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# EFFECT OF SOME COMMONLY USED HERBICIDES ON PLANT SUCCESSION AND SOIL CHEMISTRY IN NIGERIA

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## ABSTRACT

The growing concerns of the high concentration of metals in soils as a result of agricultural activities are becoming alarming. This study investigated some physiochemical properties of soil such as pH, conductivity, organic matter, organic carbon, nitrogen, phosphorus, sodium, potassium, calcium, and magnesium. Soil samples were collected from nine different points at three different sites, sprayed with different herbicides. Three control samples were used. The physiochemical characteristics of the various soil samples were as follow; Herbicide A (delsate): pH (5.317± 0.26), conductivity (264 ± 77.67), organic matter (1.20 ± 0.077) , organic carbon (0.71 ± 0.043), nitrogen (0.50 ± 0.051), phosphorus (4.04 ± 0.29), sodium (146 ± 3.33), potassium (113.3 ± 4.67), calcium (37.26 ± 10.27), and magnesium (19.7 ±1.33). Herbicide B(force-up): pH (4.97 ± 0.173) conductivity (73.17 ± 22.07) organic matter (1.08 ± 0.15) organic carbon (0.64 ± 0.087) nitrogen (0.53 ± 0.042) phosphorus (4.05 ± 0.597) sodium (111.3 ± 2.67), potassium (100 ± 12), calcium(44.8 ± 5.61), and magnesium (23.3±4.67) Herbicide C(maxiquat) : pH (5.3 ± 0.26) conductivity, (150.10 ± 24.53), organic matter (1.22±0.033), organic carbon (0.7±0.02), nitrogen (0.52 ± 0.014), phosphorus (4.75 ± 0.623), sodium (116.7 ± 11.33), potassium (103.3 ± 6.67), calcium (33.22 ± 3.57), and magnesium (14 ± 2.67).These findings reveal that medicinal herbs, are lost as new plant species are replaced in the soil under investigation. The metal level was found to be elevated. This is attributed to the effect of the herbicide on the soil.

Key words: Herbs, Succession, Herbicides, Soil Chemistry, Physiochemical properties.

## INTRODUCTION

Herbicides also commonly known as weed killers and are used to kill unwanted plants or weeds. Selective herbicides kill specific targets, while leaving the desired plants relatively unharmed. Herbicides used to clear waste ground, industrial sites, railways and railway embankments are not selective, but kill all plant material with which they come into contact. Smaller quantities are used in forestry, pasture systems, and management of areas set aside as wildlife habitat. Some plants produce natural herbicides such as the genus juglans (walnuts) or the tree of heaven and such action of natural herbicides and other related chemical interactions is called allelopathy (Peterson, 1967).

Herbicides have widely variable toxicity. In addition to acute toxicity from high exposure levels; there is concern of possible carcinogenicity as well as other long term problems, such as contributing to Parkinson's disease. Some herbicides cause a number by health effects ranging from skin rashes to death. The pathway of attack can arise from intentional or unintentional direct consumption, improper application resulting in herbicide coming into direct contact with people or wildlife, inhalation of aerial sprays or food consumption prior to the labeled pre-harvest interval. Under extreme conditions, herbicides can also be transported via surface run-off to contaminate distant water sources. Most herbicides decompose via soil microbial decomposition, hydrolysis or photolysis (Reuber, 1981). Herbicides can be grouped by activity, chemical family, mode of action, or type of vegetation controlled. Crop safety for selective Herbicides is the relative absence of damage or stress to the crop (Kolberg, 2002).

Fertilizers, pesticides, herbicides, and some other materials applied to soil often contribute to water and air pollution. Therefore, soil is a key component of environment chemical cycles. Dissolved mineral matter in soil is largely present as ions. Prominent among the cations are $H^+$, $Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$ and usually very low levels of $Fe^{2+}$, $Mn^{2+}$ and $Al^{3+}$ . Cultivation of land and agricultural practices (use of herbicides) can influence both the atmosphere and hydrosphere. Pesticides, particularly insecticides and herbicides are an integral part of modern agricultural production as soil remains the fundamental requirement for agriculture. To humans and most terrestrial organisms, soil is the most important part of the geosphere. In addition to being bound to hydrogen ions in species such as carbonate, anions may be complexed with metal ions such as $AIF_2^+$. Multivalent cations and anions form ion pairs with each other in soil, solutions (Maynard, 2000).

