Constituents of Leachate Generation and Migration in Ministry of Agriculture Forest Nursery Open Dumpsite in Jos Plateau State, Nigeria

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Abstract. The constituents of leachate generation and migration in ministry of agriculture nursery open dumpsite in Jos Plateau were determined. Leachate extraction from solid waste (SW) was carried out. Test dumpsite soil with different elevations. Elevations were with uniform density. Representative solid waste dumpsite soil sample were collected from one dumpsite. The collected SW soil subjected to column experimental test, results showed physicochemical parameters (pH, TSS, TDS and EC) range of descriptive value in terms of histogram values of $5.66 - 8.23$ (1.0m to 1.5m depth) pH, $90.65 - 1125.96$mg/l (0.5 to 2.0m depth) TSS, $17.78 - 156$mg/l (1.5 to 0.5m depth) TDS, $9.02 - 80.01$ us/cm and principal component summary analysis. The histogram and principal component summary values increase. Alkalinity has highest concentration, followed by hardness which has least, BOD5 has lower values, followed by COD which has higher value, Cl decreases, SO$_4^{2-}$, NO$_3$ values increases, PO$_4$ in waste decreases with increase time and depth. The Na$^+$, increasing K$^+$ second to Na$^+$, increases, Mg$^{2+}$ and Ca$^{2+}$ in MSW increases as time and depth proceed. The results of Cu, Fe, Cd and Pb in histogram had moderate to high values. All were examined for physicochemical, alkalinity and hardness, BOD5, COD, anions, cations and heavy metals to study the seasonal variation of significant parameters. The results from the leachate analysis were used as a tool to identify the processes and mechanisms affecting the soil and water chemistry from the study area.
1. Introduction
In Nigeria today, urban centers are experiencing an increased rate of environmental deterioration, with refuse dumped along drainage channels. Most cities in Nigeria are faced with waste Management problems, in which Plateau State is not an exemption. Open dumping or landfill is therefore expected to remain a relevant source of soil surface and groundwater pollutant for the foreseeable future. The dumpsite leachate discharge may lead to serious environmental problems. Leachate may percolate through dumpsites liners or geological structures as fractures and sub solid causing pollutions of surface and groundwater resources. Generation of leachate from dumpsite is a complex combination of physical, chemical and biological processes whereby waste age has effect to performance of dumpsite that generate leachate. The major potential environmental impacts related to solid waste dumpsite leachate are pollution of surface water and groundwater. The risk of groundwater pollution is probably the most severe environmental effect from the dumpsite because historically most dumpsite were build without engineering liners and leachate collection and treatment systems .Generally, it is accepted that dumpsites undergo at least four phases of decompositions (a) an initial aerobic phase (b) an anaerobic acid phase (c) an initial methanogenic phase (d) a stable methanogenic phase [34].

Figure 1. Open waste disposal near water channel at Sabon Baki Area
Water is a precious resource and it has to be treated as such. The challenge of open dumping of municipal solid waste in Jos metropolis is an issue of water and waste mismanagement.

Depending on leachate accumulation, it can increase (during rainy season) or decrease (during dry season). Leachate deposited in landfills or in refuse dumps immediately becomes a part of the prevailing hydrological system. Fluids derived from rainfall, and groundwater, along with liquids generated by the waste itself through processes of hydrolysis and solubilisation, caused by an entire series of complex biochemical reactions during degradation of organic wastes, percolate through the deposit and mobilise different components within the waste. This leachate, the liquid drains from the dump, chiefly organic carbon largely in the form of fulvic acids migrate downward and contaminate the groundwater [29]. The leachate from MSW dumpsite may leak into groundwater aquifers due to rainfalls, spread into the adjacent river system by groundwater flow and pollute the surrounding environment. However, this process does not stop even after the dumpsite activities have stopped receiving solid waste. Hence, it is very essential to keep assessing and monitoring the surroundings of dumpsites [7].

This dumpsite has been used as a processing site for the municipal solid waste generated from the Kugiya market in Jos South local government area. Jos metropolis receives an average annual rainfall of 107 mm on long term basis. The entire year rainfall of 177.33 days and collect 1.233 mm of rainfall. The primary rainy season is from April to September. The ministry of Agriculture forest nursery dumpsite is open dumping started operation since 2008 and the site is on the main road. Total area of the dumpsite 68,598 m² including projected site area, perimeter area covered by open dumping operation 1.33km. Visual inspection shows reddish brown colored and stony sand with very little clay. Previous dumping activities started next to the road, several small heaps and also larger areas still exist alongside of the access road, notable erosion of the access road due to surface run-off:

Municipal solid waste (MSW) is a broad and ill-defined term, covering all the waste generated by households and light commercial activities. Local conditions in the community may also have a major impact on the composition of the MSW produced.

Leachate is a contaminated liquid emanating from the solid waste dumps such as dumpsite and contains soluble organic and inorganic compounds as well as suspended particles. Open dumping is the simplest and normally cheapest method for disposing of waste. Generally, the municipal solid waste landfalls create lots of environmental pollution due to dumpsite gas combustion, leakage of leachate and foul smells. Among all these, leakage of leachate affects the surrounding environment the most, especially the surface and ground water bodies because the
leachate consists of high concentrations of heavy metals, organic compounds and toxic contents.

In most low-to medium-income developing nations, almost all generated solid waste goes to open dumping or landfill. Even in many developed countries, open dumping or land filling is the most popular disposal method. Recently, several cases have been reported around the world related to pollution of water bodies which were caused by municipal solid waste landfills.

The usage of heavy metals has increased substantially over the years [11]. The excess quantity of heavy metals disposed of the land can cause significant damage to the environment and human health as a result of their mobility, solubility and their ability to transfer in water or plants [11, 22].

Additionally, although the proportion of waste to open dumping or landfill may in future decrease and the total volumes of municipal solid waste (MSW) being produced are still increasing significantly for many developed countries. Due to the decomposition of organic matter, leachate derived from landfills or dumpsite comprises primarily dissolved organic carbon, for the most part within the form of fulvic acids [17]. The solubility of metals in leachate is enhanced through complexation by dissolved organic matter. The solubility of organic contaminants (e.g. solvents) in waste may also be slightly enhanced through the presence of high levels of organic carbon in leachate. Hydrophobic compounds may be mobilised through leachate, as they adsorb to organic carbon in solution.

The effect on soil and water resources from open dumping site and landfills in most areas must be noticed. Low costs and high availability of marginal land have made dumpsites and landfilling the most commonly used waste disposal method, dumpsite or land filling has many effects on soil, water resources. In fact, most arid areas suffer from the sever rainfall erosion which could increase the possibility of surface and ground water contamination. Disposal of liquid waste is not uncommon in open dumpsite or landfills in arid areas. Jos, Plateau State capital and its environs, as an example, has seen a large increase in population during the past five decades as a result of population growth and forced migrations.

The open dumping method used in most of Jos metropolis (dumpsites lands) due to their simple set-up and low operational requirements. Open dumping lead to leachate formation and migration of leachate pollutants to permeate soil, surface and groundwater.

Factors that affect leachate generations are: climate (rainfall), topography (run on/run-off), landfill cover, vegetation, and type of waste. In open dumpsite like the one in ministry of agriculture forest nursery in Jos metropolis, the leachate infiltrating into groundwater causes severe contaminations.

The process depends on several factors; soil chemistry and mineralogy, leachate/soil interaction, groundwater aquifer system and water characteristics. Solid waste disposed in open dumpsite and landfills is usually subjected to series of
complex biochemical and physical processes, which lead to the production of both leachate and gaseous emissions. When leachate leaves the dumpsite or landfill, permeate soil and water resources, it causes surface water and ground water pollution.

Leachate liquid seeps from solid wastes or other medium and have extracts with dissolved or suspended materials from it. The volume of leachate depends principally on the area of the dumpsite, the meteorological and hydro-geological factors and effectiveness of capping.

Leachate from the solid waste dump has a significant effect on the chemical properties as well as the geotechnical properties of the soil. Leachate contains a host of toxic and carcinogenic chemicals, which may cause harm to both human and the environment.

2. Methods

2.1. Study Area

![Figure 2. Jos South and Jos North Local Govt. Area in Plateau State](image-url)
The Jos metropolis is located in Nigeria’s North-Central, with an area of about 26,899 square kilometers, with population of about 850,000 people based on the result of 2006 Nigerian census figures. The study area lies between latitudes 9° 47’ 04.2” and 9° 47’ 12” N and longitudes 8° 52’ 13.11” and 8°52’ 14.9” E. The study area is located within the Bukuru (kugiya) market of Jos Plateau State, Nigeria covering an area of 68,598 square meters with perimeter 1.33km.

