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Evaluation of Soil Quality in Parts of Israel and Nigeria

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Author's contribution

This work was carried out solely by the author. The author read and approved the final manuscript.

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ABSTRACT

The levels of physiochemical parameters and some heavy metals in top soil and sediment from parts of Israel and Nigeria were determined using standard methods and Atomic Absorption Spectrophotometer by GBC Avanta Version 2.02. The results showed ranges of mean levels of pH 5.78±0.4 – 8.08±0.001 in Israel and 5.3±0.1 – 6.70±0.2 in Nigeria; Organic matter 0.04±0.09% - 13.49±0.03% in Israel and 1.10±0.7% – 2.69±0.9% in Nigeria; Total Nitrogen 0.03±0.01% - 0.96±0.1% in Israel and 0.05±0.7% - 0.14±0.2% in Nigeria; Available Phosphorus 1.40±0.06 ppm – 70.18±0.06 ppm in Israel and 14±0.1 ppm – 64.6±0.2 ppm in Nigeria; Potassium 0.64±0.6 meq/100 g – 5.74±0.02 meq/100 g in Israel and 0.07±0.05 meq/100 g – 0.08±0.04 meq/100 g in Nigeria. The highest C/N ratios were 65.25 and 53.67 in Israel and 13.89 and 12.80 in Nigeria which implies high decomposition and mineralization in Nigeria. The levels of all the heavy metals were below their standard limits. The mean levels of physicochemical parameters of soils from Israel and Nigeria showed significant difference ($p<0.05$). The soil metal index of the heavy metals ranged from 0.013 – 0.070 in Israel and 0.004 – 0.058 in Nigeria. Cadmium was found to be the heavy metal with highest enrichment factor value of 87.871 in Israel and 5853.66 in Nigeria. The soils from Israel were found to be alkaline while those from Nigeria were acidic, nutrient deficient and need application of land amendment materials.

Keywords: Soil quality; physicochemical; parameters; heavy metals; Israel; Nigeria.

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1. INTRODUCTION

Urban soil environment is characterized by human disturbances. Some of the more visible disturbances are construction projects, cutting and filling to make roads, building sites and garage dumps. Other less apparent disturbances are caused by automobile exhausts, urban dust, manufacturing wastes and emissions which contribute some amounts of contaminant materials to the soil, water bodies and the atmosphere. Soil quality is the ability of the soil to serve as a natural medium for the growth of plants that sustain human and animal life [1].

Soil reaction (expressed as soil pH) is a major controller of plant nutrient availability and microbial reaction in soils [2]. Low pH of mine soils increases the solubility of toxic metals such as Aluminum and Manganese and allows leaching of essential nutrients [3].

Organic matter deficiency in soil is one of the major constraints to agricultural sustainability. Organic matter is the food source for soil microbes and serves as a slow-release nutrient source for plants [3].

According to [4] Nitrogen has been studied for centuries and is still the most studied element of soil chemistry, fertility and mineralogy.

The availability of phosphate to plants, however, tends to decrease as soils become more acid and the proportion of Al and Fe phosphate increases [4]. In acid soils, the phosphate ions react with soluble Fe and Al ions to form insoluble phosphates, they also adsorb to surfaces of insoluble Fe, Al and Mg hydroxides [5]. Much of the phosphorus used by plants, other than those from applied phosphate fertilizers, come from organic phosphates released from decomposition of organic matter.

Cation exchange capacity (CEC) gives an indication of the soil's potential to hold plant nutrients. Soils with a high CEC have a much lower percentage of cations in the soil water, so are far less susceptible to nutrient loss by leaching [6]. The Base Saturation (BS) of a soil tells what percentage of the exchange sites are occupied by the basic cations. It is the ratio of the quantity of exchangeable bases to the CEC expressed as a percent [7].

Tropical soils with a pH of less than 5 are not productive because of high soil solution aluminum and high exchangeable aluminum which are toxic to roots of many plants [5]. While also describing acid soils as infertile, [8] also mentioned such soils as having calcium and phosphorus deficiency problems.

Heavy metal contamination of the environment is one of the main environmental problems of pollution. This is because, once in soil, some of these metals will be persistent because of their fairly immobile nature. Other metals however, will be more mobile migrating to either ground water aquifers or plants (bioavailability) [9]. Heavy metal pollution can affect all facets of the environment but their effects are most long lasting in soils due to the relatively strong absorption of many metals onto humic and clay colloids in soil [10].

The main sources of heavy metal contamination are; urban industrial aerosols, created by combustion of fuels, metal ore refining, battery and power generation operations and other industrial processes. Acute lead, chromium and copper poisoning in humans causes severe dysfunction in the renal, reproductive and nervous system and are harmful to human health even at low concentrations in the environment [11].

This study was carried out to create awareness of the nutrient status of soils from the study areas.

2. MATERIALS AND METHODS

2.1 The Study Areas

Seven topsoil and one sediment samples were collected from Jordan, Mt. Tabor, Galilee and Dead sea in Israel and Umuola, Ozuzu, Egbema and Port Harcourt in Nigeria, Rivers State.

Israel is located, between 29°-33° north of the equator, which is characterized as a subtropical region, between the temperate zone and the tropical zone. The northern and coastal regions of Israel show Mediterranean climate characterized by hot and dry summers and cool rainy winters. The southern and eastern areas of Israel are characterized by an arid climate. The rainy season extends from October to early May, and rainfall peaks in December through February [12]. Israel is a major exporter of fresh produce