The effectiveness and safe use of the numerous brand name and generic herbicides registered for forest vegetation management in Florida. (Osiecka *et al*. 2009) requires developing site-specific herbicide prescriptions made with careful consideration of site factors and knowledge of herbicide characteristics. Familiarity with chemical and physical properties of herbicides and their effects on biological systems enables the selection of appropriate herbicide products, application methods, rates, and timing. In addition to understanding herbicide characteristics, it is crucial to understand terminology used on herbicide labels. These labels are legally binding documents for herbicide use. The single most important rule in employing herbicides is to always read and follow the label instructions which are provided on the herbicide container. Herbicide characteristics, such as: Mode of action, Selectivity, Activity, Mobility in soil, Volatility, Persistence in the environment, Toxicity are determined by the active ingredients as well as by the formulations of the herbicide products in which the active ingredients are packaged.

## HERBICIDE PRODUCTS OR FORMULATIONS

They may contain one or more active ingredients, adjuvants, and a carrier/solvent. Formulated herbicide products are registered and marketed under various trade names intended for uses specified on the product label. Because of the multitude of existing herbicide formulations, one has to make sure that the selected formulation is appropriate for the desired application. The important determining factors include: application method, target weed species, crop tree species and environmental considerations. Knowing the formulation helps the applicator properly dispense herbicides in an appropriate carrier, add appropriate adjuvants if necessary, and select the appropriate application method. Forestry herbicides are manufactured as liquid or solid formulations (Osiecka and Monigue, 2009).

## LIQUID FORMULATIONS

They may be used undiluted, as in the case of “ready-to-use (RTU)” herbicide products, mixed with water to form a solution, mixed with oil, or mixed with water plus oil carriers to form an emulsion. In a solution, herbicide product is dissolved in water and is dispersed uniformly in the spray preparation. In an emulsion, the herbicide is suspended in minute globules of oil (micelles) in a predominately water carrier through the use of an emulsifier. The water and oil phases will separate over time without agitation. Invert emulsions are a suspension of water droplets containing herbicide in a predominately oil carrier, are very thick in nature, and provide some drift mitigation because they produce a larger droplet size. Mode of Action is the mechanism by which an active ingredient interferes with the metabolism of a plant in order to kill or suppress it. It largely determines the effectiveness of a herbicide in controlling a particular species, and thus the selectivity of the herbicide product. A herbicide’s mode of action includes the nature by which it is absorbed by plants (activity), the pattern of movement within the plant (translocation) and the physiological processes that are affected by the herbicide (site of action).The mode of action is generally determined by the chemical structure and properties of an active ingredient. Herbicide active ingredients that are chemically similar belong to the same “herbicide family” and tend to have the same mode of action.

However, active ingredients belonging to different families may also exhibit the same mode of action. For example, triclopyr and clopyralid which are in the pyridine family, and 2, 4-D within the phenoxy family, are all auxin analogs and mimic this plant hormone physiologically.

Alternating between herbicides with different modes of action helps prevent creating herbicide-resistant weed populations. The most common modes of action among forestry herbicides are:

- Auxin analogs (e.g. 2, 4-D, clopyralid, and triclopyr) mimic the plant growth hormone auxin, resulting in disorganized growth.
- Mitosis inhibitors (e.g. fosamine, pendimethalin) affect cell division, preventing new growth.
- Photosynthesis inhibitors (e.g. hexazinone, atrazine) interfere with photosynthesis.
- Amino acid synthesis inhibitors (e.g. glyphosate, imazapyr, and sulfometuron methyl) prevent the synthesis of amino acids (the building blocks of proteins).
- Lipid biosynthesis inhibitors (e.g. fluazifop-p-butyl, triclopyr and sethoxydim) prevent the synthesis of lipids, crucial elements of cell membranes (Osiecka and Minogue, 2009).