The dumpsite at ministry of agriculture forest nursery is located close to Kugiya market Bukuru, Jos South local Government area. The elevation of the site is not measured. The dump site is reached first through the main road leading to Theological College of Northern Nigeria (TCNN), Dorouwa and then by a smaller road leading directly to the dump with the following:

| Northing | Easting      |
|----------|--------------|
| 09°47’05.5” | 08°52’18.5” |
| 09°47’07.2” | 08°52’17.0” |
| 09°47’08.7” | 08°52’15.9” |
| 09°47’07.8” | 08°52’13.6” |
| 09°47’04.2” | 08°52’13.11”|
| 09°47’12.0” | 08°52’14.9” |

Haphazard waste dumping began in 2007 along the main road. The existing dump heaps activities are being piled not compacted and covered with soil. Dumping is not organized in cells and covered with soil. Dumping is carried out on daily basis. There are no specified opening times for the dumpsite as no entry controls exists. The Plateau Environmental Protection and Sanitation Agency (PEPSA) and Municipality did not set up a controlled entry procedure. However my visit to the dumpsite in the month of August 2020 shows that some farmers in the area farm maize on the heap of the waste.

Due to the coarse soil characteristics of the dumpsite bed, seepage is considered in areas of underlying bedrock as low and occurs mostly in fractures or weathered zones as seen in the study area. This is as a result of unsustainable mining activities that were carried in the area without remediation. During heavy rains the run-off is high due to the hilly topography leading to erosion on the site and of the access road. Burning is still very common. This site receives majorly municipal solid wastes from different areas including Bukuru market and other wastes.

The dumpsite consists of mix waste including municipal, institutional, residential, industrial, and commercial waste. Sample collection was carried out in the month of November 2019, after rainy season so that the measured parameter was not affected by the rainwater.
2.2. Sample Collection

An active dumping site located at ministry of agriculture forest nursery Bukuru close to kugya market, Jos south local government area of Plateau State, had been selected for investigation of constituents leachate generation and percolation. This
site was in operation since 2008 to receive mainly municipal solid wastes from different areas including Bukuru market.

The present practice of municipal solid waste dumping in the area was unscientific, disposing wastes on open space without considering the geology and its underground structures as well as future environmental consequences.

To understand the effect of leachate generated from ministry of agriculture forest nursery, Kugiya Market dumping site.

2.3. Method of Leachate Extraction Column

The material was spread on the plastic sheet and the waste was mixed using the shovel in order to obtain the homogeneous mixture of the sample. Out of the total waste of 1000 kg, the waste samples of 100 kg were extricated randomly throughout sampling period in order to acquire representative waste samples. In the sampling procedure, the samples kept at (n ¼ of 10 for the site). The waste samples thus obtained were segregated manually with the help of informal waste collectors in the study area.

Leachate that was collected from each MSW column was put on the top of special soil column, where leachate from 0.5m MSW column was put in the 0.5m column of soil, and leachate from 1m MSW column was put in the 1.0m column of soil and so on. There were six (6) soil columns. Each one contains soil from the same disposal dumpsite. Soil was put in columns after removing the rocks and big stones. Each column contains mesh wire and gravel. Then the leachate that was produced from each column of MSW was poured into each soil column, where four columns of MSW were poured into four soil column. The other two columns of soil were used for other purposes which the fifth column was pure water(rainfall) that passed through 2m dump site soil column, in the sixth column leachate that came out of the 2m soil column was allow to passed through a 1.5m MSW elevation.

2.4. Material Preservation

All the samples were collected in pre-cleaned polyethylene containers of 5.0L capacity and after returning to the laboratory the samples were stored in 4o C in the incubator and were eventually analyzed as per the Standard Methods (APHA, 17thEdition). The samples were kept in refrigerator before analysis. The samples were analyzed for MSW leachate parameter and the same test for the leachate that came out from soil column. The parameters were: pH, EC, TSS, TDS, alkalinity, hardness, BOD5, major anions, major cations and heavy metals. Leachate analyses were conducted according to the guidelines prescribed in ASTM D5231-92(2008). Samples for heavy metals were preserved separately by adding 1.0 ml conc. Nitric acid so that there will be no precipitation of the heavy metals.
2.5. Analysis of environmental samples

The leachate, samples prepared for transportation in special boxes and then taken to National geosciences research laboratory Kaduna using atomic absorption spectrophotometer. The anions were determined at geochemistry department of Geology, University of Jos using titration method. The methods of determination followed Table 1

Leachate collected from each MSW columns and from soil column. Samples collected in plastic bottle at the end of experiment. The samples were analyzed in the laboratory.

### Table 1. Details of Parameters Monitored, Methods of Analysis and Instrument used

| Parameter                  | Method Adopted          | Apparatus/Instrument Used                     |
|----------------------------|-------------------------|----------------------------------------------|
| pH                        | Electrometric Method    | Electronic pH meter                          |
| Electrical Conductivity (EC) | Laboratory Method      | Deluxe conductivity meter                     |
| Total Dissolved Solid (TDS) | Gravimetric Method      |                                              |
| Total Hardness (TH)        | EDTA Titrimetric Method |                                              |
| Chemical Oxygen Demand (COD) | Open Reflux Method    | Digestion vessels                             |
| Biochemical Oxygen Demand (BOD5) | Winkler’s Method | Air incubator                                  |
| Chloride (Cl–)             | Argentometric method    |                                              |
| Sulphate (SO\textsubscript{4}\textsuperscript{2–}) | Turbidimetric Method | UV-Visible Spectrophotometer (Varian Make, Model-50 Bio) |
| Phosphate (PO\textsubscript{4}\textsuperscript{3–}) | Colorimetric Method | UV-Visible Spectrophotometer (Varian Make, Model-50 Bio) |
| Arsenic (As),              | Atomic Absorption       | Atomic Absorption Spectrophotometer           |
| Cadmium (Cd),              | Spectrometric Method    | Atomic Absorption Spectrophotometer           |
| Chromium (Cr),             | Atomic Absorption       | Atomic Absorption Spectrophotometer           |
| Lead (Pb),                 | Spectrometric Method    | Atomic Absorption Spectrophotometer           |
| Zinc (Zn),                 | Atomic Absorption       | Atomic Absorption Spectrophotometer           |
| Copper (Cu)                |                         |                                              |

Samples collected homogenized, dried at 105°C to a constant weight, ground into fine powder using an acid prewashed mortar and pestle and sieved through a 2mm nylon sieve. Analysis were done using Atomic Absorption Spectroscopy (AAS) model (AAS VGB 210 System) following digestion with 10 ml Aquilegia in a digestion tube, for the level of the heavy metals in the soil and water samples. The samples dried in an oven at 105°C to a constant weight and sieved through a 2mm...
mesh to remove large debris, gravel sized materials and other unwanted materials. A portion (0.5g) of the sieved samples measured after homogenization and ground with a laboratory mortar and pestle. The ground samples were transferred into a 250ml beaker. A portion (10ml) of 1:1 nitric acid measured into the beaker and covered with a water glass. The beaker placed on a steam bath at 99°C and left for 1 hour. The samples removed from the steam bath and allowed to cool for 10 minutes after which 2ml of distilled water and 3ml of 30% hydrogen peroxide added to the sample, the beaker covered with watch glass and placed on steam bath and allowed to digest until the sample appearance remained unchanged. The samples filtered through a Whitman No.1 filter paper and the solution made up to 50ml mark with distilled water. The samples subsequently analyzed for lead, cadmium, copper, iron, zinc, cobalt and nickel using atomic absorption spectrophotometer (AAS) machine to analyze and the result of the various heavy metals determined and data recorded. (Conversions: A *50ml=mg/kg. 0.5g where A is concentration in ppm).

2.6. Statistical Analysis
Geostatistical, descriptive statistics (histogram,) and Multivariate (correlation) were calculated using paleontological statistics (PAST).

3. Results

| Table 2. Physicochemical properties (pH, TSS, TDS and EC) |
|---------------------------------------------------------|
| Contaminated sample | Coordinates (9° 47’ 09”N, 8° 52’ 15”E) |
| Sample ID | pH | Time(8) | TSS(mg/l) | pH | Time(8) | TSS(mg/l) |
| Sample ID | 2.0 | 1.5 | 1.0 | 0.5 | 2.0 | 1.5 | 1.0 | 0.5 |
| MSW 1 | 6.06 | 7.13 | 5.66 | 7.15 | 299.64 | 302.4 | 666.54 | 972.65 |
| MSW 2 | 6.43 | 8.23 | 6.31 | 7.4 | 205.92 | 583.8 | 161.28 | 449.82 |
| MSW 3 | 6.44 | 7.25 | 6.47 | 7.37 | 1125.96 | 526.39 | 340.2 | 197.96 |
| MSW 4 | 6.41 | 7.14 | 6.44 | 7.27 | 25.41 | 210.17 | 327.6 | 90.65 |
| Natural 5 | 6.27 | 7.03 | 6.41 | 7.17 | 114.84 | 187.61 | 340.2 | 107.8 |
| Sample ID | TDS(mg/l) | EC(ms/cm) |
| Sample ID | 2.0 | 1.5 | 1.0 | 0.5 | 2.0 | 1.5 | 1.0 | 0.5 |
| MSW 1 | 1362.9 | 1384.6 | 1580.5 | 1560.0 | 681.5 | 692.3 | 800.1 | 790.3 |
| MSW 2 | 858.4 | 546.3 | 726.1 | 1167.2 | 430.5 | 290.6 | 370.8 | 595.0 |
| MSW 3 | 636.5 | 630.8 | 817.3 | 926.4 | 320.8 | 315.7 | 411.8 | 470.2 |
| MSW 4 | 269.7 | 177.8 | 260.8 | 538.4 | 135.2 | 90.2 | 140.4 | 270.9 |
| Natural 5 | 264.3 | 186.4 | 204.8 | 355.2 | 132.2 | 100.3 | 110.5 | 180.2 |
### Table 3. Concentration of Alkalinity and Hardness (in mg/l) in the Dumpsite

| Coordinates (09° 47’ 09”N, 8° 52’ 15”E) | Alkalinity (mg/l) | Hardness (mg/l) |
|-----------------------------------------|-------------------|-----------------|
| **Sample ID**                          | **Time(8)** 2.0   | **Time(8)** 2.0  |
| MSW 1                                  | 9001 8001 6502   | 2503 5004 4401  |
| MSW 2                                  | 6002 4003 3501   | 1802 3202 2503  |
| MSW 3                                  | 5103 3504 3004   | 1401 2803 1902  |
| MSW 4                                  | 3101 1802 803    | 304 1401 901   |
| Natural5                                | 3112 1601 703    | 402 1303 801   |

