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Quality Studies for Some Physicochemical Parameters and Textural Properties of Soil On Irrigated Farm Sites in FCT, Abuja, Nigeria

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Abstract The study was carried out to evaluate the quality of some physicochemical parameters and textural properties of soil on irrigated farm sites in FCT, Abuja, Nigeria**.** The Soil samples were collected along the river bank in dry seasons from three (3) irrigated farm sites and were analysed using standard methods. Soil pH wa generally acidic in all the farm sites. Levels of pH, cation exchange capacity (CEC), nitrate, phosphate, chloride and sulphate did not vary significantly according to sites ($P \leq 0.05$) except for phosphate in farm B. Levels of pH (5.94±0.78) and Cl^- (0.32±0.01) were higher in farm A, PO_4^{3-} (15.05±0.94) and NO_3^- (0.28±0.03) in farm B and CEC (0.37±0.04) and (0.48±0.36) SO_4^{2-} in farm C. Levels of physicochemical parameters of soil were within the WHO/FAO permissible limits for irrigation. The acidic nature of soil may lead to remobilization of heavy metals adsorbed onto the sediment surfaces into the water column, which may result to pollution. Textural properties of soil recorded higher sandy fractions (75±0.63) in all the farm sites; however, Silt (5±0.03) and Clay (20±0.18) were lower. The nature of the soils from these farms may be suitable for sanitary landfills. Since high sand content of any soil implies high leaching potentials with high permeability of water, the underground water beneath these farm areas could be threatened by pollutants from the farm sites. The implication is that the vegetables grown in these farm lands may be deficient in some of the nutrients to grow.

Keywords Physicochemical, parameters, textural properties, soil, irrigated sites

1. Introduction

The earth is covered with loose fine rocky particles called soil WHO/FAO [1], [2]. Soil is a natural body consisting of minerals, water, air, organic matter. Water is an essential natural resource for sustainability of life on earth. It is used for domestic, industrial and agricultural purposes. Rivers serve as sinks for wastes from different sources, mainly from anthropogenic activities which include various toxic chemicals, acids, alkalis, detergents and agrochemicals which greatly affect the physicochemical properties of water used for irrigation on soils [3], [4], [5]. Some of these parameters include pH, temperature, organic matter, cation exchange capacity, nitrate ion, sulphate ion, phosphate, ions, chloride ions, solids and also heavy metals such as chromium, manganese, cadmium and copper which may be affected by seasonal variations. Sources such as domestic, agricultural, industrial and other wastes find their ways into the soil through leaching, thereby interacting with the soil system and changing the soils physical and chemical properties [6], [7]. Solid wastes constitute environmental pollution through introducing into the environment chemical substances above their threshold limits. To manage solid wastes have become an environmental challenge in many developed areas in Nigeria and the world at large. This is because all manner of wastes have been indiscriminately discharged in the city both the bio-degradable, non-bio degradable, toxic and nontoxic wastes [8], [9]. The deterioration in the health of the people and environment caused by the impact of the by-product of wastes decomposition cannot be overemphasized such as the generation of methane gas, leachates and more so, open dump wastes acts as sinks for potential carriers of so many communicable diseases. The presence of heavy metals such as, Pb, Zn, Ni, Cr, Cd in wastes is as a result of intended use of heavy metals in industrial products and some of them end up in dumpsites as wastes. These toxic metals constitute serious problems to humans and the environment because of their bio-degradable tendencies [10].

However, numerous ecosystems are threatened with heavy metal pollution from mining and petrochemical industries and emission of some of these toxic metals from exhaust of the machinery on vegetation and soil equally increased the natural content of soil, which would affect crop yield and pollution of the food chain [11], [12]. A number of studies have been done by a lot of researchers on the physicochemical parameters of soil on selected dumpsites but there is limited information on the physicochemical parameters and textural properties of soil along the bank of Mpape River in FCT, Abuja. Therefore, the objective of this study is to assess some physicochemical parameters of soil from irrigated land lands along the bank of Mpape River in Federal Capital Territory (F.C.T.) Abuja. Information from this study would be a useful tool for further assessment and monitoring of the river quality.

