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Impacts of Some Heavy Metals on the Population of Micro-Organisms in the Soil of Maiganga Coal Mining Area, Gombe-Nigeria

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ABSTRACT

The number of bacterial and fungal colony forming unit (CFU) were determined in soils of Maiganga Coal mining area using a plate dilution technique on Thorton agar at dilution factor 10^{-3} and 10^{-4}. Samples of soils were collected from farms in the areas: Farms: Coal mine: as well as residential areas which serve as the control site. Two sets of data were collected for the research: at the beginning of the rainy season (April/May 2012): and at the peak of rainy season (August/September 2012). The number of colony forming unit in the soils of the first sample were generally lower with the highest recorded at the residential area, farmlands and coal mined areas respectively. While the number of colony forming unit in the soils of the second sample were higher, also with the highest number of colony at the residential area followed by coal mined and farming areas respectively for bacterial count. While for the fungal count the highest number of colony were recorded at the residential, farmlands and coal mined areas respectively. The research concluded that for the future: investigation of soil microbial community structure and their activities should be done together; this would give more reliable and accurate information about the toxic effects of heavy metals on soil for either farming, mining or housing purposes.

Keywords: Coal Mining, heavy Metals, Soil Pollution, Micro-Organisms

Introduction

The goal of mining is to obtain minerals from the ground. Coal is valued for its energy content, and since the 1880s has been widely used to generate electricity. Most steel and cement producing industries use coal as a fuel for extraction of iron from iron ore and for cement production. In developed countries such as United States, United Kingdom and South Africa a coal mine and its structures are called a colliery. "Colliery" generally refers to an underground coal mine (Chrisman *et al,* 1980). Coal mining and its related activities have damaging effects on the environment generally. Surface mining of coal completely eliminates existing vegetation, destroys the genetic soil profile, displaces or destroys wildlife and their habitats, degrades air quality, alters current land uses and to some extent permanently changes the general topography of the area mined (U.S Environmental Protection Agency 2005).

The metals that are considered as heavy are those with a "density greater than a certain value, usually 5 or $6gcm^{-3}$" (Wild, 1996 p 190). Heavy metals agreeably are one of the major pollutants that are encountered in the soil. Hill and Petrucci (1999) showed that these metals are among the transition metals, which fall in the d-group of the periodic table (which comprise of groups 1B, 2B and 8B) and periods 4 and 5 of the periodic table.

It is shown by Bingham (2004) that although some are essential for some biological processes as trace elements, all are toxic above certain tolerance level. Most readily cited examples of these substances as shown by Wild (1996) include Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni) and Zinc (Zn).

To the concern of the soil however, the effects of heavy metals pollutants could be enormous. Major amongst which is their effect on microbial activities (Wyszkowska and Wyszkowska, 2002).

Literature Review

Pollution of soil ecosystem is the introduction of excessive amount of substances which impair the health of living organisms or interfere with the legitimate use of the soil environment. Pollution of soil ecosystem is a major source of soil degradation (Mbagwu, 2008). Soil ecosystem is an essential component of life and man depends on it for food and natural resources while plants depend on it for their growth. It is also a medium for the biochemical cycling of soil nutrients. So, as the soil is being contaminated with all manner of pollutants, the life process is being disturbed and hence there may be imbalance in the whole system.

Wide varieties of wastes generated from human activities are dumped on soil (Adeoye *et al,* 2005). Soil has long being used as dump sites for household and commercial wastes (Uchegbu, 2008). Wastes containing heavy metals: if disposed on agricultural soils or around residential areas can enter into the food chain (Ademoroti, 1996). Animals that forage on the vegetation of the heavy metals polluted soils are also in danger. Soils affected by heavy metals suffer degradation due to impairment of physicochemical, biological and mineralogical properties: hence undermine its agricultural potential (Mbgwu, 2008).

Soils polluted with heavy metals had reduced soil microbial activity and reduced soil fertility status (McGrath *et al,* 1995). Heavy metal toxicity and insufficient soil aeration to growing plants are associated problems to soil polluted with heavy metals (Anoliefo and Vwioko, 1995). Heavy metals runoff indirectly increases the native concentrations of some heavy metals. The growing crops take-up these heavy metals and thereafter transport them to different parts of the plants (Adewole, 2006). The degraded soil leads to low crop yield (Rainbow, 2007) and reduced crop quality (Adeoye *et al,* 2005). Soil microorganisms are a very important element of healthy soil knowing what microbes in soil eat, the conditions they thrive in and the temperatures that they are most active in is important in organic gardening and organic lawn care. From a practical standpoint, it boils down to organic matter, but not just any organic matter (Carow, *et al,* 2013).