### Table 4. Concentration of BOD5 and COD (in mg/l) in the Dumpsite

| Coordinates (09° 47’ 5.9”N, 8° 52’ 12.1”E) | BOD5 (mg/l) | COD (mg/l) |
|--------------------------------------------|-------------|------------|
| **Sample ID**                              | **Time(8)** | **Time(8)** | **BOD5/COD** |
| MSW 1                                      | 1500        | 1480 1460 1440 10400 10381 10363 10344  |
| MSW 2                                      | 1481        | 1462 1443 1422 10380 10362 10343 10324  |
| MSW 3                                      | 1463        | 1443 1424 1403 10360 10345 10323 10304  |
| MSW 4                                      | 1444        | 1424 1406 1385 10340 10322 1030 10285    |
| Natural5                                   | 1426        | 1406 1387 1366 10320 10302 10283 10265  |

#### BOD5/COD

|                | 0.144 | 0.143 | 0.140 | 0.139 |
|----------------|-------|-------|-------|-------|
|                | 0.143 | 0.141 | 0.140 | 0.138 |
|                | 0.141 | 0.139 | 0.138 | 0.136 |
|                | 0.140 | 0.138 | 0.136 | 0.135 |

### Table 5. Concentration of Major Anions (in mg/l) in the Dumpsite

| Coordinates (09° 47’ 09”N, 8° 52’ 15”E) | Cl⁻ (mg/l) | SO₄²⁻ (mg/l) | NO₃⁻ (mg/l) | PO₄⁻ (mg/l) |
|-----------------------------------------|------------|--------------|-------------|-------------|
| **Sample ID**                           | **Time(8)** | **Time(8)** | **Time(8)** | **Time(8)** |
| MSW 1                                   | 7548.3     | 2.0          | 506.7       | 2.0         |
| MSW 2                                   | 4006.3     | 1480         | 91759.6     | 1470        |
| MSW 3                                   | 3258.4     | 1604.8       | 1006.4      | 1047.7      |
| MSW 4                                   | 197.4      | 605.4        | 358.5       | 455.7       |
| Natural5                                 | 1607.6     | 1358.9       | 304.7       | 298.6      |

#### Cl⁻ (mg/l)

|                | 2.0 | 1.5 | 1.0 | 0.5 |
|----------------|-----|-----|-----|-----|
|                | 2.0 | 1.5 | 1.0 | 0.5 |

#### SO₄²⁻ (mg/l)

|                | 506.7 |         | 2.0 | 1.5 | 1.0 | 0.5 |
|----------------|-------|---------|-----|-----|-----|-----|
|                | 604.2 | 339.5   | 317.8 | 317.8 | 317.8 | 317.8 |
|                | 544.5 | 306.7   | 289.9 | 289.9 | 289.9 | 289.9 |
|                | 304.7 | 257.5   | 229.5 | 229.5 | 229.5 | 229.5 |
|                | 289.6 | 229.5   | 189.9 | 189.9 | 189.9 | 189.9 |

#### NO₃⁻ (mg/l)

|                | 2.0 | 1.5 | 1.0 | 0.5 |
|----------------|-----|-----|-----|-----|
|                | 2.0 | 1.5 | 1.0 | 0.5 |

#### PO₄⁻ (mg/l)

|                | 2.0 | 1.5 | 1.0 | 0.5 |
|----------------|-----|-----|-----|-----|
|                | 2.0 | 1.5 | 1.0 | 0.5 |
### Table 6a. Concentration of Major Cations of Na⁺ and K⁺ (in mg/l) in the Dumpsite

| Time(8) | Na⁺ (mg/l) | K⁺ (mg/l) |
|---------|------------|-----------|
| 2.0     | 2.98       | 2.50      |
| 1.5     | 0.99       | 0.28      |
| 1.0     | 135.40     | 128.70    |
| 0.5     | 115.80     | 112.90    |
| Natural | 35.61      | 31.69     |

### Table 6b. Concentration of major Cations of Mg²⁺ and Ca²⁺ (in mg/l) in the Dumpsite

| Time(8) | Mg²⁺(mg/l) | Ca²⁺(mg/l) |
|---------|------------|------------|
| 2.0     | 2.70       | 2.0        |
| 1.5     | 0.87       | 1.5        |
| 1.0     | 0.59       | 1.0        |
| 0.5     | 0.36       | 0.5        |
| Natural | 75.8       | 75.8       |

### Table 7a: Concentration of Heavy metals of Co and Cu (in mg/l) in the Dumpsite

| Time(8) | Co(mg/l) | Cu(mg/l) |
|---------|----------|----------|
| 2.0     | 18.82    | 7.97     |
| 1.5     | 17.52    | 6.86     |
| 1.0     | 16.20    | 5.75     |
| 0.5     | 14.88    | 4.64     |
| Natural | 13.56    | 3.52     |
Table 7b. Concentration of Heavy metals of Cr and Ni (in mg/l) in the Dumpsite

| Sample ID | Cr(mg/l)     | Ni(mg/l)     |
|-----------|--------------|--------------|
| MSW 1     | 210.30       | 185.07       |
| MSW 2     | 160.07       | 179.84       |
| MSW 3     | 109.84       | 174.61       |
| Natural5  | 50.61        | 169.38       |

The results of physicochemical properties in histogram had moderate to high values. For pH in histogram (5.66 to 8.23) normal fit (corresponding to frequency of 15, for TSS in histogram (25.41 to 1125.96) normal fit corresponding to frequency of 4, for TDS in histogram (17.8 to 158.05) normal fit corresponding to frequency of 3, for EC in histogram (9.02 to 80.01us/cm) normal fit corresponding to frequency of 2 (Figure 5).
Figure 5. Histogram Plot for Physicochemical properties (pH, TSS, TDS and EC) at different depth

Figure 6. Histogram Plot for Alkalinity and Hardness (Mg/l) at different depth (Fit normal)

The results of alkalinity and hardness in histogram had moderate to high values. For alkalinity histogram shows (304 to 9001) normal fit corresponding to
frequency of 6, for hardness the histogram shows (201 to 5004) normal fit corresponding to frequency of 5.25, as the column MSW depth increase the alkalinity and hardness concentration increasing. The increases as the depth of MSW increases is evidence as the result of the histogram, shows that alkalinity has highest concentration, followed by hardness which has least concentration (Figure 6).

Figure 7. Histogram Plot for BOD5 and COD (Mg/l) at different depth (Fit normal)

For BOD5 in histogram (1366.09 to 1500) normal fit corresponding to frequency of 3 (Figure 7), for COD in histogram (10264.76 to 10400) normal fit frequency of 2.90 (Figure 3), as the column MSW depth increase the BOD5 and COD increasing. The increases as the depth of MSW increases is evidence in the result of the histogram shows that BOD5 has lower concentration, followed by COD which has higher concentration (Figure 7).

The results of anions of Cl\(^-\), SO\(_4\)\(^{2-}\), N\(_3\)\(^-\) and P\(_4\)\(^{3-}\) in histogram, had moderate to high values (197.4 to 91759.6 normal fit with highest frequency of 130 and most values at 50), Cl\(^-\) increasing S\(_4\)\(^{2-}\) (189.9 to 878.2 normal fit, most frequency of 9.8), N\(_3\)\(^-\) (0.02 to 2.98 normal fit, with most frequency of 13) values increases as the depth of MSW increases, increases .P\(_4\)\(^{3-}\) (4.99 to 135.4 normal fit with most frequency of 6.70).in MSW also increase as time depth proceed, Figure 8).

The results of cations of Na\(^+\), K\(^+\), Mg\(^{2+}\) and Ca\(^{2+}\) in histogram had moderate to high values. For Na\(^+\) in histogram (1768 to3804.77) normal fit value 2500 corresponding to frequency of 50,for K\(^+\) in histogram (836.8 to 1675) normal fit value (800 to 1700) corresponding to frequency of 22, for Mg\(^{2+}\) in histogram (29.6 to 367.8) normal fit value (-37.5 to 225) corresponding to frequency of 5.75 and for Ca\(^{2+}\) in histogram (48 to 1407) normal fit value (250 to 1000) corresponding to frequency
of 5.0 $\text{Na}^+$, increasing $\text{K}^+$ second to $\text{Na}^+$, increases $\text{Mg}^{2+}$ and $\text{Ca}^{2+}$ in MSW also increasing as time depth proceed (Figure 9).