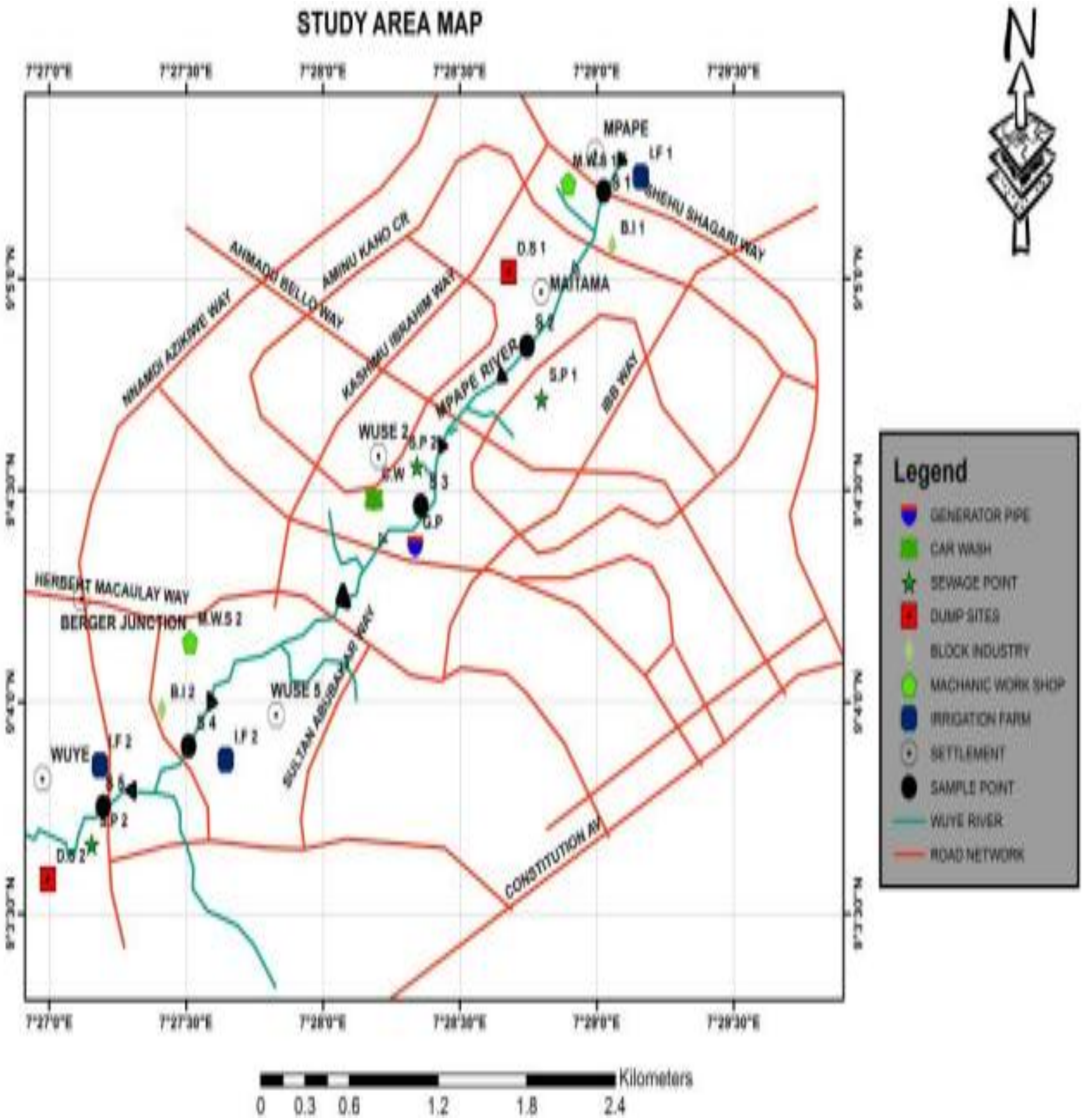

Figure 1: Mpape River showing sampling location

2. Materials and Methods

2.1. Study Area

Three different irrigation sites; Mpape, Wuse Zone 5 and Wuye areas along Mpape River in Abuja Municipal Area Council in the Federal Capital Territory were chosen for the study. Mpape River is located at latitude 9 ^{0} 5' N and longitude 7 ^{o} 29 ' E and originates from Mpape Rock in Federal Capital Territory, Abuja, Nigeria (Figure 1). The River experiences large influx of wastes from both points and non-point sources, especially during the rainy season. Irrigation activities that take place in these areas during dry seasons use the river as the major source of water for irrigation purposes. A lot of activities carried out by inhabitants of these areas such as fishery as well as domestic purposes, however, depend on this river. Some industrial activities such as block moulding industries, mechanic workshops, car wash shops take place along the bank of the river. Domestic sewage, agricultural runoffs and domestic wastes are often emptied into the river.

