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Physiochemical analysis of agricultural soil in Amansea, Anambra State, Nigeria

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ABSTRACT

Chlorpyrifos (O, O-diethyl O-(3, 5, 6-trichloro-2-pyridyl phosphorothioate) is a broad spectrum moderately toxic organophosphorous insecticide which is widely used for pest control on grain, cotton, fruits, and vegetable crops. However, the extensive use of chlorpyrifos has been one of the major causes of pollution of soil and ground water. Therefore, the aim of this research was to evaluate the physiochemical analysis of agricultural soil in Amansea, Anambra State, Nigeria. The results showed that soil maintained a temperature and pH of 32^{0}C and 6.55 respectively. The moisture content (%) and organic carbon (%) were 3% and 4% respectively while cadmium and lead content was 0.09ppm and 0.15ppm respectively. The feel method for analysis of soil texture also revealed that the soil texture was silty clay because the soil was excessively wet and has smooth feeling predominantly. In conclusion, the results from this research shows that the temperature of the soil sample was high and confirms the presence of small amount of heavy metals (cadium and lead) and this could inhibit inherent degradation by indeginous bacteria because they are an alarming combination of environmental and health problem.
Keywords: Physiochemical, agricultural, soil, Amansea, Anambra State and Nigeria

INTRODUCTION

The use of Pesticide has greatly improved crop productivity and has also effectively controlled vector borne diseases like Malaria [1]. Although, pesticides have an important role in agriculture to solve the problem of feeding the world's over growing population, the extensive use has led to the wide spread microbial imbalance, environmental pollution and health hazard [2]. Chlorpyrifos (O, O-diethyl O-(3,5,6-trichloro-2-pyridyl phosphorothioate) is a broad spectrum moderately toxic organophosphorous insecticide [3] and acaricide, and is widely used for pest control on grain, cotton, fruits and vegetable crops, as well as lawns and ornamental plants [4] against rice leaf moth, plant hoppers, gall midge, wheat army worm, cotton boll worm, aphid and red spider [5]. Chlorpyrifos (CP) was first commercialized in the USA by Dow Chemical Co. (Midland, MI, USA) in 1965 [6]. The widespread and continuous application of chlorpyrifos has caused several toxicological, environmental contamination and residue problems, which seriously threaten human health, ecological and environment security [7]. The manufacturing and formulation process of chloropyrifos also generate waste that contain the compound [8]. Previous studies have shown that chlorpyrifos not only has acute and chronic toxicity to mammals, aquatic organisms and other non-target organisms, but also has neurotoxicity, genotoxicity and other multiple toxic influences [9,10]. A systematic review of data published between 2006 and 2018, supplemented by mortality data from WHO, found that there were approximately 740,000 annual cases of unintentional, acute pesticide poisoning (UAPP), with 7,446 fatalities and 733,921 non-fatal cases. On this basis, it is estimated that 385 million cases of UAPP occur annually world-wide including 11,000 fatalities (International labor organization, 2021). According to the world health organization (WHO), about 1000,000 human being are affected by acute poisoning by contact with pesticide. Over 150,000 people die each year from pesticide poisoning. Most deaths result from self-poisoning by ingestion, rather than occupational or accidental exposures, which are typically topical or inhalation. Severe pesticide poisoning is more common in rural lower- and middle-income countries where pesticides are widely used in small holder agricultural practice and therefore freely available [11]. Work related contact with pesticides could be behind 70% of these mortalities. Furthermore, constant contact to lower pesticides dosages was associated with a group of syndromes in the medium and long term, involving numerous tumors and nervous system disorders [12]. WHO warns that every year, as many as 2.5 million people worldwide suffer from acute poisoning with pesticides and 0.2 million people die [13]. Chlorpyrifos has also become a potential public health concern as it considered to be genotoxic, damage DNA and affect neurodevelopment in children [14].