Selectivity refers to a herbicide’s capability to affect different categories of plants to different extents due to physiological or morphological differences between species, and is largely dictated by the herbicide active ingredient’s mode of action. Ideally, differences between crop plants and weed species are exploited. Selective herbicides have a specific range of susceptible species and often target a particular class of plants, for example broadleaf plants (e.g. fluroxypyr and 2, 4-D) or grasses (e.g., fluazifop-P-butyl and clethodim). Non-selective or broad-spectrum herbicides (like glyphosate) negatively affect most species by impacting metabolic processes common to many plant groups. Non-selective herbicides therefore are normally not used over-the-top of crop trees, especially during periods of active growth. Selectivity may also be achieved by manipulating application method, rate, and timing. For example, one can control undesirable trees by applying a non-selective herbicide directly to their stems or foliage without damaging crop trees. Also, some herbicides applied at lower rates may selectively control unwanted vegetation without affecting crop trees. Non-selective herbicides can sometimes be applied with selectivity over-the- top of crop trees during their dormancy (Osiecka and Monigue, 2009).

## MATERIALS AND METHODS

### RESEARCH DESIGN

The soil samples were collected from three different sites that were sprayed with chosen herbicides (delsate, force-up, and maxiquat ) within Auchi Polytechnic, Auchi, Edo State, 2018. In each site, herbicides, three locations were selected at a row and it was tagged A, B, and C respectively. In each sampling point, a stainless steel auger was used to collect the samples from the sub- surface layer at a depth of 13cm. The collected soil samples were then poured together to form a composite sample. The composite samples were mixed thoroughly and stored in polyethylene bags. The soil samples were then air-dried for one week, passed through 2.0mm sieve, and further pulverized to a fine powder. Three different samples collected 10meters from the sprayed sample served as control samples. The control samples were tagged as CD (Delsate), CF (Force-up), and CM (Maxiquat). Designations used to represent the selected herbicides are DA (Delsate in site A), FB (Force-up in site B), and MC (Maxiquat in site C).

0.5g of the powdered and sieved soil sample was digested in a mixture of perchloric acid (70%), nitric acid (70%) and Hydrofluoric acid (40%). 5ml of $HNO_3/HClO_4$ mixture (2:1) and 5ml HF were added to the sample in the digestion crucible using an automatic dispenser. The acid-soil mixture was heated for about 30 minutes at 80ºC - 90ºC on a hot plate until there was no more evolution of brown fumes. The temperature was raised to 150ºC for 20minutes until the content was close to dryness. It was then allowed to cool. About 10ml of distilled water was added and the mixture filtered into a 50ml volumetric flask. More distilled water was added to make up to mark. The resulting solution was used for the analysis.

### DETERMINATION OF PHYSIOCHEMICAL PARAMETERS

Physiochemical parameters of soil samples such as were determined according to the method of Vernma (2008), while organic matter, exchangeable sodium and potassium were determined according to the method proposed by Udo *et al.,* (1978). Total phosphorus and exchangeable calcium and magnesium were determined according to the method of Head (2012). Carbon was determined according to the method of Jackson and Vansyke (1958).

**Table 1**: **Physio-chemical properties and trace metals of content soil from Delsate treated site**.

| Parameter | Value | Control |
|---|---|---|
| Ph | 5.317 ± 0.26 | 2.20 ± 0.03 |
| Conductivity | 264 ± 77.67 | 150 ± 0.66 |
| Organic matter | 1.20 ± 0.077 | 1.00 ±.0.037 |
| Organic carbon | 0.71 ± 0.043 | 0.52 ± 0.01 |
| Nitrogen | 0.50 ± 0.051 | 0.25 ± 0.007 |

| | | |
|---|---|---|
| Phosphorus | 4.04 ± 0.29 | 2.90 ± 0.017 |
| Sodium | 146 ± 3.33 | 115 ± 0.67 |
| Potassium | 113.3 ± 4.67 | 102 ± 0.67 |
| Calcium | 37.26 ± 10.27 | 30.40 ±0.05 |
| Magnesium | 19.67 ± 1.33 | 17.24 ±0.017 |

Results displayed are triplicate determination (mean ± S .E. M)

**Table 2**: **Physiochemical properties and trace metals content of soil from Force-up treated site**.

| **Parameter** | **Value** | **Control** |
|---|---|---|
| pH | 4.97 ± 0.173 | 2.42 ± 0.01 |
| Conductivity | 73.17 ± 22.07 | 70.55± 0.01 |
| Organic matter | 1.08 ± 0.15 | 0.78 ± 0.01 |
| Organic carbon | 0.64 ± 0.087 | 0.37 ±0.007 |
| Nitrogen | 0.53 ± 0.042 | 0.38 ±0.007 |
| Phosphorus | 4.05 ± 0.597 | 2.20 ± 0.017 |
| Sodium | 111.33 ± 2.67 | 100 ± 0.17 |
| Potassium | 100 ± 12 | 89 ± 0.10 |
| Calcium | 44.77 ± 5.61 | 21.62 ±0.01 |
| Magnesium | 23.33 ± 4.67 | 18.14 ±0.007 |