2.1.1. Sample Collections

Soil samples (4 kg) were collected randomly at the depth of 10 cm using soil auger from six different locations in the area of the irrigated farm to form a composite sample. Soil samples were taken to the laboratory and air- dried on a table surface for 3 days and was ground using pestle and mortar. They were sieved using 2 mm mesh to obtain more homogenous samples. They were sealed in cellophane bags for metal analysis [13].

2.1.2. Sample Digestion Soil

Three replicate samples of soil (5 g) were weighed and placed in 100 cm^3 beaker. The samples were digested with 20 cm^3 aqua regia (3HCl: $1HNO_3$) for 2 hrs on a hot plate. The digest was diluted with 50 cm^3 of deionized water and allowed to cool, then filtered into a 100 cm^3 volumetric flask using Whatman 541 filter paper. The solution was made up to mark with distilled water and stored in a high density plastic bottle for metal analysis [13].

2.2. Determination of the Physicochemical Properties of Soil

2.2.1 Soil pH

Soil pH was determined by shaking 5 g of sample with 10 cm^3 of water. The soil solution was allowed to stand overnight. pH meter was inserted inside the solution and the value was read and recorded AOAC [14].

2.2.2. Cation Exchange Capacity (CEC)

Soil sample (5 g) was weighed into a 50 cm^3 beaker and 10 cm^3 of distilled water was added, and then stirred vigorously. Methyl blue solution 0.5cm^3 was added to the soil sample. After 3 minutes, blue suspensions were formed on the surface of solution. They were removed with a glass rod and deposited on Millipore filter paper. When a light blue dark patch of soil appeared on the filter paper, the test was over. The calculation of CEC was obtained using the formula [15].

$$CEC = V \times C \times 100 / M \quad (2.1)$$

Where V = Vol. consumed of Methylene blue solution (cm^3), C = Concentration of methylene blue solution and M = Mass of dry soil (kg) while , Cl^- , PO_4^{3-}, NO_3^- and SO_4^{2-} were determined using the method by Association of Analytical Chemists AOAC [14]

2.3. Determination of the Textural Properties of Soil Samples

This refers to the relative proportion of sand, silt and clay in soil. It is a very important soil parameter because it determines the suitability of a sight for fish culture. An electrical sieve shaker with a graded series of sieves is the instrument commonly used. It was determined in the laboratory by particle size analysis using sieve of different sizes in (mm). The sieves were arranged with the coarsest on top and finest at the bottom. Further determination was carried out using AOAC [14] method.

2.4. Statistical Analysis

Statistical techniques such as mean, standard deviation were used in determining the mean levels of physicochemical parameters of soil samples**.**

3. Results and Discussions

The results for the physicochemical parameters and textural properties of soil samples are presented in Table 1 and 2 respectively

Table 1: Physicochemical Parameters of Soil Samples

Farms	Sandy	Silt	Clay	Textural Class
A	77.00±0.52	5.00±0.02	18.00±0.36	Sandy-Loamy
B	79.00±0.84	6.00±0.05	15.00±0.02	Sandy-Loamy
C	69.00±0.53	4.00±0.01	27.00±0.15	Sandy-Clay
Mean±SD	75.00±0.63	5.00±0.03	20.00±0.18	

Table 2: Textural Properties of Soil Samples (%)

Parameters	Farms			Mean±SD
	A	B	C	
pH	$5.94±0.78^b$	$5.23±0.87^b$	$5.68±0.52^b$	$5.62±0.72^b$
CEC(Cmol/Kg)	$0.25±0.04^a$	$0.22±0.02^a$	$0.37±0.04^a$	$0.28±0.03^a$
PO_4^{3-} (mg/kg)	$4.42±0.76^b$	$15.05±0.94^b$	$5.90±0.93^b$	$8.48±0.65^b$
NO_3^- (mg/kg)	$0.08±0.03^a$	$0.28±0.03^a$	$0.07±0.05^a$	$0.14±0.04^a$
Cl^- (mg/kg)	$0.32±0.01^a$	$0.29±0.01^a$	$0.25±0.03^a$	0.29±0.02a
SO_4^{2-} (mg/kg)	$0.33±0.06^a$	$0.36±0.05^a$	$0.48±0.36^b$	$0.39±0.16^b$

Means levels with the same alphabets within the same row are not statistically different (P≤0.05)

The Physicochemical parameters of soil samples are presented in Table 1 respectively.