The results of Cu, Fe, Cd and Pb in histogram had moderate to high values. For Co in histogram (3.52-18.02) normal fit value 11 corresponding to frequency of 5.75, for Cu in histogram (0.57-5.46) normal fit value (0.50-2.20) corresponding to frequency of 600, for Cr in histogram (50.61-260.53) normal fit value (100-170) corresponding to frequency of 17, for Ni in histogram (0.7-39.6) normal fit value (0.2-13) corresponding to frequency of 12, for Fe in histogram (10.67-4035) normal fit value (0-4100) corresponding to frequency of 100, for Zn in histogram (1254-6219) normal fit value (1400-2850) corresponding to frequency of 63.25, for Cd in histogram (0.006-2.911) normal fit value (0-3.25) corresponding to frequency of 11 and for Pb in histogram (3.88-82.7) normal fit value (-16-95) corresponding to frequency of 3.0 heavy metals concentration of effluent leachate was increasing (Figure 10).

![Figure 8. Histogram Plot for Major Anion (Cl-, $\text{SO}_4^{2-}$, $\text{NO}_3^-$, and $\text{PO}_4^{3-}$) at different depth (Fit normal)](image-url)
Figure 9. Histogram Plot for Major Cations (Na$^+$, K$^+$, Mg$^{2+}$ and Ca$^{2+}$) at different depth (Fit normal)
Figure 10. Histogram Plots for Heavy Metals (Co, Cu, Cr, Ni, Fe, Zn, Cd and Pb) at different depth (Fit normal)
3.1. Multivariate Relationship of Physicochemical Properties using Principal Component Analysis

Principal component analysis (PCA) was performed in past statistical software used to identify the major physicochemical properties of leachate in the study area. Table 7 presents the principal component (PC) loadings for possible components of different major physicochemical properties of leachate concentration in the data. Loadings, that represent the importance of the variables for the components are positive. Component Matrix for municipal solid waste column analysis data and its component eigenvalue and percent of variance are presented, on the principal component analysis.

pH in the first components explain eigenvalue 0.263 corresponding to variance of 65.977%, second component eigenvalue 0.131 corresponding to variance of 32.848%, with scores of 0.879. The other components are not more important, they explain low variance and their eigenvalues are less and can only indicate that these components are related to more local effects than the first components (Table 7).

TSS in municipal solid waste column component matrix (Table 7), also explain that the first components has eigenvalue of 209324 corresponding to variance of 52.331 % and the second components has eigenvalue of 154569 corresponding to variance of 38.642 which are greater than one, scores of (795.47 and 668.68). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects.

TDS in municipal solid waste column component matrix (Table 7), also explain that the first components has eigenvalue of 9677.95 corresponding to variance of 97.513% and second component has eigenvalue of 216.098 corresponding to variance of 2.1774 which is greater than one, scores of (150.54). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects.

EC in municipal solid waste column component matrix (Table 7), also explain that the first components has eigenvalue of 2432.8 corresponding to variance of 97.643% and second component has eigenvalue of 51.5983 corresponding to variance of 2.0709% which is greater than one, scores of (75.229). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects.

3.2. Multivariate Relationship of Alkalinity and Hardness

The results of principal component (correlation) summary Table 8, for alkalinity and hardness are presented.
Component Matrix for municipal solid waste column analysis data and its component eigenvalue and percent of variance are presented, on the principal component analysis for alkalinity in municipal solid waste columns component matrix (Table 8), the first components explain eigenvalue 3.93593 corresponding to variance of 98.398 which is greater than one, scores of 2.988. The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects than the first components. Component one shows positive loadings for alkalinity of column analysis with highest value of Pc1. It shows positive and strong loadings of 0.50378 that indicates the relationships of loading plot C maximum loadings of 0.50378 for the columns.

Principal component analysis for hardness in municipal solid waste column component matrix (Table 9), also explain that the first components has eigenvalue of 3.8336 corresponding to variance of 95.84% and 0.15836 corresponding to variance of 3.595% which is greater than one, scores of (2.8605). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for hardness of column analysis with highest value of Pc1. It shows positive and strong loadings of E (0.99528, G 0.50613, F 0.5051, and H 0.4793) that indicates the relationships of loading plot at maximum loadings for the columns follows by (G).

| PC | Eigenvalue | % variance | Eigenvalue | % variance |
|----|------------|------------|------------|------------|
| 1  | 1.90235E07 | 99.212     | 3.834      | 95.840     |
| 2  | 138988     | 0.725      | 0.158      | 3.959      |
| 3  | 11773.8    | 0.061      | 0.006      | 0.153      |
| 4  | 255.5      | 0.001      | 0.002      | 0.048      |

Table 8. Principal Component (Correlation) Summary for Alkalinity and Hardness at different depth

On the principal component analysis for BOD5 in municipal solid waste columns component matrix (Table 9), the first components explain eigenvalue 3420.27 corresponding to variance of 99.996% which is greater than one. The other
components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects than the first components (Table 9). Component one shows positive loadings for BOD5 of column analysis with highest value of Pc1. It shows positive and strong loadings that indicates the relationships of columns 2.

Principal component analysis for COD in municipal solid waste column component matrix (Table 9), also explain that the first components has eigenvalue of 3.99164 corresponding to variance of 99.966% which is greater than one. The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for COD of column analysis. It shows positive and strong loadings that indicate the relationships of component Pc1 that relate Pc 2.

3.3. Multivariate Relationship of Major Anions

On the principal component analysis for Cl− in municipal solid waste columns component matrix (Table 10), the first components explain eigenvalue 1.0180E07 corresponding to variance of 98.235% which is greater than one. The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects than the first components.

Table 10. Principal Component (Correlation) Summary for Anions (Cl−, SO₄²⁻, NO₃⁻ and P0₄³⁻) at different depth

| PC | Eigenvalue | % variance | Eigenvalue | % variance | Eigenvalue | % variance | Eigenvalue | % variance |
|----|------------|------------|------------|------------|------------|------------|------------|------------|
| 1  | 1.0180E07  | 98.235     | 7566.4     | 97.036     | 3.1327     | 94.284     | 4695.21    | 99.090     |
| 2  | 149487     | 1.443      | 2001.1     | 0.3951     | 0.001      | 0.0434     | 0.12       | 0.000      |
| 3  | 33366.3    | 0.322      | 1.4813     | 0.0002     | 4.8528E-05 | 1.60       | 0.034      |            |

Component one shows positive loadings for Cl− of column analysis with highest value of Pc1. It shows positive and strong loadings that indicates the relationships of two columns.

Principal component analysis for SO₄²⁻ in municipal solid waste column component matrix (Table 10), also explain that the first components has eigenvalue of 75656.4 corresponding to variance of 97.036% which is greater than one. The other
components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects.

Component one shows positive loadings for \( \text{SO}_4^{2-} \) of column analysis. It shows positive and strong loadings that indicate the relationships of component \( \text{Pc1} \) that relate to two.

\( \text{NO}_3^- \) in municipal solid waste leachate column component matrix (Table 10), the first components has eigenvalue of 3.15271 corresponding to variance of 94.284% and components two has 5.6707 corresponding to variance of 36.4455 which is greater than one. The other components are not more important, they explain low variance and their eigenvalues are less than one indicating that these components are related to more local effects than the first components.

Table 11. Principal Component (Correlation) Summary for Cations (Na\(^+\), K\(^+\), Mg\(^{2+}\) and Ca\(^{2+}\)) at different depths

| PC  | Eigenvalue | % variance | Eigenvalue | % variance | Eigenvalue | % variance | Eigenvalue | % variance |
|-----|------------|------------|------------|------------|------------|------------|------------|------------|
| 1   | 3839.87    | 99.152     | 2496.4     | 100.000    | 37582.9    | 99.388     | 499824     | 97.759     |
| 2   | 32.853     | 0.8479     | 1.6857E-26 | 6.752E-28  | 163.9080   | 0.433      | 0.8510     | 1.756      |
| 3   | 4.6664E-05 | 1.205E-06  | 1.3390E-30 | 5.364E-32  | 55.6779    | 0.147      | 212.165    | 0.415      |
| 4   | 2.0177E-33 | 5.210E-6   | 0.5916E-6  | 2.641E-61  | 11.8137    | 0.031      | 9.0560     | 0.07       |

Component Matrix for municipal solid waste column analysis data and its component eigenvalue and percent of variance are presented, on the principal component analysis for \( \text{Na}^+ \) in municipal solid waste columns component matrix (Table 11), the first components explain eigenvalue 3839.87 corresponding to variance of 99.152% which is greater than one, scores of 80.005. The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects than the first components. Component one shows positive loadings for \( \text{Na}^+ \) of column analysis with highest value of \( \text{Pc1} \). It shows positive and strong loadings of 0.99906 that indicates the relationships of loading plot (A, B, D) maximum of the columns.