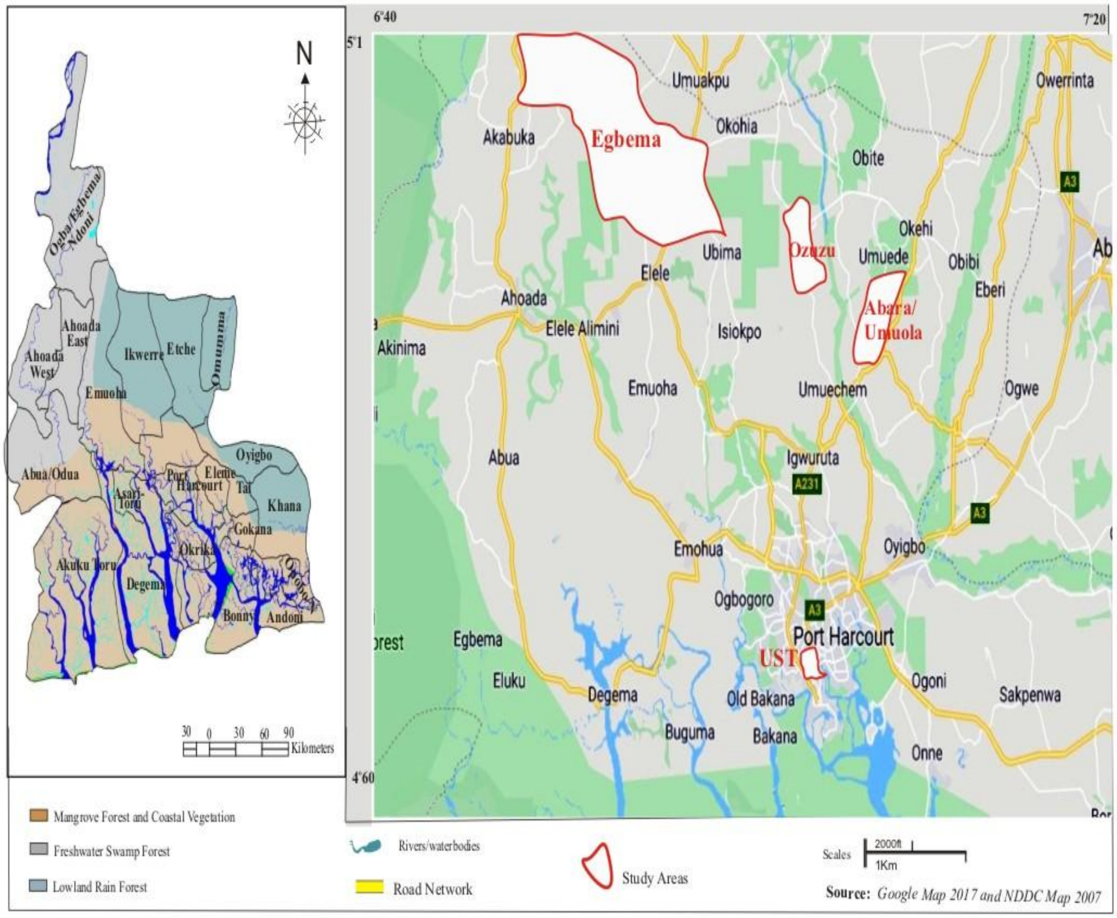

Fig. 1a. Map of Rivers State Nigeria showing the study areas

and a world-leader in agricultural research and development (agricultural technologies) despite the fact that the geography of the country is not naturally conducive to agriculture. Water shortage is a major problem. Rain falls between September and April, with an uneven distribution across the country [13]. A variety of soils are found, due to their origin, properties, and weathering. The major causes of this variety are the extreme conditions which form soils in Israel such as climate, different topographic circumstances and physical weathering from both water and wind [14].

The Dead Sea is about 400 m below sea level. It contains a lot of minerals on which many industries depend.

The study areas in Nigeria are the Rivers State University Teaching farm Port Harcourt and communities in Etche Local Government Area in North Eastern part of Rivers State.

Port Harcourt metropolis is in the Niger Delta sedimentary basin of Nigeria. It is covered on the surface by the Benin Formation which is otherwise called the Coastal Plain Sands [15]. Port Harcourt lies within latitudes 4°43' 07" and 4°54"N and longitudes 6°56'04" and 7°03'20"E with a mean annual rainfall of over 2000 mm and mean annual temperature of about 29°C. The sampling location, Rivers State University Port Harcourt lies between latitude 4° 47' 49"N and longitude 6° 58' 52"E. Etche Local Government area is in Rivers State. It lies within latitude 5˚ and 6˚ N and longitude 4˚ and 5˚E. Agriculture is the main economic base of the people with about 90% of the population engaged in agricultural activities. The area experiences the normal Niger Delta climate conditions. The climate of the area is that of equatorial tropical rainfall occurring almost through the year except in December, January and February, which are not completely free from rainfall.

The identification and coordinates of the sampling stations in the study areas are shown in Table 1.

2.2 Sample Collection and Preparation

Soil samples were collected with trowel and an auger at 0-15 cm depths into polythene bags and taken to the laboratory for preparation and analyses. The samples were air-dried, ground to pass through a 2 mm mesh sieve and stored at room temperature in well labeled polythene bags.

2.3 Soil pH

The soil pH was determined in a 1:2.5 soil to water ratio using a glass electrode pH meter; 4 g of air-dried and sieved (2 mm sieve) soil samples were weighed into a beaker. Ten milliliters (10 ml) of distilled water was added, stirred and allowed to stand for 30minutes before measurement of the pH [16].

2.4 Available Phosphorus

Available phosphorus was determined spectrophotometrically using Bray no.1 method, modified by [17].

2.5 Total Nitrogen

Total nitrogen concentration was determined using the macro Kjeldahl method [18,19]. In this method, 5 g of the sample was digested and distilled. The distillate was titrated with 0.01M standard sulphuric acid. The percent total nitrogen was then determined by calculation [16].