Soil pH

Soil pH varied according to sites and ranged from 5.23 ± 0.87 to 5.94 ± 0.78. Soil pH was generally acidic. pH affects the mobility of heavy metals in soil. It has been found that soil pH correlated with the availability and transport of nutrients to the plants [16]. As pH decreases, solubility of metal elements in the soil increases and they become more readily available to plants [17], [18]. Heavy metal mobility and uptake decreases with increasing soil pH due to precipitation of hydroxides, carbonates or formation of insoluble organic complexes [19], [20]. The soil mean pH value (5.62 ± 0.72) obtained from the three farms were lower than the (7.30 to 8.60) reported for soil pH from irrigated dumpsites in Port Harcourt [21] and (7.84 to 8.26) for soil pH from irrigated dumpsites in Kano [22]. However [23] and [24] reported similar soil pH values between 4.89 ± 0.05 to 7.60 ± 0.02 and 5.98 to 7.26 from open agricultural dumpsites in Yenagoa in Bayelsa State and Maidiguri in Borno State respectively. The values obtained from the present study were below the 7.1 to 8.2 WHO/FAO [1] permissible limits. This suggests that low pH would favour the increased micro nutrient availability, mobility, redistribution and solubility in acidic medium. Heavy metals are generally more mobile at pH < 7 than at pH > 7, therefore, the soil mean pH (5.62 ± 0.72) from the three agricultural farms would pose threat for agricultural purposes since crops are known to take up and accumulate heavy metals from contaminated soils in their edible portions WHO/FAO [1].

Cation Exchange Capacity (CEC)

Cat ion exchange capacity (CEC) is the amount of exchangeable cation per unit weight of dry soil that plays an important role in soil fertility. It depends especially on the pH, clay and on the soil organic matter content. CEC from the three farms varied from 0.22 ± 0.02 to 0.37 ± 0.04 Cmol/kg with farms B and C having the lowest and highest exchangeable cations respectively (Table 1). [21] reported higher values of CEC (13.20 to 28.80 Cmol/kg) for soils from irrigated dumpsites in Port Harcourt than the low mean value of 0.28 ± 0.03 Cmol/kg reported in the present study. These values were below the 18 Cmol/kg set by WHO/FAO [1]. In this study, the CEC values obtained may be classified as very low [25] and could be attributed to low clay content in the soils, suggesting low retention of metal ion in the studied sites thereby increasing the leachability of heavy metals in soils into the underground waters which may pose health hazards to humans and other animals that may use the water.

Phosphate (PO_4^{3-})

Soil PO_4^{3-} ranged from 4.42 ± 0.76 to 15.05 ± 0.94 mg/kg in the three farm sites. Lowest level was recorded in farm A and significantly highest level (15.05 ± 0.94 mg/kg) ($P \leq 0.05$) was recorded in farm B. Higher levels in farm B could be attributed to the presence of fertilizer applications, organic matter and plant deposits. Increase in phosphate ion may, however contribute to increase phytoplankton, algea bloom [26], [27]. Similar studies were carried out on the physicochemical properties of soils on irrigated farmlands from Port Harcourt dumpsites and Yenagoa, Bayelsa State where higher PO_4^{3-} levels from 132.14 to 167.98 mg/kg and 68.22 ± 0.89 to 84.20 ± 1.02 mg/kg [21] were reported respectively. However, the significantly higher mean level of PO_4^{3-} (8.48 ± 0.65) ($P \leq 0.05$) in the study was higher than 1.7 mg/kg reported by [28] for soil from tannery affected areas in Pakistan. The mean PO_4^{3-} level in the present study was lower than the value 10 mg/kg considered suitable for crop production [29], however within the 1.4 to 13.70 mg/kg WHO/FAO [1] permissible limits. This implies that all the soil samples have available PO_4^{3-} that will be suitable to support plant species diversity and growth [26].

Nitrate (NO_3^-)

NO_3^- ranged from 0.07 ± 0.05 to 0.28 ± 0.03 mg/kg (Table 1). Farm B recorded a considerable higher level while farm C recorded the lowest level. [21] and [23] reported NO_3^- levels that ranged from 0.11 to 0.36 mg/kg from irrigated dumpsites along Enugu- Port Harcourt express way, South East of Nigeria and 0.06 ± 0.07 to 0.24 ± 0.09 mg/kg for soil from irrigated dumpsite area of Yenagoa, Bayelsa State, which were similar to the mean nitrate levels (0.14 ± 0.04 mg/kg) recorded in this study, but lower than the level (301.3 ± 743 mg/kg) reported for soil from tannery affected irrigation areas in Pakistan [28] . The mean NO_3^- level (0.14 ± 0.04 mg/kg) in the present study was lower than the 7.43 mg/kg WHO/FAO [1] permissible limit for irrigated soils showing that the farm soils will be fit for irrigation purposes.