The Study Area

This research was conducted on the soils of Maiganga coal mining area, Akko-Gombe. The soil of the study area is a combination of sandy and loamy types of soils, and they response positively to the growth of maize and beans. The study area has only two distinct season, dry season (November – March) and rainy season (April – October) with mean annual rainfall of about 969mm, and the mean annual temperature ranges from about 50-100^{0}F (10-38^{0}C) (Reyment, 1965).

Fig. 1: Location of Mining Area at Maiganga Coal Mine Site

Source: Google Earth

Methodology

From each of the experimental plots, including control plot, four composite soil sample each to the depth 0-5cm and 15-30cm were taken after 100metre using simple random technique which gave a total of 32 soil samples collected at the beginning of the rainy season April/May and at the peak of the rainy season August/September with the help of steel augur and were put in polythene bags and labeled serially to avoid mistake. Samples were taken to the laboratory for the bacterial and fungal count of colony forming unit (Adepetu *et al,* 2000). And the study area have been divided into three (3) farmland area (refer to as area Y), Coal mined area (refer to as area X) and the residential area (refer to as area Z).

Analysis and Discussion of Result

Macroscopic and Microscopic Identification

Table 1 and 2 below shows the bacterial and fungal count colony forming units per mil in the soil of the study area respectively during the first soil sampling at the beginning of the rainy season in the month of April/May 2012 showing the impact of these selected heavy metals (Lead, Zinc, Cadmium and Nickel) on the population of microorganism in the soil of the study area:

Table 1: Bacterial Count Colony Forming Unit per Mil (CFU/MIL)

Focal Point	Number of Colony Count	
	No. of Dilution Factor 10^{-3}	10^{-4}
Farmland (Y)	CFU/ML 139	CFU/ML 51
Coal Mined Side (X)	CFU/ML 96	CFU/ML 54
Residential Side (Z)	CFU/ML 276	CFU/ML 147

Source: Adamu 2012 (Macroscopic and Microscopic Identification)

Table 2: Fungal Count Colony Forming Unit per Mil (CFU/ML)

Focal Point	Number of Colony Count	
	No. of Dilution Factor 10^{-3}	10^{-4}
Farmland (Y)	CFU/ML 82	CFU/ML 61
Coal Mined Side (X)	CFU/ML 31	CFU/ML 31
Residential Side (Z)	CFU/ML 102	CFU/ML 73

Source: Adamu 2012 (Macroscopic and Microscopic Identification)

From the result obtained in table 1 and 2 for bacterial and fungal count colony forming unit per mil, it is evident that the microbial activities in the soil sample of the study area are insignificant even at dilution factor of 10^{-3} and 10^{-4}. This is to say there are less microbial activities in the sample area due to un-conducive environment for this organism to reproduce and multiply properly because of the mining activities that is going on at the area. The decrease in microbial density caused by heavy metal contamination as a result of the coal mining activities going on at the area is in agreement with Kikovic (1997).

Table 3 and 4 below also shows bacterial and fungal count colony forming units per mil in the soil of the study area respectively during the second soil sampling at the peak of the rainy season in the month of August/September 2012 showing the impact of these selected heavy metals (Lead, Zinc, Cadmium, Chromium and Nickel) on the population of microorganism in the soil of the study area:

Table 3: Bacterial Count Colony Forming Unit per Mil (CFU/ML)

Focal Point	Number of Colony Count	
	No. of Dilution Factor 10^{-3}	10^{-4}
Farmland (Y)	CFU/ML 278	CFU/ML 153
Coal Mined Side (X)	CFU/ML 288	CFU/ML 162
Residential Side (Z)	CFU/ML 301	CFU/ML 249

Source: Adamu 2012 (Macroscopic and Microscopic Identification)

Table 4: Fungal Count Colony Forming Unit Per Mil (cfu/ml)

Focal Point	Number of Colony Count	
	No. of Dilution Factor 10^{-3}	10^{-4}
Form land (Y)	CFU/ML 246	CFU/ML183
Coal Mined side (X)	CFU/ML 124	CFU/ML 124
Residential side (Z)	CFU/ML 204	CFU/ML 219

Source: Adamu, 2012 (Macroscopic and Microscopic Identification)

From the result obtained in table 3 and 4 for bacterial and fungal count colony forming unit per mil, it is clear that the microbial activities in the soil sample of the study area are not insignificant even at dilution factor of 103 due and 104. That is to say there more microbial activities in the sample area due to the moisture content of the soil there at that particular period of time, as such it create conducive environment for organism to reproduce and multiply properly. These increases in microbial activities in the samples of soil collected at the peak of the rainy season August/September 2012 corroborate the work of Zaguralskaya (1997).