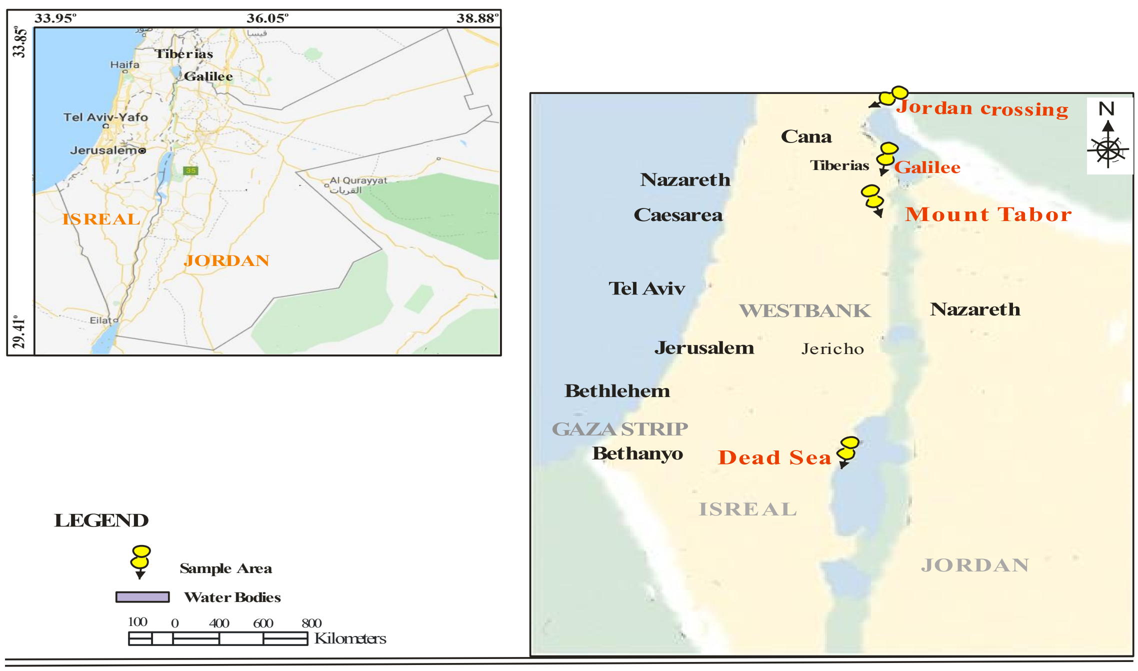

Fig. 1b. Map of Israel showing study areas

Table 1. Geographical location of soil sampling stations

Station No	Location	Geographical location	
		East (longitude)	North (latitude)
1	Jordan	035°32′ 48.33″	31°50′ 13.09″
2	Mt. Tabor	035°23′ 23.76″	32°41′ 11.82″
3	Galilee	035°31′ 32.64″	32°50′ 38.52″
4	Dead sea	035°30′ 15.54″	31°45′ 44.04″
5	Umuola	007°01′ 48.0″	04°53.0′ 28.0″
6	Ozuzu	006°59.0′ 46.0″	05°08′ 51.0″
7	Egbema	006°44.0′ 08.94″	05°26′ 06.54″
8	Port Harcourt(UST farm)	006°58.0′ 37.32″	04°48.0′ 13.98″

2.6 Organic Matter (OM)

The organic matter was determined by the Walkley and Black method which involve the titration the titration of un-reacted dichromate ion with standard ferrous ions. The percent organic matter was calculated by multiplying percent organic carbon by 1.724.

2.7 Organic Carbon (OC)

10 ml, 1M potassium dichromate was added to 5 g of soil sample and swirled. 20 ml of concentrated H_2SO_4 were added to the mixture and swirled. Then after 30 minutes, 100 ml of distilled water were added followed by 3-4 drops of ferroin indicator and titrated with 0.5M ferrous sulphate solution.

2.8 Potassium, Sodium and Magnesium

Potassium, was determined using a flame photometer [20]. Sodium and magnesium were determined by flame emission photometer.

2.9 Particle Size

The particle size distribution was determined using the hydrometer method and the textual class determined from the Textural Triangular Diagram [16].

Chloride: Chloride was determined by the Argentometric method [21]. The chloride ion concentration of the sample was determined by titration.

Nitrate: Nitrate was determined using the Brucine colorimeteric method. Limit of detection was 0.05 mg/l $N\text{-}NO_3$ [21]. 2 ml of each sample was measured into another test tube as blank. To each of the samples and blank 2 ml of H_2SO_4 solution was added. The solution was warmed and the test tubes were dipped into cool water bath for cooling. 0.2 ml of brucine was added to each of the solutions in the test tube. The solution turned pink.

This was followed by heating indirectly for 25 minutes in a well-stirred boiling water bath at temperature of not less than 95°C. The test tubes were immersed in cold water bath for cooling. The solution turned yellow when thermal equilibrium was reached (at approximately room temperature). The test tubes were dried and the solution measured with UV spectrophotometer.

Sulphate, Calcium and Sodium: Sulphate was determined by the Turbidimetric method. Calcium was determined by the EDTA titration method and Sodium was determined by direct aspiration into Flame Emission Photometer.

2.10 Heavy Metals

Heavy metals (Cu, Zn, Pb, Fe, Cd, Mn, Cr, Ni) were analyzed using Atomic Absorption Spectrophotometer (AAS) by GBC Avanta version 2.20 following the standard procedures in [21].

2.11 Soil Metal Index

The soil pollution level and its variation along the station were determined using soil metal index (SMI) which compares the pollution status of the different stations.

The soil metal index (SMI) for each sampling station was calculated by dividing the ratio of the heavy metal concentration in the soil sample to the standard value of the metal for each metal.

The sum of the value obtained was divided with the number of metals investigated. The result was multiplied by 100.

$$SMI = \frac{\left(\frac{C_1}{S_1} + \frac{C_2}{S_2} + \cdots + \frac{C_n}{S_n}\right)}{n}$$

Where C in mg/kg is the concentration of the metal at a station and S in mg/kg is the standard (reference) concentration of the metal and n is the number of metals determined.

The SMI >100% indicates polluted soils while the SMI<100% indicates unpolluted soils.

2.12 Enrichment Factor (EF)

The enrichment factor (EF) of metals is a useful indicator of the station and degree of the environmental contamination [22]. The EF compares each value with a given standard level. The EF was calculated using the method of [23] shown below.

$$\text{Enrichment Factor (EF)} = \frac{\left(\frac{\text{Me}}{\text{Fe}}\right)_{\text{sample}}}{\left(\frac{\text{Me}}{\text{Fe}}\right)_{\text{standard}}}$$

Where (Me/Fe) sample is the metal to Fe ratio in the sample of interest; (Me/Fe) standard is the permissible value of the metal to Fe ratio. Iron is used for normalization because natural sources (1.5%) greatly dominated its input [24].

Where EF < 2 is deficiency to minimal enrichment; EF = 2-5 is moderate enrichment; EF = 5-20 is significant and EF > 40 is extremely high enrichment [25].

3. RESULTS AND DISCUSSION

The pH of the soils ranged from 7.30 – 8.08 with mean of 7.56±0.26 in soils and 5.78± 0.4 Dead sea sediment (Israel) and 5.3 – 6.7 with mean of 5.95± 0.7 (Nigeria) is moderately acidic. This range in Nigeria is typical of Niger Delta soils [26,27] and is less than that of Israel. The soils in Nigeria were moderately acidic based on pH ratings by [28] while those in Israel are alkaline except in the Dead sea sediment which is similar to the soils in Nigeria. Low pH implies increased solubility and availability of toxic metals (Fe, Al, Mn) and this could lead to reduced vegetation growth, reduced population of N-fixing bacteria and allows for leaching of essential nutrients. [5] reported that tropical soils with pH less than 5 are not productive because of high soil solution aluminum and high exchangeable aluminum which are toxic to roots of many plants while [8] described such acid soils as infertile.

Itanna [29] reported that the availability of heavy metals increases with decreasing pH. The pH values obtained in Nigeria imply high tendency of heavy metal availability. As pH increase from 5.0 to 8.0, iron, manganese, zinc and copper become less available while phosphorus is readily available at pH 6.5 [30]. This implies that the soils in Israel could allow enrichment of essential nutrients. The similarity of the pH in soils from Nigeria to the Dead sea sediment speaks volume for the soils from Nigeria. These observations imply that the soils from Israel are more fertile than those from Nigeria.

Organic carbon levels varied from 1.61% at Jordan – 7.83% at Galilee with a mean of 3.99±1.94% and 0.02 in Deadsea sediment in Israel while it ranged from 0.64 at Umuola – 1.56% at Egbema with a mean of 1.14±0.19% in Nigeria. Organic carbon levels below 2% are taken to be very low for tropical soils [31,32]. Based on this rating, all the soil samples from Nigeria and Dead sea sediment are low in organic carbon while those analyzed in Galilee are high in organic matter.

