elements in the Table-4.

Metals such as Co, Cr, Cu, Fe, Mn, Ni, and Zn are essential nutrients that are required for various biochemical and physiological functions¹¹.

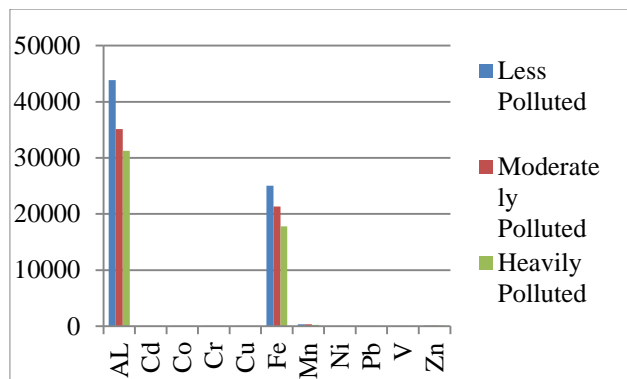


Figure-11: Summer 2016.

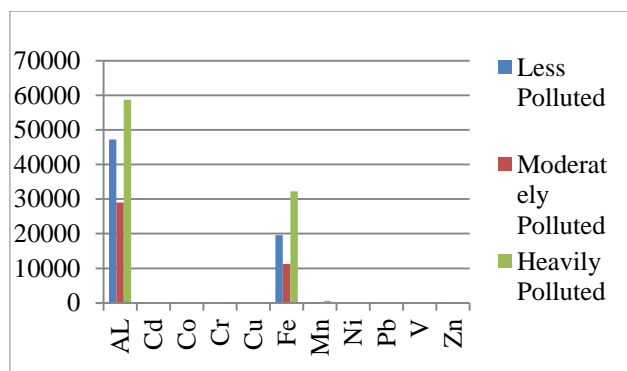


Figure-12: Winter 2017.

Al, Cd, Pb, Ni, V has no biological functions and are considered as non-essential metals¹². Nickel is an essential nutrient for some microorganisms and plants with nickel as an additional active site, wikipedia.org/wiki/Nickel¹³.

The seasons in environment showed a common behavior for all elements. Different analyses confirmed that the main pollution source of soil was from vehicles movements, populations and from some developmental activities¹⁴.

Conclusion

The Al has high metal value while Cd has the lowest concentration in soil in all sites and in seasons. From above data presentation it concluded that Al values are in the high order at all 3 sites and in 2 seasons. In contrast, Cd value at the lowest at all 3 sites and in 2 seasons. Fe and Mn are in the second and in third of the elements series. Zn and Cr are in fourth and fifth order of the series. V and Pb elements are nearly at the middle

in the elements series. Co is in second last position in elements order. The Cu and Ni are in eight and ninth position in the series in 2 different seasons and at 3 different sites. However, the V is in sixth position and lead is in seventh position in summer season. A little changed in Pb position in winter season. The elements values are different in summer and in winter seasons along with different study sites. In summer, values of Cd, Co, Cr, Cu, Ni and Pb values are smaller. Values of Al, Fe and Mn are higher in winter season. In this way, the elements values are with a little variation in different sites as well.

Nitrogen values are high in less polluted sites rather than in other sites which is important in the environment. The result of soil pH in road soil environment is suitable for different plants.

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WHO (1996): WHO Permissible Limits for Heavy Metals in Soil

| Parameter | Soil (mg/kg dry matter) |
|-----------|-------------------------|
| Cd | 0.8 |
| Cr | 100.0 |
| Co | 9.0 |
| Cu | 36.0 |
| Ni | 35.0 |
| Pb | 85.0 |
| V | 42.0 |
| Zn | 50 / 140 |

"Soil Target Values" The Dutch Standards Values for Soil, 2009¹⁵.