Principal component analysis for \( \text{K}^+ \) in municipal solid waste column component matrix (Table 11), also explain that the first components has eigenvalue of 2496.4 corresponding to variance of 100% which is greater than one, scores of (63.2,31.6). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for \( \text{K}^+ \) of column analysis with all showing loading value of 100%. It shows positive and strong loadings of all columns (E, F, G, and H) of 1.0 that indicate the relationships of component \( \text{Pc1} \) which relate to others.
Principal component analysis for Mg$^{2+}$ in municipal solid waste column component matrix (Table 11), also explain that the first components has eigenvalue of 37582.9 corresponding to variance of 99.388% which is greater than one, scores of (282.82). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings plot for Mg$^{2+}$ of column analysis for I(0.63173, 0.60979, 0.43685, 0.19555). It shows positive and strong loadings of all columns (I, J, K, and L) that indicate the relationships of component Pc1 which relate to others.

Principal component analysis for Ca$^{2+}$ in municipal solid waste column component matrix (Table 11), also explain that the first components has eigenvalue of 499824 corresponding to variance of 97.759% which is greater than one, scores of (1102.3) second component has eigenvalue of 8978.51 corresponding to variance of 1.7561% with scores(191.93). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings plot for Ca$^{2+}$ of column analysis for M and O (0.57077, 0.56661, 0.55132, and 0.22185). It shows positive and strong loadings of all columns (M, O, N, and P) that indicate the relationships of component Pc1 which relate to others.

3.4. Multivariate Relationship of Heavy Metals
Component Matrix for municipal solid waste column analysis data and its component eigenvalue and percent of variance are presented, on the principal component analysis for Co in municipal solid waste columns component matrix (Table 12a), the first components explain eigenvalue 16.9522 corresponding to variance of 99.986% which is greater than one, scores of 5.185. The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects than the first components. Component one shows positive loadings for Co of column analysis with highest value of Pc1. It shows positive and strong loadings of 0.99999 that indicates the relationships of maximum loadings of 1 for the columns.

Principal component analysis for Cu in municipal solid waste column component matrix (Table 12a), also explain that the first components has eigenvalue of 0.170608 corresponding to variance of 99.87 % which is greater than one, scores of (0.52264).

The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for Cu of column analysis with highest value of Pc1. It shows positive and strong loadings of
0.99528 that indicates the relationships of loading plot (E) maximum loadings of 1 for the columns.

### Table 12a. Principal Component (Correlation) Summary for Heavy metals (Co,Cu,Cr and Ni) at different depth

| PC | Eigenvalue | % variance | Eigenvalue | % variance | Eigenvalue | % variance | Eigenvalue | % variance |
|----|------------|------------|------------|------------|------------|------------|------------|------------|
| 1  | 16.9522    | 99.986     | 0.1706     | 99.987     | 7025.7     | 99.970     | 530.275    | 99.885     |
| 2  | 0.0023     | 0.013      | 1.2462E-05 | 0.007      | 1.9916     | 0.028      | 0.6107     | 0.115      |
| 3  | 6.2423E-05 | 0.0004E-06 | 0.0029     | 0.149      | 0.0021     | 3.389E-05  | 6.3828E-06 | 0.001      |
| 4  | 4.9066E-06 | 2.894E-05  | 4.9680E-06 | 0.003      | 2.4214E-2  | 3.445E-30  | 4.3201E-3  | 8.138E-34  |

Principal component analysis for Cr in municipal solid waste column component matrix (Table 12a), also explain that the first components has eigenvalue of 7025.74 corresponding to variance of 99.970% which is greater than one, scores of (104.07). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for Cr of column analysis with highest value of Pc1. It shows positive and strong loadings of 0.982086 that indicates the relationships of loading plot (I) maximum loadings of 0.98 for the columns.

### Table 12b. Principal Component (Correlation) Summary for Heavy metals (Fe,Zn,Cd and Pb) at different depth

| Eigenvalue | % variance | Eigenvalue | % variance | Eigenvalue | % variance | Eigenvalue | % variance |
|------------|------------|------------|------------|------------|------------|------------|------------|
| 2502.72    | 100.000    | 2.6759E06  | 100.000    | 0.4280     | 94.739     | 1267.88    | 100.000    |
| 5.6297E-25 | 2.249E-26  | 0.7301     | 2.728E-05  | 0.0238     | 5.2612     | 0.0070E-28 | 7.942E-30  |
| 1.4486E-26 | 5.788E-28  | 0.1899     | 7.098E-06  | 1.3632E-06 | 6.0004E-30 | 5.962E-31  | 0.0004     |
| 9.1611E-30 | 3.661E-31  | 0.0024     | 8.775E-08  | 1.5502E-33 | 3.432E-31  | 3.4665E-30 | 2.734E-31  |

Principal component analysis for Ni in municipal solid waste column component matrix (Table 12a), also explain that the first components has eigenvalue of 530.275 corresponding to variance of 99.970% which is greater than one, scores of (29.443). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for Ni of column analysis with highest value of Pc1.

Principal component analysis for Fe in municipal solid waste column component matrix (Table 12b), also explain that the first components has eigenvalue of 2502.72 corresponding to variance of 100% which is greater than one, scores of (63.28). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings plot for
Fe of column analysis for maximum loadings. It shows positive and strong loadings of all columns that indicate the relationships of component Pc1 which relate to others. Principal component analysis for Zn in municipal solid waste column component matrix (Table 12b), also explain that the first components has eigenvalue of 2.67591E06 corresponding to variance of 100% which is greater than one, scores of (2068.3).

The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for Zn of column analysis with highest value of Pc1. It shows positive and strong loadings of 0.99847 that indicates the relationships of loading maximum loadings for the columns.

Principal component analysis for Cd in municipal solid waste column component matrix (Table 12b), also explain that the first components has eigenvalue of 0.427966 corresponding to variance of 94.139% which is greater than one, scores of (0.56509). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for Cd of column analysis with highest value of Pc1. It shows positive and strong loadings of 0.89855 that indicates the relationships of loading plot maximum loadings for the columns.

Principal component analysis for Pb in municipal solid waste column component matrix (Table 12b), also explain that the first components has eigenvalue of 1267.88 corresponding to variance of 100% which is greater than one, scores of (45.04). The other components are not more important, they explain low variance and their eigenvalues are less than one and can only indicate that these components are related to more local effects. Component one shows positive loadings for Pb of column analysis with highest value of Pc1. It shows positive and strong loadings of same value that indicates the relationships of loading plot all at maximum for the column.

4. Discussion

4.1. Waste Characterization

The results of the dumpsites soils treated as leachate, from the experiment conducted using ministry of agriculture forest nursery land in Bukuru Jos South Local Government area are discussed as follows.

Municipal wastes within Jos-Bukuru dumpsite areas cove the scope of this study. Waste generated from the Market, Industries in the area, Animals market opposite the dumpsite, Private and Public Hospital in addition to clinics in the area. Some hospital in the area uses an incinerator for the disposal of hospital/surgical waste,
although such means of disposal is not always functional due to limitation as lack of fuel. Clinics send their medical waste to the dumpsite. Leachate from decomposing garbage percolates into soil and nearby water sources, and the resultant contamination of food, water and soil can have serious environmental consequences. The leachate generated at bottom of dumpsite carries different contaminants. Leachate is generated when water percolate through the waste in the dumpsite. The water coming in the dumpsite can be from all sources of water that fall from the atmosphere or flow from the surrounding land into the landfill or from the waste itself (George, 2014). These reactions alter the original soil properties. The leachate compositions of the experimental samples were statistically analyzed, and the results are given in Table 1 to 7 and Table 7 to 12. Concentrations of important of physico-chemical constituents are presented in histogram and principal component (correlation) summary. Wide ranges and great values of histogram and principal component analysis occur for most parameter in indicating leachate composition of Ministry of Agriculture forest nursery Bukuru affected by open dumping of unsorted municipal solid waste. Figure 1 show the concentration of physicochemical (pH, TSS, TDS and EC) m parameters in the leachate test (mg/l). As the leachate percolate through the soil, in the experiment it was observed that the physicochemical parameters concentration in the leachate sample changes. From the test results, the maximum concentration of both measured physicochemical parameters was observed at 2.0, 1.5, 1.0 and 0.5 m depth varies from histogram plotted, pH decreases from 7.15 to 6.06 as the depth increases from column 0.5 to 2.0 with some abnormality. This was noticeable in TSS, TDS and EC concentration in histogram.

In leachate experimental Test the physicochemical concentrations of the parameters was found to vary from 5.66 to 8.23(1.0 m depth to 1.5m depth) for pH, 90.65 to 1125.96mg/l (0.5m depth to 2.0m depth) for TSS, 17.78mg/l to 156mg/l (1.5m depth to 0.5m depth) for TDS and 9.02us/cm to 80.01us/cm (1.5m depth to 1.0m depth) for EC. The descriptive statistics of the concentrations of soluble major physicochemical properties of TSS, TDS and EC in the leachate samples which was backed by histogram, in leachate are listed in Figure 5. For TSS in histogram (25.41 to 1125.96) normal fit corresponding to frequency of 4, for TDS in histogram (17.8 to 158.05) normal corresponding to frequency of 3, for EC in histogram (9.02 to 80.01) normal fit corresponding to frequency of 2, physicochemical properties concentration increasing. The increases as the depth of MSW increases is evidence as the result of the histogram shows that TDS has highest concentration, followed by TSS and EC. Leachate is created by liquid percolating through waste, with the chemical composition of the waste and the biochemical processes within it playing a role. As the liquid migrates through the waste, it encounters pathogenic micro-organisms
and extracts solutes and suspended solids from the waste, thus becoming contaminated [34]. Increased levels of leachate occur with increased precipitation, such as during the wetter seasons.