Discussion of Result

In soil ecosystem, heavy metals exhibit toxicological effects on soil microbes which may lead to the decrease of their numbers and activities. This study demonstrated that toxicological effects of heavy metals on soil microbial community structure and activities depend largely on the type and concentration of metal and incubation time. The inhibition extend varied widely among different incubation period of these enzymes.

In this research, the microbial community was highly affected, consistent with the lower microbial activities in different levels of heavy metals. Furthermore, a great community change in this study, particularly at high level of contamination, was probably a result of metals toxicity and also unavailability of nutrients because no nutrients were supplied during the whole incubation period.

Conclusion

The added concentrations of heavy metals have changed the soil microbial community structure and activities. The highest inhibitory effects on soil microbial activities were observed at two weeks of incubation. Finally the research recommended that for the future: investigation of soil microbial community structure and activities should be done together, this would give more reliable and accurate information about the toxic effects of heavy metals on soil for farming, mining or housing purposes.

References

Ademorati C.M.A. (1996). Environmental Chemistry and Toxicology, 1st ed. Foludex Press Ltd, Ibadan, Nigeria. 215 pp.

Adeoye G.O, Sridhar, M.K.C., Adeoluwa O.O and Akinsoji N.A (2005). Evaluation of Naturally Decomposed Solid Wastes from Municipal Dumpsites for their Manurial Value in Southwest Nigeria. *Journal of Sustainable Agricultural.* 26 (4): 142-152.

Adepetu, J.A Nabhan, H. and A. Osinubi (eds) (2000). Sample Soils, Water and Plant Testing Techniques for Soils Resource Management: Proceedings of Training Course Held in Ibadan, Nigeria, 16-27 September 1996. Ibadan, IITA, 168pp.

Adewole M.B (2006). Phytoremediaton of Contaminated Soils with Some Heavy Metal Using *Helianthus annuls* L. and *Tithonia diversifolia* (Hemsl) as Influenced by Fertilizer Application. PhD. Thesis. Department of Agronomy, University of Ibadan, Ibadan Nigeria. 149pp.

Anoliefo G.O. and Vwioko D.E. (1995). Effect of Spent Lubricating Oil on the Growth *Capsicum annuus* L and *Lycopersicon esculentum* Mill. Environmental Pollution 88: 361-364.

Bingham, S. (2004). Heavy Metal in Agricultural Top Soils-Background and Data, Natural Soil Resource Institute, UK England.

Christman R.C., J. Hesibeck, B. Sedik, W. Murray, and W. Wilson (1980). Activities, Effects and Impacts of the Coal Fuel Cycle for a 1000MW Electric Power Generation Plant. Washington DC: US Nuclear Regulatory Commission.

Hill, J.W and Petrucci, R.H (1999). General Chemistry, An Integrated Approach. Prentice Hall, Upper Saddle Rivers, New Jersey 1199pp.

Kikovic D.D. (1997): Influence of Heavy Metals Emitted by Thermoelectrical Power Plants and Chemical Industry on Kosovo Soil Microflora. Rev. Res. Wk Fac. Agric. Belgrade 42: 61-75.

McGrath, S. Chaudri A.M. and Griller KE. (1995). Long Term Effects of Metals in Sewage Sludge on Soils, Micro-organisms and Plants. *J. of Ind. Microbiology* 14:94-104.

Rainbow R.W. (2007). Integration of No-till and Precision Agriculture Technologies and Future Changes to Conservation Agriculture in Australia in No-till Farming Systems. Special Publication No.3. Part 3 ed., T. Goddard. M. Zoebisch, Y. Gan, W. Ellis, A. Watson, and S. Sombatpanit Eds. Pp. 223-246. World Association of Soil and Water Conservation Beijing, China.

Reyment, R.A. (1965). Aspect of Geology of Nigeria Ibadan University Press, Ibadan, pp: 14.

US Environmental Protection Agency, Philadelphia, PA (2005). "Mountaintop Mining/Valley Hills in Appalachia. Final Programmatic Environmental Impact Statement".

Wild, A. (1996). Soils and Environment: An Introduction Cambridge University Press: Cambridge, 290 pp.

Wyszkowska, J. and Wyszkowski, M. (2002). Effects of Cadmium and Magnesium on Microbial Activities in Soil. *Polish Journal of Environment Studies;* 11(5): 585-591.

Zaguralskaya L.M. (1997). Microbiological Monitoring of Forest Ecosystems in the Northern Taiga Subzone in Conditions of Anthropogenic Impact Lesovedenice, 5:3-1 2.

References to this paper should be made as follows: Adamu, S.J. *et al* (2014), Impacts of Some Heavy Metals on the Population of Micro-Organisms in the Soil of Maiganga Coal Mining Area, Gombe-Nigeria. *J. of Agriculture and Veterinary Sciences,* Vol. 6, No. 1, Pp. 50 – 58.

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