Organic matter levels in Israel varied from 2.78% at Jordan to 13.49% at Galilee with a mean of 6.89±3.33% and 0.04% in Deadsea sediment while in Nigeria the levels varied from 1.10% at Umuola – 2.69% at Egbema with a mean of 1.97±0.19%. The values of organic matter from Galilee exceeded the permissible limit of 3-5% recommended for 0-15cm depth by [30]. The organic matter content of soil depends on the rate of production and decay of wastes and is a function of temperature, rainfall and nutrient status [33]. The level of biochemical activity influenced the variations in organic matter content. Increased biochemical activity depends on the level of organic matter as it is the main source of energy for microorganisms.

According to [34], when soil organic carbon declines, plant nutrients such as nitrogen and phosphorus are mostly at risk. This implies that soils at Galilee and some parts of Israel are of high value. [35] reported that reduction of organic carbon in soil is as a result of the ability of microorganisms to degrade organic carbon. The very low levels in Dead sea sediment is attributed to absence of biochemical activity.

The Total nitrogen levels in Israel ranged from 0.03% at Jordan to 0.96% at Mt. Tabor with a mean of 0.37±0.30% and 0.05% in Deadsea sediment while in Nigeria the levels ranged from 0.05% at Umuola to 0.14% at Egbema with a mean of 0.10±0.02%. [32] rated soils with total Nitrogen levels from 0.1 – 0.2% as low and <0.1% as very low for tropical soils. The soils of Nigeria varied from very low to low at Egbema in their total nitrogen content while in Israel the soils are moderate at Tabor which is low. Nitrogen deficiency is more in Nigeria than Israel and this can limit vegetation growth and sustained productivity.

Baker and Herson [36] reported that high levels of total nitrogen suggest active mineralization of organic nitrogen in soil. The variations observed in the levels of total N suggest that they depend on the type of plants grown in the area. The levels of nitrogen can be classified as low, medium or high depending on the organic matter content, total nitrogen and nitrate nitrogen level of the soil. They showed that when organic matter is 0 – 1.5% and total nitrogen is 0.1%; the availability of nitrogen is regarded as low. It is medium when organic matter and total nitrogen are 1.5 – 2.5% and 0.1-0.2%, respectively and high when the soil has more than 0.2% total nitrogen. [37] further classified total nitrogen in soils as < 8 µg/g (low), 8 – 20 µg/g (moderate) and > 20 µg/g (High). The very low level of total nitrogen in sediment from Dead sea is typical of inactivity in that sea.

Table 2. Mean concentrations of physicochemical parameters in soils and sediment in Israel and Nigeria

Parameters	Jordan	Mt. Tabor	Galilee	Dead sea sediment	Umuola	Ozuzu	Egbema	Port Harcourt
pH	7.30±0.2	7.30±0.03	8.08±0.001	5.78±0.4	6.40±00.1	6.70±0.2	5.4±0.32	5.3 ± 0.1
Organic carbon(%)	1.61±0.1	2.54±0.02	7.83±0.02	0.02±0.3	0.64±0.6	1.12±0.5	1.56±0./4	1.25 ±0.07
Organic matter %)	2.78±0.2	4.39±0.01	13.49±0.03	0.04±0.09	1.10±0.7	1.93±0.8	2.69±0.9	2.16±0.2
Total N. (%)	0.03±0.01	0.96±0.1	0.12±0.04	0.05±0.08	0.05±0.7	0.10±0.6	0.14±0.2	0.09 ± 0.02
C:N Ratio	53.67±0.3	2.65±0.2	65.25±0.05	0.4±0.07	12.8±0.8	11.2±0.9	11.14±0.1	13.89±0.5
Available P. (ppm)	3.51±0.1	14.04± 0.3	70.18±0.06	1.40±0.06	14.04±0.3	64.6±0.2	14.0±0.1	58.74 ± 1.77
Mg (meq/100g)	2.40±0.4	16.60±0.4	9.80±0.07	67.60±0.05	1.80±0.4	1.60±0.5	1.56±0.6	0.76 ± 0.20
Ca (meq/100g)	14.20±0.5	40.20±0.5	32.60±0.08	50.80±0.04	3.20±0.9	4.80±0.8	5.42±0.7	3.44 ± 0.08
Na (meq/100g)	1.09±0.02	2.17±0.6	2.72±0.09	39.35±0.03	1.35±0.01	1.09±0.02	1.10±0.03	0.43 ± 0.03
K (meq/100g)	0.64±0.6	2.05±0.7	2.31±0.1	5.74±0.02	0.07±0.06	0.07±0.05	0.08±0.04	0.06 ± 0.00
Ex.Acidity(cmol/kg)	0.24±0.02	0.72±0.8	0.32±0.2	0.80±0.01	0.40±0.03	0.32±0.02	0.36±0.01	0.55± 0.05
Ex.Al (cmol/kg)	0.11±0.5	0.35±0.9	0.16±0.3	0.40±0.1	0.16±0.4	0.08±0.3	0.12±0.2	0.20±0.1
ECEC (cmol/kg)	19.82±0.7	61.71±0.01	48.16±0.4	164.29±0.2	6.90±0.5	7.88±0.6	3.64±0.7	5.32±0.8
BS (%)	98.73±0.3	98.33±0.02	99.34±0.5	99.86±0.3	93.04±0.1	95.94±0.3	94.62±0.7	91.86±0.9
Cl^- (ppm)	47.61±0.1	156.13±0.03	121.82±0.6	9798.00±0.4	22.64±0.5	82.52±0.1	43.41±0.9	116.34±0.5
SO_4^{2-} (ppm)	1.96±0.03	0.410±0.04	5.0±0.7	184.61±0.5	1.54±0.2	0.912±0.1	0.542±0.6	8.48 ± 0.0
NO_3^- (ppm)	0.062±0.04	0.212±0.05	0.160±0.8	14.00±0.6	0.08±0.3	0.150±0.4	0.112±0.5	0.03 ± 0.0
Silt (%)	1.28±0.05	19.15±0.06	15.28±0.9	4.52±0.7	12.0±0.8	4.0±0.7	3.0±0.6	3.8 ± 0.0
Clay (%)	2.48±0.06	22.42±0.07	22.48±0.09	5.2±0.8	13.20±0.2	3.2±0.3	12.0±0.4	7.8 ± 0.0
Sand (%)	96.24±0.07	60.43±0.08	62.24±0.07	90.28±0.9	74.80±0.8	92.8±0.7	85.0±0.6	88.4±0.5
Textural class	S	CL	SCL	S	LS	S	LS	S

S=Sand, CL=Clay Loam, SCL=Sandy Clay Loam, LS=Loamy Sand

Table 3. Heavy metal concentrations (ppm) in soils and sediment in Israel and Nigeria