An analysis of leachate from the dumpsite at the experimental site of municipal solid waste soil, surface water and the groundwater covered generally, physiochemical characteristics: (pH value, total suspended solid total suspended solids-TSS, electrical conductivity -EC and total dissolved solid-TDS) anions (chloride-Cl⁻, sulphate-SO₄²⁻, nitrate-NO₃⁻, and phosphate-PO₄³⁻), cations (sodium-Na⁺, potassium-K⁺, magnesiu-Mg²⁺ and calcium-Ca²⁺) and heavy metals (Co, Cu, Cr, Ni, Fe, Zn, Cd, and Pb).

Leachate characterization of major physicochemical properties of pH, TSS, TDS and EC demonstrated reactions between municipal solid waste leachate, immediate soil and water (surface and ground water) which influence the leachate’s chemistry and are useful in understanding the origin of leachate using column experiment as described above. The results from the leachate analysis were used as a tool to identify the processes and mechanisms affecting the soil and water chemistry from the study area.

In the present study, the variation in different parameters values may be attributed to the fluctuations in waste type and characteristics, the absence of waste shredding before disposal, compaction of the waste which retards degradation, and land filling meteorological conditions such as temperature and pressure (Table 2 to 7).

4.2. pH, Temperature and Total Suspended Solids (TSS)

The result of pH in the leachate from ministry of Agriculture forest nursery shows that as the leachate percolate through the soil, in the experiment, it is observed that the physicochemical parameters concentration in the leachate sample changes. From the test results, the maximum concentration of both measured physicochemical parameters 2.0, 1.5, 1.0 and 0.5 m depth which varies from histogram plotted, pH decreases as the depth increases from column 0.5 to 2.0 with some abnormality at column 0.5 and 1.5 (7.23 and 8.23).

The pH of leachate in multivariate analysis fluctuating. The pH of the leachate is increasing with the dumpsite age (Abu-Rukah and Al-Kofahi, 2001). These values indicated that the biochemical activity in the Jos metropolis dumpsites was as in its transition stage and the organic load was biologically unstabilized. During the initial stage the pH values were quite low due to acid formation but during the methanogenic stage the pH was mainly in the alkaline region.

The conductivity values ranged within levels that are reported in this work. These high values can be attributed to the high levels of the various anions.
According to [28] Soil temperature is one of the deciding factors in the process of litter decomposition. The growth of plants is unaffected due to warming of the soil around their roots by the interior heat of the earth (Miller and Turk 2002). In present study, it was observed that the temperature at ministry of agriculture forest nursery was 24.5°C. The temperature at experimental site may be higher because of the stabilized waste where microbial population was low. The increase in temperature at site appeared to be due to high metabolic activity of microbes at the initial stage of compost development.

4.3. Electrical Conductivity and Total Dissolved Solids
TDS and EC in the leachate samples which was backed by histogram in leachate are listed in Tables 2 and Figure 5.
Leachate characterization of major physicochemical properties of pH, TSS, TDS and EC demonstrated in the reactions between municipal solid waste leachate, immediate soil and water (surface and ground water) which influence the leachate’s chemistry and are useful in understanding the origin of leachate using column experiment as described.
The EC and TDS values almost multiplied as the depth of MSW multiplied but decreased exponentially with time as depth increases. This general trend was followed with small variations by other measured MSW leachate dissolved constituents.
The ministry of Agriculture forest nursery dumpsite values compared with the WHO/National Environmental Standards, the recommended range found to be in unacceptable range.

4.4. Alkalinity and Hardness
Alkalinity and hardness increases as the column increases from 0.5 to 2.0 evident in histogram.
According to [9] alkalinity causes by bicarbonate, Carbonate and Hydroxyl ions. It is important in treatment of waste water: coagulation, softening, evaluating buffering capacity of water.
However, for dumpsite leachate total alkalinity values are often found to be significantly higher than natural waters. The high hardness is due to carbonate and bicarbonate of calcium and magnesium.

4.5. Biological Oxygen Demand for Five Days (BOD5) and Chemical Oxygen Demand (COD)
The BOD of ministry of agriculture forest nursery dumpsite leachate concentration was (1366.1 to 1500) in a histogram. The higher BOD5 values indicate the
presence of organic matter in water. National Environmental Standards (30 mg/l) corresponding to studies of [20].

**COD:** The value of COD measured at ministry of agriculture forest nursery dumpsite leachate concentration was (1440.2 to 1500) in histogram. The high COD concentrations in the groundwater samples of both measured dumpsites revealed the presence of some chemically oxidized organic.

The ratio of BOD5/COD expressed in table 9 shows the ministry of agriculture forest nursery dumpsite age of more than 5 years of existence (0.144). Researchers reported COD and BOD values in the range of 31.1 to 71,680 mg/L and 3.9 to 57,000 mg/L, respectively. A BOD range between 20 to 40,000 mg/L was also reported.

A decrease in the concentrations of BOD and COD occurs over time. A decline in BOD concentrations can be attributed to a combination of reduction in organic contaminants available for leaching and the increased biodegradation of organic compounds.

A constant decrease in COD is also expected as degradation of organic matter continues. Since the BOD test is predominately a biological test, it generally reflects the biodegradability of the organic matter in leachate. Like the COD, the BOD to COD ratio, an indicator of the proportion of biologically degradable organic matter to total organic matter, decreases as the dumpsite ages and more degradation products are leached from deposited residues.

Any solid waste, having its BOD5/COD ratio more than 0.63, can be considered to be for controlled biological treatment, since it does not contain non-biodegradable organics [9]. The value of BOD5/COD characterize the age of the dumpsite according to the leachate constituents (Table 9). The value of COD and BOD5/COD from Table 9 shows that the leachate sample in this study was collected from the dumpsite with the age more than 5 years [21]. Assessed that young leachates are more polluted than the mature ones where BOD5 may reach up to 81,000 mg/l for young and 42000 mg/l for mature samples. BOD5/COD ratio in young dumpsite, where biological activity corresponds to the acid phase of anaerobic degradation, reaches values of 0.85. Old dumpsite produce stabilized leachate with relatively low COD and low biodegradability (BOD5: COD ratio< 0.1).

The differentiation that was observed for the dump under study, which have been operating since 2008, is mainly due to the high quantities of organic material that are disposed since municipal waste contains about 60-70% organics.

**4.6. Major Anions and Cations**

Table 10 show concentration of major anions in the ministry of agriculture forest nursery dumpsite (Cl⁻, S0₄²⁻, N0₃⁻ and P0₄³⁻).
Chloride ion has higher concentration in the histogram, followed by \( \text{SO}_4^{2-} \), \( \text{PO}_4^{3-} \) and \( \text{NO}_3^{-} \). PO_4 in MSW decreases, time depth proceed. Leachate dumpsite was lower than the stated permissible limits. The constituent’s sodium, potassium, magnesium and calcium are considered generally to be major cations typically present in leachate. Derived from the waste materials through mass transfers process, concentration of these cations in leachate is specific to composition of the mass and the prevailing phase of stabilization in the dumpsite [34]. Concentration of major cations (\( \text{Na}^+ \), \( \text{K}^+ \), \( \text{Mg}^{2+} \) and \( \text{Ca}^{2+} \)) in the leachate of ministry of agriculture forest nursery shows that sodium ion exhibited higher value than potassium ion and calcium ion exhibited higher value than magnesius ion in histogram.

The increase in values as the column depth increases is in the order \( \text{Na}^+ > \text{K}^+ > \text{Ca}^{2+} > \text{Mg}^{2+} \)

Contrary to the previous trend, potassium in leachate coming out of the soil column was highly reduced. This may be attributed to soil content of \( \text{K}^+ \) and to the adsorption capacity of the soil. The \( \text{Ca}^{2+} \), \( \text{Mg}^{2+} \) and \( \text{K}^+ \) concentration in leachate coming out of soil column was higher than that of MSW leachate notably with little variation due to homogenous composition of \( \text{Ca}^{2+} \), \( \text{Mg}^{2+} \) in soil in addition to the decreasing availability of \( \text{K}^+ \) in the soil.

The results from the leachate analysis were used as a tool to identify the processes and mechanisms affecting the soil and water chemistry from the study area. In leachate, cations are sourced usually from the degradation of organic materials and the dissolution of inorganic wastes such as concrete, plaster and tiles. Sodium and potassium are both present at considerably high concentrations in the entire samples of this investigation.

The sodium and potassium are not affected significant by microbiological activities within the dumpsite. These ions play an important role in plant physiology and are most likely derived from vegetable residues and domestic wastes. Increased concentration of potassium in ground water is often considered as an indicator of leachate pollution.

Main source of potassium is weathering and erosion of potassium bearing minerals such as feldspar and leaching of fertilizer. Sodium is an essential nutrient and adequate levels of sodium are required for good health, too much sodium is one risk factor for hypertension. Sodium is used for water softening.