Pesticides when sprayed to crops get dispersed into different compartments of the environment. Through plant and animal uptake, a large part of these pesticides enter the food chain or get eliminated from the environment by degradation through biological or non-biological pathways. However, a considerable quantity applied is dissipated into the environment, through air drift, leaching and surface run-off. The presence of pesticides in freshwater supplies have become a matter of great concern, with detected levels often surpassing the fixed limit of 0.5lg/L for total pesticides or 0.1lg/L for any individual active ingredient in the EU. Such is the case in Switzerland where about 70% of surface waters contained pesticide levels above the prescribed limit. In addition, their environmental fate is affected by their physicochemical characteristics, along with the environmental conditions [15]. The soil environment gets contaminated with chlorpyrifos when it is sprayed to the crop. The nature of the adsorbents in the soil and water solubility is the factors responsible for the mobility of chlorpyrifos in soil and water [16]. Soil adsorption decreases chlorpyrifos mobility which reduces its availability to the degradative forces thereby increasing its persistence in the soil. Chlorpyrifos adsorbs to particles of soil, organic matter, clay particles and soil sediments to variant measures, and organic soils promote higher adsorption than the sandy loams [17]. The half-life of chlorpyrifos in soil ranges from 60–120 days to 1 year and even extent up to 4 years, depending largely on factors like pesticide application rate, various biotic factors in soil and abiotic factors like the climatic conditions etc. The half-life of chlorpyrifos increases to about 3 folds at higher application rates as pesticide concentration in soil increases. Chlorpyrifos level in soil has been detected in various parts across the globe. Chlorpyrifos has been in use by growers in Canada and the USA for the commercial production of fruits, vegetables, cereals and nuts as foliar, soil granular and drench application. Environmental protection agency (EPA) has banned the use of chlorpyrifos on all crops [18]. In India, chlorpyrifos residues were detected in water samples [19] and breast milk [20].

Bioremediation of Chlorpyrifos

Although incineration and chemical hydrolysis have been extensively used to wipe out organophosphorus compounds [21], microbial degradation has gained importance as microorganisms are the predominant creatures in the biosphere with a remarkable capability to breakdown various harmful xenobiotics. Extensive use of chlorpyrifos contaminates air, ground water, rivers and lakes. Chlorpyrifos-oxon and 3, 5, 6-trichloro-2-pyridinol (TCP) are the two potent transformation products of chlorpyrifos that have been found in groundwater.

Factors affecting microbial degradation of pesticide in the soil

Biodegradation of pesticide is influenced by many factors which is mainly intrinsic factors and extrinsic environmental factors. The effect of internal factors originated from the structure of pesticide and the micro-organisms [22].

Intrinsic factors

Microorganisms

Microbial species, metabolic activity, and adaptability directly affect transformation and detoxification of pesticides [23]. Many experiments have shown that the reactions of different species of microorganism or the same species of different strains to the same organic substrate or toxic metal were different, and the microorganism had a strong ability to adapt environment and to be domesticated [24]. Through the adapted process, the new compounds could induce microorganism to produce the corresponding enzyme system or establish a new enzyme system to degrade them. Functional characteristics and changes of degradation were the most important factors [25].

Aim of the Study

The aim of this study was to evaluate the physiochemical parameters of agricultural soil in Amansea, Anambra State, Nigeria

MATERIALS AND METHODS

Study Area

The study was carried out in Ukukwa Amansea, Awka North Local Government Area of Anambra State, Nigeria. Amansea is in the tropical rainforest region and is located between latitude 6°16' 30" N and longitude 7° 07'30"E. Awka North has an estimated population of 112,192 in 2006 and 159,900 projected by Nigeria statistic of bureau 2022 (Nigeria Bureau of Statistic, 2022). The land mass is 460.2/km^2. Awka north consists of low-lying plains of agricultural land. It has derived savanna vegetation resulting from human activities. The people are mainly farmers and itinerant traders. Agricultural crops include yam, cocoyam, cassava, maize, fruits and vegetables.