Parameters	Jordan	Mt. Tabor	Galilee	Dead sea sediment	Umuola	Ozuzu	Egbema	Port Harcourt	Standards
Mn	20.77	25.06	23.91	31.69	8.970	170.40	0.01	19.25	2000
Cr	1.65	1.62	2.74	1.46	0.18	0.29	0.24	0.16	100
Fe	214.33	286.34	816.75	78.28	26.74	1.07	402.37	2.05	50000
Ni	2.95	2.09	3.05	0.93	0.06	0.08	0.03	0.35	50
Cd	1.13	0.04	0.94	0.09	0.01	0.01	0.02	0.72	3
Pb	7.78	0.09	7.54	0.05	9.37	12.30	0.01	3.15	100
Zn	2.69	1.95	5.05	2.05	23.92	35.30	1.80	32.63	300
Cu	0.58	0.85	0.75	0.52	12.60	8.76	0.90	6.42	100
SMI	0.0698	0.0132	0.06617	0.01643	0.0417	0.05262	0.00402	0.0578	

Table 4. Enrichment factor values of heavy metals at the study areas

Parameters	Jordan	Mt Tabor	Galilee	Dead sea sediment	Umuola	Ozuzu	Egbema	Port Harcourt
Mn	2.423	2.188	0.732	10.121	8.386	3981.308	0.00062	234.7561
Cr	3.849	2.829	1.677	9.325	3.366	135.514	0.298	39.0244
Ni	13.773	7.299	3.734	11.88	2.244	74.766	0.075	170.7317
Cd	87.871	2.328	19.182	19.162	49.863	155.763	0.828	5,853.66
Pb	18.15	0.157	4.616	0.319	175.21	5747.66	0.0124	768.293
Zn	2.092	1.135	1.031	4.365	149.09	5498.44	0.746	2652.845
Cu	1.3531	1.484	0.459	3.321	235.612	4093.458	1.118	1565.854

Table 5. Soil metal index of heavy metals at the study areas

Parameters	Jordan	Mt Tabor	Galilee	Dead sea sediment	Umuola	Ozuzu	Egbema	Port Harcourt
Mn	0.010	0.013	0.012	0.016	0.004	0.085	0.000	0.010
Cr	0.016	0.016	0.027	0.015	0.018	0.003	0.002	0.002
Fe	0.004	0.006	0.016	0.002	0.001	0.000	0.008	0.000
Ni	0.059	0.042	0.061	0.019	0.001	0.002	0.001	0.007
Cd	0.376	0.013	0.313	0.030	0.026	0.003	0.006	0.240
Pb	0.078	0.001	0.075	0.001	0.094	0.123	0.000	0.032
Zn	0.009	0.007	0.017	0.007	0.080	0.118	0.006	0.109
Cu	0.006	0.009	0.008	0.005	0.126	0.088	0.009	0.064
TOTAL SMI	0.070	0.013	0.066	0.016	0.042	0.052	0.004	0.058

Table 6. Pearson's correlation matrix of heavy metals in soils from Israel and Nigeria

Location	Jordan	Mt. Tabor	Galilee	Dead sea	Umuola	Ozuzu	Egbema	Port Harcourt
Jordan	1							
Mt. Tabor	0.0639	1						
Galilee	0.9991	0.0742	1					
Dead sea	0.7222	0.5484	0.7177	1				
Umuola	-0.0990	-0.5055	-0.1166	-0.4874	1			
Ozuzu	-0.3241	-0.5537	-0.3427	-0.5278	0.7538	1		
Egbema	0.1321	-0.3601	0.1208	-0.1353	0.3323	-0.1310	1	
PortHarcourt	0.8484	-0.1626	0.8368	0.5536	0.2343	-0.0136	0.4360	1

Table 7. Pearson's correlation matrix of heavy metals in soils from Israel

Parameters	Mn	Cr	Fe	Ni	Cd	Pb	Zn	Cu
Mn	1							
Cr	-0.3423	1						
Fe	-0.3935	**0.9873**	1					
Ni	**-0.9360**	**0.6483**	**0.6784**	1				
Cd	**-0.7677**	**0.5292**	0.4749	**0.8434**	1			
Pb	**-0.7666**	**0.6269**	**0.5784**	**0.8759**	**0.9926**	1		
Zn	-0.3633	**0.9809**	**0.9418**	**0.6668**	**0.6480**	**0.7306**	1	
Cu	-0.3372	0.3954	**0.5346**	0.3796	-0.1698	-0.0829	0.2223	1

Table 8. Pearson's correlation matrix of heavy metals in soils from Nigeria

Parameters	Mn	Cr	Fe	Ni	Cd	Pb	Zn	Cu
Mn	1							
Cr	**0.7610**	1						
Fe	-0.4403	0.2299	1					
Ni	-0.1368	**-0.6056**	-0.4776	1				
Cd	-0.2576	**-0.6481**	-0.3471	**0.9885**	1			
Pb	**0.7385**	0.3606	**-0.7264**	-0.2317	-0.3745	1		
Zn	**0.5983**	-0.0644	**-0.9648**	**0.5268**	0.3926	**0.7008**	1	
Cu	0.2569	-0.2147	**-0.8236**	0.0011	-0.1147	**0.8235**	**0.6729**	1

Table 9. Pearson's correlation matrix in soils from Israel

Location	Jordan	Mt. Tabor	Galilee	Dead sea
Jordan	1			
Mt. Tabor	**0.9995**	1		
Galilee	**0.9980**	**0.9982**	1	
Dead sea	**0.9511**	**0.9516**	**0.9318**	1

Table 10. Pearson's correlation matrix is soils from Nigeria

Location	Umuola	Ozuzu	Egbema	Port Harcourt
Umuola	1			
Ozuzu	0.0677	1		
Egbema	**0.6362**	-0.1899	1	
Port Harcourt	**0.5262**	**0.5567**	-0.2044	1

Available Phosphorus concentrations varied from 3.51 ppm at Jordan to 70.18 ppm at Galilee with a mean of 29.24±20.69 ppm and 1.40 ppm at Dead sea while it varied from 14.0 ppm at Umuola to 64.60 ppm at Ozuzu with a mean of 37.85±13.81 ppm. According to [38] and [32], available phosphorus value below 15 mg/kg is regarded as low for tropical soils. The results of this study show that the top soils had available phosphorus values that are below the critical limit. Low phosphorus levels could hinder nitrogen accumulation since symbiotic N-fixing bacteria have a high phosphorus demand.