Results displayed are triplicate determination (mean ± S .E .M)

**Table 3**: **Physiochemical properties and trace metals content of soil from Maxiquat treated site**.

| **Parameter** | **Value** | **Control** |
|---|---|---|
| pH | 5.32 ± 0.26 | 2.86 ±0.017 |
| Conductivity | 150.10 ± 24.53 | 139 ± 0.50 |

| | | |
|---|---|---|
| Organic matter | 1.22 ± 0.033 | 1.09 ± 0.67 |
| Organic carbon | 0.70 ± 0.02 | 0.50 ±0.0033 |
| Nitrogen | 0.52 ± 0.014 | 0.28 ± 0.0017 |
| Phosphorus | 4.75 ± 0.623 | 2.60 ± 0.007 |
| Sodium | 116.67 ± 11.33 | 112± 0.33 |
| Potassium | 103.33 ± 6.67 | 89 ± 0.83 |
| Calcium | 33.22 ± 3.57 | 28.19 ±0.01 |
| Magnesium | 14.00 ± 2.67 | 10.75 ± 0.007 |

Results displayed are triplicate determination
(mean ± S.E.M)

## DISCUSSION OF RESULTS

The metal content of the soil samples taken varies from one herbicide to another as presented in tables 1, 2 and 3. The investigation of the metal content in the tested soil was restricted to the top (0 – 13cm) because detailed studies have shown that surface soils are better indicators of metallic burdens (Nyangababo and Hamya, 1986).The soils pH range from 4.9 – 5.3, indicating that the tested soils are acidic in nature. The textural class of the tested soil is sandy loam with mean sand proportion of 85.25%, clay of 6.28%, and silt of 8.48% respectively. The sandy nature of the soil makes it highly permeable and this will allow large quantities of leachate to pass through the soil thereby polluting the underground water around these areas. (Nyangababo and Hamya, 1986).The physiochemical parameters assayed for phosphorus, conductivity, organic matter, and organic carbon range from 4.04 – 4.75, 73.2 – 264, 1.07 – 1.2, and 0.6 – 0.7 mg/kg respectively. The presence of the organic matter is due to the deposition of carbon containing compounds in the test site. This acts as a reservoir for essential and non- essential mineral elements for plant growth and development (Odoemelam and Ajunwa, 2008). The detected amount sodium, Potassium, calcium and magnesium are (111.3 – 146, 100 - 113.3, 33.32 – 44.8 and 14-23.3) mg/kg respectively. The total nitrogen content was low in all the study area, 0.5. Conductivity was found to have the highest value (264 ± 77.67) with the herbicide, delsate when compared to the control and with other herbicides force-up and maxiquat. Total phosphorus was highest (4.75 ± 0.623) with maxiquat than the control (2.72) and other herbicides force-up and delsate. Sodium was highest (146 ±3.33) with the herbicide, delsate when compared to the control (118) and other herbicides force-up and maxiquat. Potassium was highest (113.3 ± 4.67) in the herbicide, delsate when compared to the control (80) and other herbicides force-up and maxiquat. Calcium was highest (44.77 ± 5.61) in the herbicide, force-up but was equal with the control but higher in the values obtained for the herbicides, delsate and maxiquat.

## CONCLUSION

The level of metals obtained from the selected herbicide is an indication of contamination in the treated soil. However, with years of anthropogenic (man- made herbicides) usage, these metals could rise to a level that could be hazardous to the ecosystem and subsequently affect humans and animals living in the environment through food chains. As a result of the effect of herbicides on soil, the plants are also affected and in most cases, new species of plant emerges through succession.

After critical study has been made, it was discovered that usage of some of the selected Herbicides increases the level of metals in the soil to toxicity level and they find their way into the human system through food chains. Hence herbicides should not be sprayed on fields containing medicinal plants, alternative method of weed control should be advocated and vivid knowledge about herbicides before application should be made.

Further studies should demonstrate the effect of these chemicals on the crops, stimulate teratogenic effect of the chemicals and the effect of the herbicides on animals that feeds on the affected plants.

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