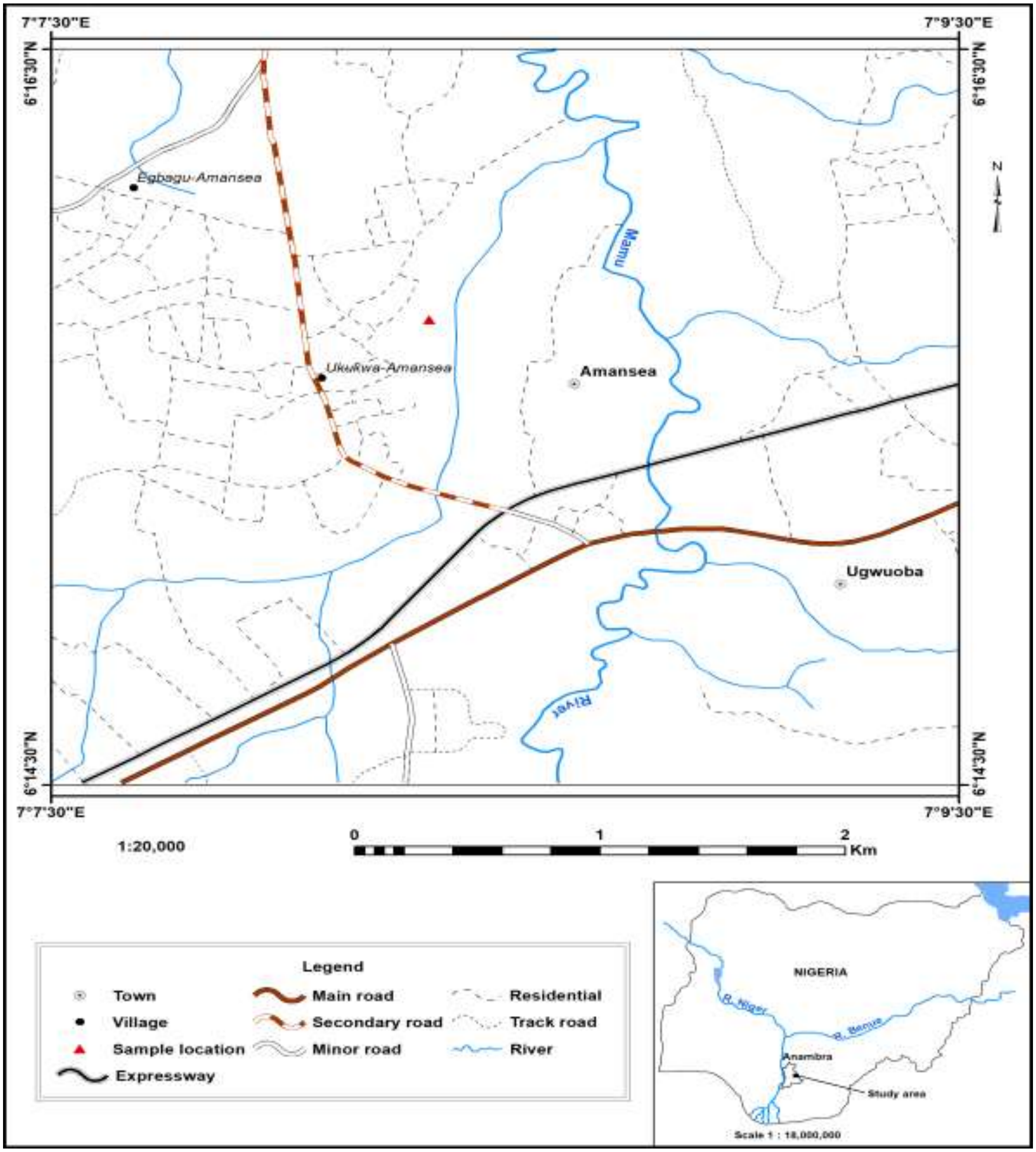

Figure 1: Geographic map Anambra state showing Awka North
Source: GIS Lab, Department of Geography and meterology Nnamdi Azikiwe University Awka Anambra State, Nigeria (2023).