4.7. Heavy Metals

Finally, the study, examine the relationship between those detected heavy metal with study locations and the distance from the dumpsite. It equally looked at the
[23] heavy metal threshold limit. This enables the study to assess the level of enforcement of [23] in waste management in Jos. Thus, the research findings include the following:

Table 7a-d) and histogram (Figure 10) shows the dumpsite soil is contaminated with Cobalt (Co), Copper (Cu), Chromium (Cr), Nickel (Ni), Iron (Fe), Zinc (Zn), Cadmium (Cd), and Lead (Pb).

The increasing order of the heavy metals in the ministry of agriculture forest dumpsite in histogram, Zinc (Zn), Iron (Fe), Chromium (Cr), Lead (Pb), Nickel (Ni), Cobalt (Co), Copper (Cu), and Cadmium (Cd) are very high at the waste dump site when compared with [23] heavy metal threshold limit.

The concentration to the heavy metals detected in the dumpsite soil reduced as distance in areas from the waste dumpsite.

The constituents of leachate Cobalt, Copper, Chromium, Nickel, Iron, Zinc, Cadmium and Lead are considered generally to be major heavy metals typically present in leachate. Heavy metals appear in the municipal solid waste like Batteries, consumer electronics, ceramics, light bulbs, house dust and paint chips, lead foils such as wine bottle closures, used motor oils, plastics, and some inks and glass can all introduce metal contaminants into the solid waste stream.

The increases as the depth of MSW increases is evidence as the result of the histogram shows copper as the most abundant of all the heavy metals in the area, which is followed by iron, zinc, chromium, nickel, cadmium, and lead which has least concentration.

For heavy metals zinc, cadmium cobalt and iron have higher value at high depth while copper, chromium, nickel and lead have higher value at lower depth (Figure 10). Consequently, the relatively higher contents of heavy metals in this site call for leachate monitoring to prevent contamination of surrounding soil and groundwater in the future. Concentration of heavy metals in a dumpsite is generally higher at earlier stages because of higher metal solubility as a result of low pH caused by production of organic acids. It is now recognized that most heavy metals are readily fixed and accumulate in soils, and because this process is largely irreversible, repeated applications of amounts in excess of plant needs eventually contaminate soil and may either render it nonproductive or the product unusable. Although plants do take up the heavy metals, the uptake is normally so small that this alone cannot be expected to reduce appreciably the heavy metals [3].

The moisture content is probably the most important factor governing the biochemical processes in dumpsites, but also the water flux has been shown to enhance the biodegradation process.

Finally, the strength of relationship between various detected heavy metal in the soil and NESREA heavy metal threshold limit as established by PAST modeling. The study was also able to trace a reduction in concentration of heavy metals as distance increases. The reduction in concentration of detected heavy metal over
distance is as a result of leachate processes and rainfall factor. The heavy metal percolates into the soil through leaching process and rainfall act as a catalyst that speeds up this action. This constitutes a serious problem to the underground aquifer and soil microorganism.

4.8. Evaluation and Modeling of Leachate
Multivariate in terms of Principal Component Analysis was used to evaluate the effect of leachate generation and flow process on municipal solid waste in Jos metropolis; Findings from this study revealed that the current municipal solid waste practices in Jos-metropolis are not sustainable. Use of dump soil for soil enrichment, waste sorting, waste recovery, waste burning, waste storage, waste composting and waste disposal in rivers, gutters/drainages, open spaces, illegal communities dumpsites and disposal in burnt houses.

The Principal Component Analysis was used to evaluate four component constituents of leachate as physicochemical properties, alkalinity and hardness, BOD5 and COD, anions, cations and heavy metals for each of the leachate constituents.

The study also revealed that PC1 in the data sets explained 97.64, 97.51,65.97 and 52.33 % for physicochemical parameters which followed increasing order of magnitude EC>TDS>pH>TSS, of total variance, and it was positively loaded with evigenvalue in descending order 2432.8,9677.95,0.263341 and 209324, which were mostly distributed.

The leachate generated had moderate to high alkalinity values with high alkalinity value of percentage variance 98.40% corresponding to evigenvalue of 3.93593 which shows Pc1 expressing highest positive and strong loading of 0.50378. Hardness had percentage variance value of 95.84 corresponding to evigenvalue 3.59500 and with Pc1 highest positive strong loading of 0.99528.

The general dominance of anions was in the order of Cl > SO4 > NO3>P04, while the dominance of cations was K+> Mg2+ >. Na+>Ca2+ exhibit component matrix for municipal solid waste column analysis data, its component eigenvalue and percent variance showing the first component. The available carbonates and sulphates in these rocks might have been dissolved and added to the groundwater system during rainfall infiltration, irrigation and groundwater movement. PC1 showed strong loading of K+ and Mg2+ are indicative of lithologic influence along with leaching of secondary salts by rain water. This trend exhibited the leaching of secondary salt precipitated when anthropogenic activities occurred in the study area.

The general dominance of heavy metals was in the order of Zn>Fe>Pb>Co>Ni>Cr>Cu>Cd. The Pc1 had loaded Zn, Fe and Pb which was distributed in ministry of agriculture forest nursery might be originated by geologic sources, which could be released by chemical weathering of parent materials. PC1 had loaded with Cr and Ni, which was also, distributed accounting
for 99.97% of total variance related to anthropogenic sources. Potential heavy metals (Ni and Zn) can be assimilated in groundwater through leaching of metals from industrial activities, burning surrounding in the study area.

Principal component analysis (PCA) performed at the ministry of agriculture forest nursery dumping site data using multivariate analysis on physicochemical properties, alkalinity and hardness, BOD5 and COD, anions, cations and heavy metals. Various physicochemical parameters values of lines and dots representing the best fitted curve of Multivariate. The soil water content was steadily high throughout the year at deeper levels, showing only minor fluctuations.

The PC1 had higher loadings of Pb samples with a 100% of total variance, showing the effect of agricultural and stagnant water (ponds and tank), fertilizers in the sample sites. The content of organic waste thus observed in the study area of Jos metropolis was not investigated in this work, however most of the dumpsites in the areas investigated shows high level of organic waste as result of nearness to the markets in the areas which aid direct disposed of municipal waste of organic nature to the dumpsites with highest level of moisture content in them content [32, 26].

4.9. Organic Content of Dumpsite in Jos Metropolis

The dumpsites investigation of Jos metropolis revealed the results of PC1 in the data sets , for alkalinity and hardness (Table 8), BOD5 and COD(Table 9), Major anions (Cl-, SO4\(^{2-}\), NO3\(^-\), and P0\(^4\)), as in Table 10, major cations(Na\(^+\), K\(^+\), Mg\(^2+\) and Ca\(^2+\)) as in Table 11 and heavy metals(Co, Cu, Cr, Fe, Zn, Cd and Pb) it was positively loaded with which EC has the most highest value of eigenvalue (2432.8) within the range corresponding to variance of 97.64% also , follow by Eigenvalue for TDS (9677.95) corresponding to variance of 97.51% and the pH has eigenvalue of 0.2633 corresponding to variance of 65.98%, as the least in value.TSS show higher eigenvalue (209324) corresponding to variance 52.33% with positive strong loading (0.99528) but not in the range with the others., indicating geogenic hydrogeochemical evolution of groundwater by rock–water interaction with ions exchange. PC1 showed strong loading of EC, and TDS, TSS over pH, alkalinity over hardness, BOD5 over COD, Cl\(^-\), SO4\(^{2-}\) over P0\(^4\), and NO3\(^-\), Na\(^+\) over K\(^+\) and Ca\(^2+\) over Mg\(^2+\) and Zn, Fe, Cr, Nb, Pb over Co, Cu and Cd. are indicative of lithologic influence along with leaching of secondary salts by rain water.

Natural sources like oxidation of iron and rain water through the leaching of secondary salts infiltrated into aquifer may be an option for possible source of groundwater contamination. The first components explain eigenvalue, corresponding to variance of which is greater than one, in all cases.

Table 14 gives the chemical concentration of experimental dumpsite soil of ministry of Agriculture forest nursery measured at different column depth of 5, 50 and 100cm. Table 14 indicates that the parameters such as physico chemical (pH,
TDS, and EC), anions (Cl, NO₃, and PO₄) and cations (Na, K, Mg, and Ca) which are the result of the initial experiment carried out at ministry of Agriculture forest nursery dumpsite. Decomposed materials are intermixed with soil minerals and formed a distinct texture in organic soil. It can retain higher proportion of water and electrolytes.

Thus, the conductivity of organic soil is high, which shows physicochemical parameters, anion and cation concentrations of different samples of soil analyzed and presented as selected dumpsites soil within Jos metropolis.

The physical compositions of solid waste vary depending on its types and sources. The nature of the deposited waste in a dumpsite or landfill will affect gas, leachate production and composition by virtue of relative proportions of degradable and non-degradable components, moisture content and specific nature of biodegradable element.

The organic waste constituted the highest fraction of the total MSW generated from urban areas of Jos metropolis. Compostable/organic waste is mainly composed of kitchen waste including vegetables, food remains, and fruits.

The leachate generated at bottom of landfill carries different contaminants. During percolation of leachate through the soil, leachate undergoes various processes such as physicochemical decomposition process, ion exchange reactions, chemical alterations, oxidation, and hydrolysis. These reactions alter the original soil properties.