Sulphate (SO_4^{2-}) and Chloride (Cl^-) (mg/kg)

Levels of $SO_4^{2-}$and Cl^- varied from 0.33 ± 0.06 to 0.48 ± 0.36 mg/kg and 0.25±0.03 to 0.32±0.01 mg/kg with highest and lowest values in farms A and C respectively. Higher values of Cl^- and SO_4^{2-} in some sites might be due to the presence of organic matter and also decomposition of plants and debris from industrial areas [26]. Mean concentrations of Cl^- (0.29 ± 0.02 mg/kg) and SO_4^{2-} (0.39± 0.16 mg/kg) were lower than the levels from 4.32 to 5.26 mg/kg for Cl^- and 5.50 to 12.42 mg/kg for SO_4^{2-} recorded in irrigated soils from Port Harcourt [21] 6.58 to 8.47 mg/kg for Cl^- and 5.20 to 6.73 mg/kg for SO_4^{2-} recorded for soil from tannery farm land areas Pakistan [28]. The reported mean values (0.39±0.16 and 0.29±0.02) in the present study were below the 6.36 mg/kg for SO_4^{2-} and 2.82 mg/kg for Cl^- FAO/WHO [1] permissible limits.

Generally, the levels of NO_3^-, SO_4^{2-} and Cl^- were lower than their permissible limits. This implies that the plants in these farms were limited by these parameters that are necessary for plant growth. PO_4^{3-} in the soil samples had considerable levels suitable for crop growth.

Textural Properties of Soil Samples (%)

Results for the textural properties of soil samples are presented in Table 2 respectively. Texture is related to certain physical properties of soil such as plasticity, permeability, and ease of tillage, fertility, water holding capacity, mobility and over all soil productivity [30]. This also reflects the particle size distribution of the soil and the content of fine particles like oxides and clay [30], [31]. Clay soils retain higher amount of metals when compared to sandy soils. From the study, the percentage contents ranged from 69 ± 0.53 to 79 ± 0.84 % for sandy soil, 4.00 ± 0.01 to 6.00±0.05 % for silt and 15.00 ± 0.02 to 27.00 ± 0.15 % for clay soil. [22] reported similar levels (58.2 ± 7.91 to 78.6 ± 6.49 %) for sandy soil, higher levels (16.2 ± 6.63 to 28.4 ± 6.80 %) for silt and lower levels (5.2 ± 1.15 to 15.0 ± 4.99 %) for clay from irrigated dumpsites in Kano State compared to the mean levels of soil texture in the present study. In this study, the soils were found to have a higher mean percentage of sand (75 ± 0.63%). Soils from farm sites that contain high sand fractions (> 70 %) allow high permeability of water and leachates [26], [31]. The nature of soils in farms A and B may be suitable for sanitary landfills [6], [31]. Since high sand content of any soil implies high leaching potentials with high permeability of water, therefore, underground water beneath these farm areas could be threatened by pollutants from the farm sites. The implication is that the vegetables grown in these farm lands may be deficient in some of the nutrients to grow.

Conclusion and Recommendations

From the study, the physicochemical characteristics of soil samples show spatial and temporal variations. The mean soil pH was slightly acidic, soil OM content and PO_4^{3-} level were significantly higher ($P \leq 0.05$) while NO_3^-, Cl^- and SO_4^{2-} were generally low. These values were below the WHO/FAO permissible limits which implied that the vegetables grown in these soils were limited by these parameters that are necessary for plant growth, thereby retarding plant performance, except for PO_4^{3-} and OM, which were within the WHO/FAO permissible limits. This implies that all the soil samples have available PO_4^{3-} that will be suitable to support plant species diversity and growth. Textural properties of soil indicated that all the farms had higher sand content implying higher leaching potentials with high permeability of water and nutrients, thus affecting healthy plant growth. Higher levels observed at different sampling sites in the physicochemical parameters of soil showed that the probable source of the pollutants was anthropogenic activities arising mainly from agricultural practices and sewage effluence, urban and municipal wastes which showed that it is paramount to subject the quality of river in those areas to proper pollution check especially during the rainy season because of the frequent discharge of pollutants from point and non-point sources into the river, which may lead to an unprecedented outbreak of diseases from consumption of fish and irrigated crops grown along the river bank since the water is used for irrigation purposes in dry season. Changes in water and sediment chemistry might be responsible for the variations in the physicochemical chemical properties of soil.

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