Study Design and Sampling Procedures

The study was a community based cross-sectional survey conducted between January and March 2022 in one of the five villages. Sample selection involved the use of in person interview of the farmers that uses the insecticide for pest control. Within the selected farmers who pledged to have used the Chlorpyrifos insecticide constantly for at least a year were selected into the final sample. One farm was eligible for the study.

Sample collection

Soil sample (1Kg) from a contaminated agricultural soil in ukukwa Amansea was collected. The properties of the soil were pH 6.5, 3.0% moisture content, 4.4% organic carbon. From the in person interview gotten from the farmer, it has been more than 2 years the farmer started using chlorpyrifos insect to control pest.

The farmer confirmed obtaining a bountiful harvest during every harvesting period. Therefore, the soil has been contaminate with chlorpyrifos insecticide for more than 2 years. Four soil sample was randomly collected from all side of the Rhizosphere at a depth of 15cm. The soil sample was sorted, mixed and put into a sterile polyethylene bag and then conveyed immediately to the Laboratory of the Department of Applied Microbiology and Brewing Nnamdi Azikiwe University Awka for further analysis.

Physiocochemical Analysis of Soil

The physical and chemical properties of the test soil were determined by standard methods. The soil texture like sand and clay were analysed using the feel method [13]. In order to determine pH, Moisture content and temperature the method of [13], was adopted, while the method of [13] and [13] was used to determine the the organic carbon and heavy metal composition respectively.

RESULTS

Physiochemical Analysis of the Soil

The result of the physiocochemical analysis of the soil sample to determine soil factors that aid biodegradation of bacteria showed that the soil maintained a temperature and pH of 32^{0}C and 6.55 respectively. The moisture content (%) and organic carbon (%) were 3% and 4% respectively while cadmium and lead content was 0.09ppm and 0.15ppm respectively. The feel method for analysis of soil texture also revealed that the soil texture was silty clay because the soil was excessively wet and has smooth feeling predominantly as shown in Table 1. physical examination of the soil shows that the soil is a clay soil.

Table 1: Physiochemical analysis of soil sample

Soil properties	Composition
Temperature (^{0}C)	32
pH	6.55
Moisture content (%)	3.00
Organic carbon (%)	4.00
Cadmium (ppm)	0.09
Lead (ppm)	0.15
Clay	Excessively wet with smooth feeling predominantly.

DISCUSSION

The soil sample collected were analysed for physiochemical properties of the soil sample. The temperature of the soil sample was high due the fact that it was collected during dry season and is directly related to the pH of the soil. This result is in agreement with the report made by [1], [2] that initial soil pH and temperature have an effect on bioremediation. Our result agrees with the conclusions of [16] that Chlorpyrifos hydrolysis proceded at a slow rate at a very low acidic soil. Our work also agrees with the work of [16] that the relationship between very alkaline (high pH) and rapid abiotic hydrolysis is poor, because high-pH soils failed to hydrolyze chlorpyrifos. He noted that Chlorpyrifos degradation was more rapid in neutral-pH (6.7) and alkaline soils. This means that there is an appreciable increase in biodegradation at a pH range of 4.8 to 6.7. The result also confirms the presence of small amount of heavy metals (cadium and lead) and this could inhibit inherent degradation by indeginous bacteria because they are an alarming combination of environmental and health problem [20]. It agrees with the work of [3] that heavy metals composition of the soil bind with Chlorpyrifos to decrease the bodegradation rate. The possible reason for the inhibition could be that heavy metal has more affinity to pesticide so making it unavailable for degradation by indeginous bacteria.

CONCLUSION

In conclusion, the results from this research shows that the temperature of the soil sample was high and confirms the presence of small amount of heavy metals (cadium and lead) and this could inhibit inherent degradation by indeginous bacteria because they are an alarming combination of environmental and health problem.

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