The soil in Jos metropolis waste dump environment is deteriorated with Lead (Pb), Cadmium (Cd), Copper (Cu), Iron (Fe), Chromium(Cr), Cobolt (Co), Zinc(Zn) and Nickel (Ni).

The rate of reduction in level of concentration as distance increase shows that the soil is slightly polluted with the metal detected. The waste dump comprised of industrial waste, chemical waste, clinical waste, household waste, commercial waste, abattoir waste among others. These chemical wastes react with each other, thus deteriorating the environment so much. There is need for urgent management strategy. The waste dump is currently seen as slow on set environmental hazard.

5. Summary

In this study, base on the experiment results obtained from the dumping site of ministry of agriculture quarters near Kugiya market part of Jos south local government area of the study area. The sample analyzed in both contaminated (dumpsite) and uncontaminated (control sample), following conclusion adopted to find the major constituents of leachate in the dumping site of ministry of agriculture forest nursery Jos Plateau State.

The study concluded that MSW leachate for physicochemical properties (pH, TSS, TDS and EC), alkalinity and hardness, BOD5 and COD shows mild increase for the first three additions of precipitation and increase to higher level after the fourth
precipitation addition and decrease after the fifth precipitation addition. The study concludes that physicochemical properties constituent of contaminated dumping site area is higher than uncontaminated area.

Based on BOD5/COD ratio suggested that the ministry of agriculture forest nursery dumping site leachate is medium aged leachate.

Following the same phenomenon of anions (Cl-, SO4^{2-}, NO_3^- and PO_4^{3-}) accumulation with column depth, anions concentrations out of MSW column were exponentially increased with depth and decrease with time.

The study concludes that the major cations (Na^+, K^+, Mg^{++} and Ca^{++}) value of contaminated dumpsite area is higher than the uncontaminated area.

The general trend indicates that the heavy metals concentration in contaminated area is higher than uncontaminated area. PAST statistics analysis results concluded that leachate sample contain high concentration of organic and inorganic constituents. Heavy metals concentration was in trace amount as the waste is mostly domestic in nature.

Comparing Na, Ca, Mg, K, and Cl concentrations, lead to the conclusion that the origin of Cl is not only NaCl and KCl, but also CaCl2 and MgCl2 that came from the content of the MSW within the biodegradation.

This indicates that due to disposal of municipal solid waste the quality of the soil is reduced as it clearly indicated by physicochemical, alkalinity and hardness, anions, cations and heavy metals. The ministry of agriculture forest nursery dumping site leachate has the potentials of migrating to the soil and percolating water resources of the area which may poses a significant threat to the environment and public health.

5.1. Heavy Metals

Finally, the study, examine the relationship between those detected heavy metal with study locations and the distance from the dumpsite. It equally looked at the [23] heavy metal threshold limit.

Thus, the research findings include the following:

Table 7a-d) and histogram(figure 6) shows the dumpsite soil is contaminated with Cobalt (Co), Cupper (Cu), Chromium(Cr), Nickel (Ni), Iron (Fe), Zinc(Zn), Cadmium (Cd), and Lead (Pb)

The increasing order of the heavy metals in the ministry of agriculture forest dumpsite in histogram, Zinc(Zn), Iron (Fe), Chromium(Cr), Lead (Pb), Nickel (Ni), Cobalt (Co), Cupper (Cu) and Cadmium (Cd) are very high at the waste dump site when compared with [23] heavy metal threshold limit.

The concentration to the heavy metals detected in the dumpsite soil reduced as distance in areas from the waste dumpsite.

The constituents of leachate Cobalt, Cupper, Chromium, Nickel, Iron, Zinc, Cadmium and Lead are considered generally to be major heavy metals typically
present in leachate. Heavy metals appear in the municipal solid waste like Batteries, consumer electronics, ceramics, light bulbs, house dust and paint chips, lead foils such as wine bottle closures, used motor oils, plastics, and some inks and glass can all introduce metal contaminants into the solid waste stream. The increases as the depth of MSW increases is evidence as the result of the histogram shows cupper as the most abundant of all the heavy metals in the area, which is followed by iron, zinc, chromium, nickel, cadmium and lead which has least concentration. For heavy metals zinc, cadmium cobalt and iron have higher value at high depth while copper, chromium, nickel and lead have higher value at lower depth (Figure 6). Consequently, the relatively higher contents of heavy metals in this site call for leachate monitoring to prevent contamination of surrounding soil and groundwater in the future. Concentration of heavy metals in a dumpsite is generally higher at earlier stages because of higher metal solubility as a result of low pH caused by production of organic acids. It is now recognized that most heavy metals are readily fixed and accumulate in soils, and because this process is largely irreversible, repeated applications of amounts in excess of plant needs eventually contaminate soil and may either render it nonproductive or the product unusable. Although plants do take up the heavy metals, the uptake is normally so small that this alone cannot be expected to reduce appreciably the heavy metals [3]. The moisture content is probably the most important factor governing the biochemical processes in dumpsites, but also the water flux has been shown to enhance the biodegradation process. Finally, the strength of relationship between various detected heavy metal in the soil and [23] heavy metal threshold limit as established by PAST modeling. The study was also able to trace a reduction in concentration of heavy metals as distance increases. The reduction in concentration of detected heavy metal over distance is as a result of leachate processes and rainfall factor. The heavy metal percolates into the soil through leaching process and rainfall act as a catalyst that speeds up this action. This constitutes a serious problem to the underground aquifer and soil microorganism. Multivariate in terms of Principal Component Analysis was used to evaluate the effect of leachate.

5.2. Evaluation and Modeling of Leachate
The generation and flow process on municipal solid waste in Jos metropolis; Findings from this study revealed that current municipal solid waste practices in Jos-metropolis are not sustainable. Use of dump soil for soil enrichment, waste sorting, waste recovery, waste burning, waste storage, waste composting and waste disposal in rivers, gutters/drainages, open spaces, illegal communities’ dumpsites and disposal in burnt houses.
The Principal Component Analysis was used to evaluate four component constituents of leachate as physicochemical properties, alkalinity and hardness, BOD5 and COD, anions, cations and heavy metals for each of the leachate constituents. The study also revealed that PC1 in the data sets explained 97.64, 97.51, 65.97 and 52.33 % for physicochemical parameters which followed increasing order of magnitude EC>TDS>pH>TSS , of total variance, and it was positively loaded with evigenvalue in descending order 2432.8, 9677.95, 0.263341 and 209324, which were mostly distributed.

Leachate generated had moderate to high alkalinity values with high alkalinity value of percentage variance 98.40% corresponding to evigenvalue of 3.93593 which shows Pc1 expressing highest positive and strong loading of 0.503 78. Hardness had percentage variance value of 95.84 corresponding to evigenvalue 3.59500 and with Pc1 highest positive strong loading of 0.99528.

The general dominance of anions was in the order of Cl > SO4 > NO3>P04, while the dominance of cations was K+ > Mg2+ > Na+>Ca2+ exhibit component matrix for municipal solid waste column analysis data, its component eigenvalue and percent variance showing the first component. The available carbonates and sulphates in these rocks might have been dissolved and added to the groundwater system during rainfall infiltration, irrigation and groundwater movement. PC1 showed strong loading of K+ and Mg2+ are indicative of lithologic influence along with leaching of secondary salts by rain water. This trend exhibited the leaching of secondary salt precipitated when anthropogenic activities occurred in the study area.

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PC1 showed strong loading of EC, and TDS, TSS over pH, alkalinity over hardness, BOD5 over COD, Cl\(^{-}\), SO\(_{4}\)^{2-} over PO\(_{4}\)^{3-} and NO\(_{3}\)^{-}, Na\(^{+}\) over K\(^{+}\) and Ca\(^{2+}\) over Mg\(^{2+}\) and Zn, Fe, Cr, Nb, Pb over Co, Cu and Cd. are indicative of lithologic influence along with leaching of secondary salts by rain water. Natural sources like oxidation of iron and rain water through the leaching of secondary salts infiltrated into aquifer may be an option for possible source of groundwater contamination. The first components explain eigenvalue, corresponding to variance of which is greater than one, in all cases.

Decomposed materials are intermixed with soil minerals and formed a distinct texture in organic soil. It can retain higher proportion of water and electrolytes. Thus, the conductivity of organic soil is high, which shows physicochemical parameters, anion and cation concentrations of different samples of soil analyzed and presented as selected dumpsites soil within Jos metropolis.

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The rate of reduction in level of concentration as distance increase shows that the soil is slightly polluted with the metal detected. The waste dump comprised of industrial waste, chemical waste, clinical waste, household waste, commercial waste, abattoir waste among others. These chemical wastes react with each other, thus deteriorating the environment so much. There is need for urgent management strategy. The waste dump is currently seen as slow on set environmental hazard.

6. Conclusions
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Based on BOD5/COD ratio suggested that the ministry of agriculture forest nursery dumping site leachate is medium aged leachate.
Following the same phenomenon of anions (Cl-, S04\(^{2-}\), N0\(_3^-\) and P0\(_4^-\)) accumulation with column depth, anions concentrations increased with depth and decrease with time.
The study concludes that the major cations (Na\(^+\), K\(^+\), Mg\(^{2+}\)and Ca\(^{2+}\)) value of contaminated dumpsite area is higher than the uncontaminated area.
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