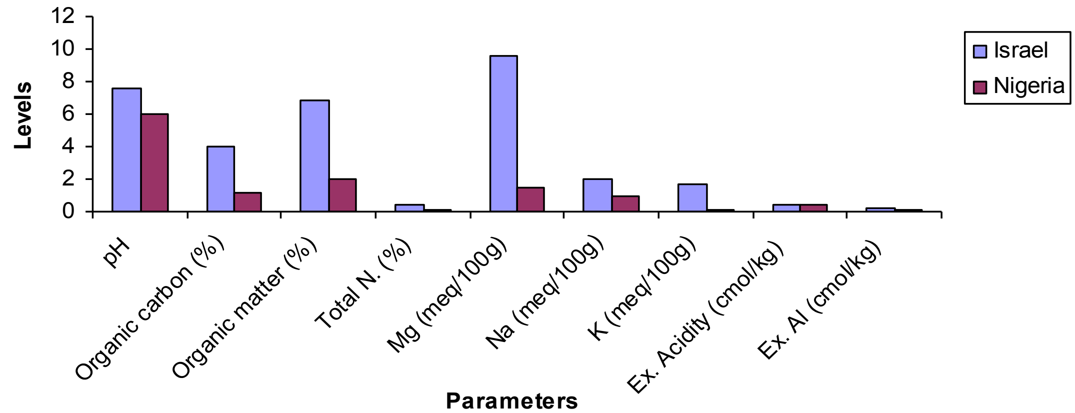

FIG. 2a. Variations in mean Soil Physicochemical Parameters

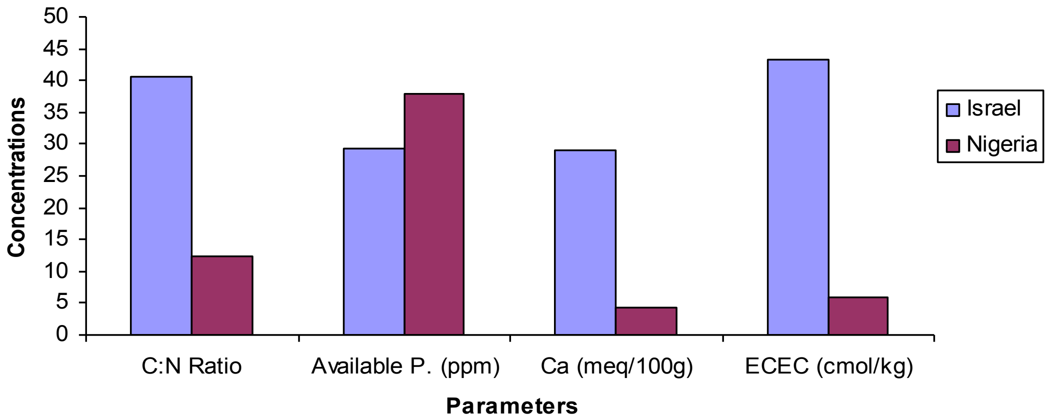

FIG.2b. Variations in mean Soil Physicochemical Parameters

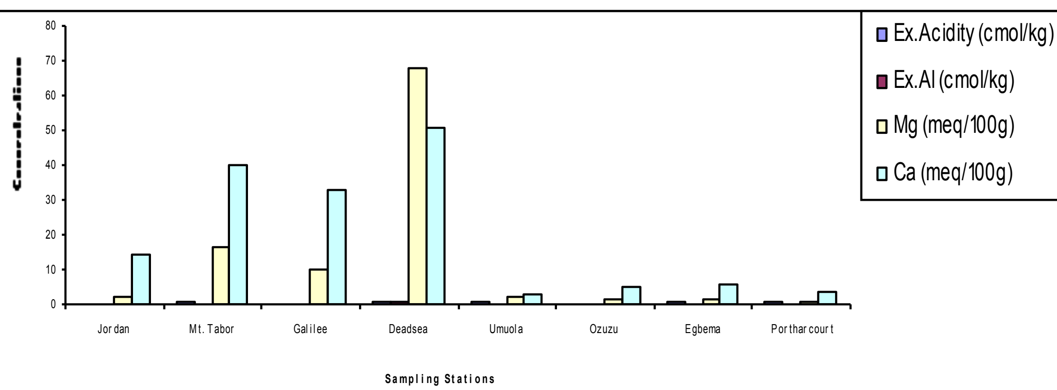

FIG.2c. Variations of Physicochemical Parameters with Stations

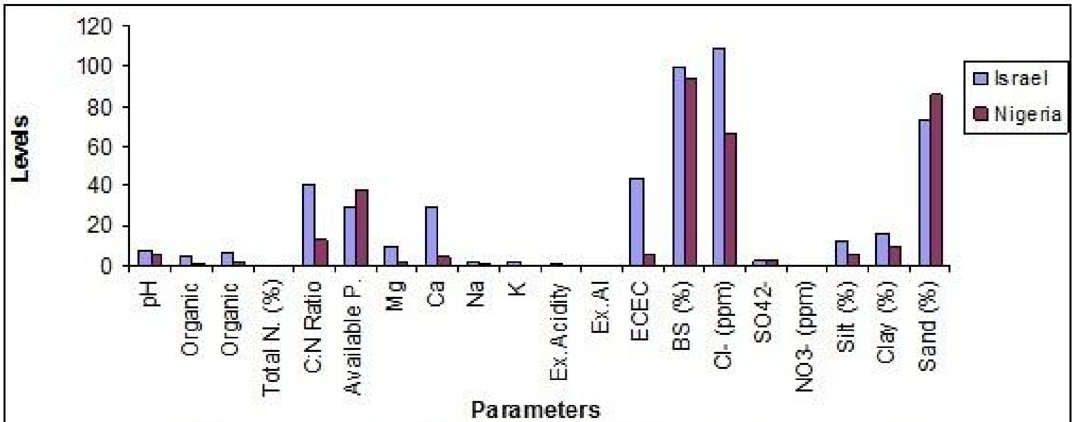

FIG 3a Comparison of Mean Levels of Physicochemical Parameters from Israel and Nigeria

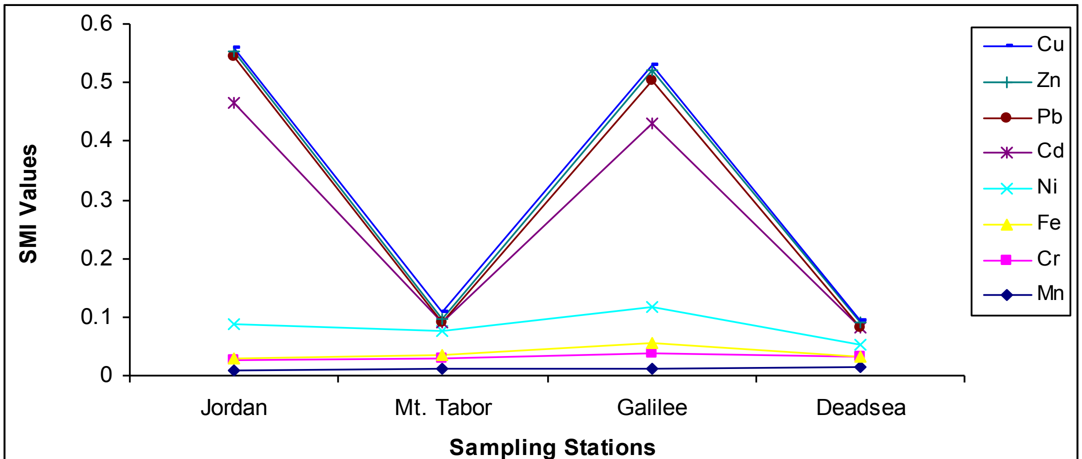

FIG. 3b. Variations of SMI Values with Stations in Israel

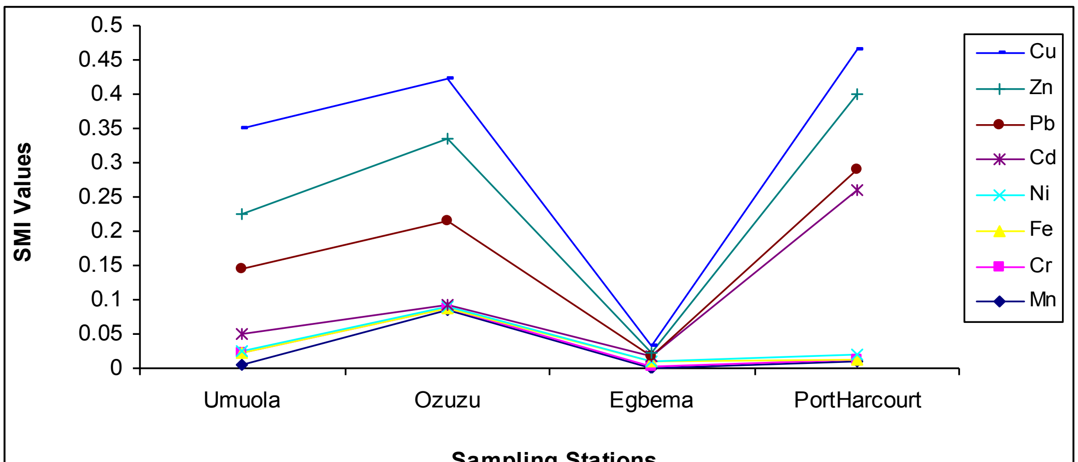

FIG. 3c. Variations of SMI Values with Stations in Nigeria

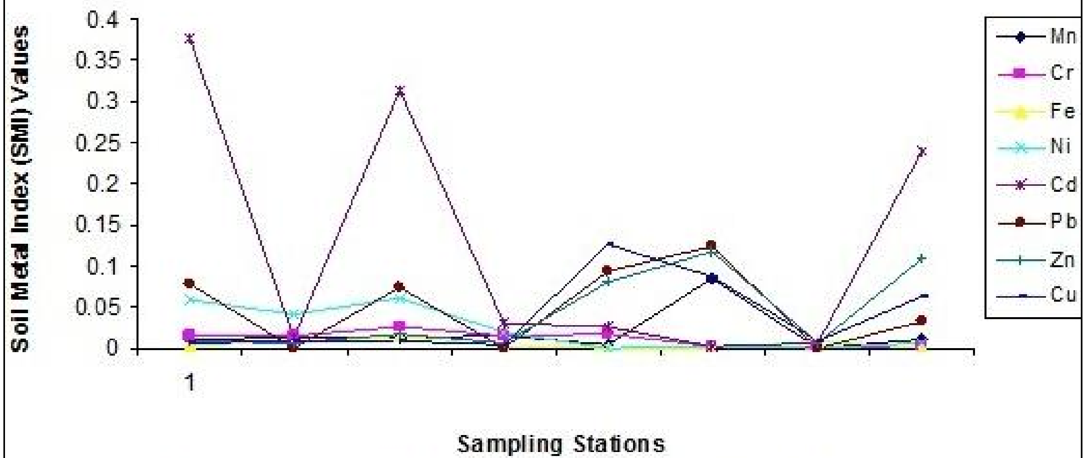

FIG 3d Variations of Soil Metal Index (SMI) at the Study Areas

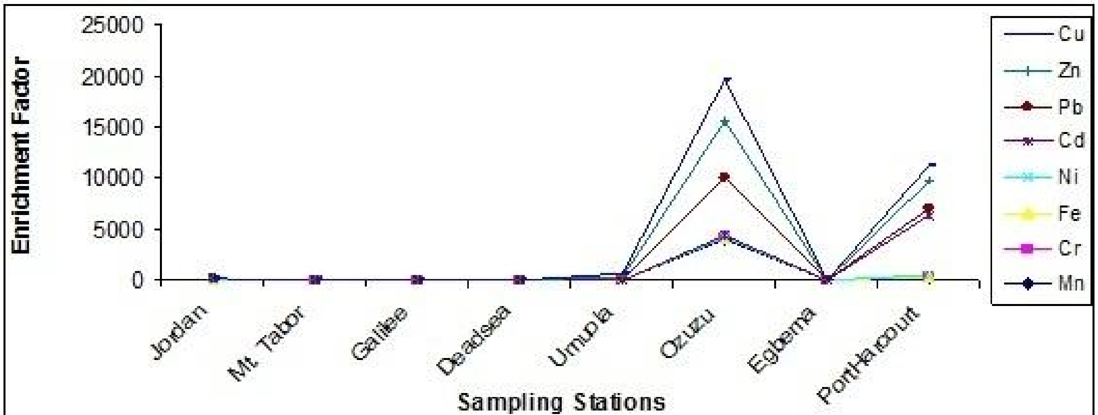

FIG 4a Variations of Enrichment Factor of Heavy Metals in Soils from the Study Areas

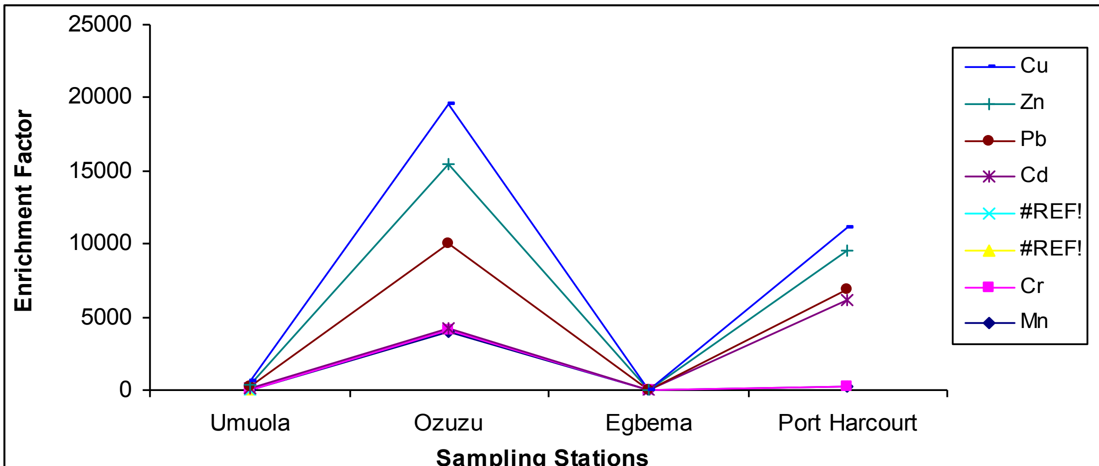

FIG. 4b. Variations of Enrichment Factor in Nigeria

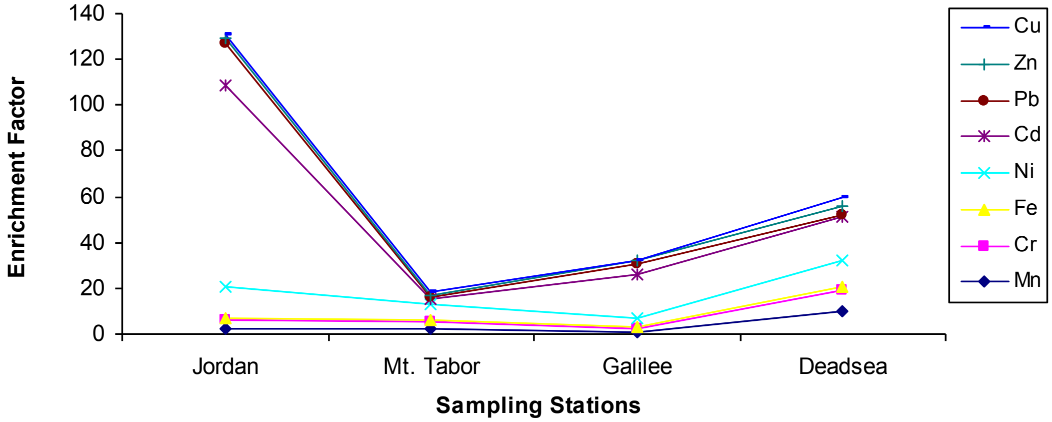

FIG. 4c. Variations of Enrichment Factor of Heavy Metals in Israel

Calcium levels in Israel ranged from 14.20 meq/100 g at Jordan to 40.20 meq/100 g at Mt. Tabor with mean of 29.0±7.72 meq/100 g and 50.80 meq/100 g in Dead sea sediment while it ranged from 3.20 meq/100 g at Umuola to 5.42 meq/100 g at Egbema with a mean of 4.22±0.53 meq/100 g. [38] and [32] rated soils with < 2.0 meq/100 g as very low in calcium, 2-5 meq/100 g as low and 5-10 meq/100 g as medium. The levels of exchangeable calcium show that the soils are low to medium while those of Israel are high in exchangeable calcium.

Magnesium ranged from 2.40 meq/100 g at Jordan -16.60 meq/100 g at Mt. Tabor with a mean of 9.6±4.10 meq/100 g and 67.60 in Dead sea sediment in Israel while it ranged from 0.76 meq/100 g at Port Harcourt -1.80 meq/100 g at Umuola with a mean of 1.43±0.23 meq/100 g in Nigeria. The soils were found to range from low to medium in exchangeable magnesium based on the ratings by [38] and [32]. According to these authors, exchangeable magnesium values from 1.5 – 3.0 meq/100 g is medium, 0.5-1.5meq/100g low and <0.5 meq/100 g very low.

Potassium in Israel ranged from 0.64 meq/100 g at Jordan – 2.31 meq/100 g at Galilee with a mean of 1.67±0.52 meq/100 g and 5.74 meq/100 g in Dead sea sediment while it ranged from 0.07 meq/100 g at Umuola and Ozuzu – 0.08 meq/100 g at Egbema with a mean of 0.07±0.0 meq/100 g in Nigeria. According to [38], levels of exchangeable potassium between 0.1 – 0.3 meq/100 g soil are regarded as low for tropical and sub-tropical soils and below 0.1 meq/100 g soil very low. Based on this rating, the soils analyzed in this study ranged between very low in Nigeria to high in Israel in their exchangeable potassium content with most of the samples falling within the ‘very low’ and ‘high’ ranges. According to [39], amounts of exchangeable potassium in the tropical savannah are low. The soils from Israel have the highest mean exchangeable potassium value. This could be attributed to cultivation and enrichment of the soils with fertilizers. The values in Nigeria agree with [40] who reported that the soils of the humid southern zone of Nigeria were deficient in potassium as a result of high leaching intensity.

The levels of sodium in Israel ranged from 1.09 meq/100 g at Jordan -2.72 meq/100 g at Galilee with a mean of 1.99±0.48 meq/100 g and 39.35 meq/100 g in Dead sea sediment while it ranged from 0.43 meq/100 g at Port Harcourt - 1.35 meq/100 g at Umuola with a mean of 0.99±0.20 meq/100 g in Nigeria. [38] and [32] rated exchangeable sodium levels below 0.1 meq/100 g as very low and 0.1 – 0.3 meq/100 g of soil as low. Based on this, all the soils studied are high in exchangeable sodium. [32] observed that although sodium could serve as a substitute for potassium, it is not an essential plant nutrient. For this reason, he added that its absence or presence in only small quantities is not usually detrimental to plant nutrition. He observed that when sodium is present in soil in significant quantities, particularly in proportion to other cations present, it can have an adverse effect, not only on many crops, but also on physical conditions of the soil.

The generally low content in Nigeria and moderate content in Israel of exchangeable bases in the soils of the study areas could be attributed to the parent material that underlies the area as well as leaching of essential plant nutrients. Increasing the pH and organic matter levels will make exchangeable bases more available in the soils.

Exchangeable Acidity (Ex. Acidity) ranged from 0.24 cmol/kg at Jordan -0.72 cmol/kg at Tabor with a mean of 0.43±0.15 cmol/kg and 0.80 cmol/kg in Dead sea in Israel while it ranged from 0.32 cmol/kg Ozuzu - 0.55 cmol/kg in Port Harcourt with a mean of 0.41±0.05 cmol/kg in Nigeria.

Exchangeable Aluminium (Ex. Al) in Israel ranged from 0.11 cmol/kg at Jordan – 0.35 cmol/kg at Mt.Tabor with a mean of 0.21±0.07 cmol/kg in soils and 0.41 cmol/kg in Deadsea sediment while in Nigeria the value ranged from 0.08 cmol/kg at Ozuzu – 0.20 cmol/kg at Port Harcourt with a mean of 0.41± 0.03 cmol/kg.

ECEC in Israel ranged from 19.82 cmol/kg at Jordan – 61.71 cmol/kg at Mt. Tabor with a mean of 43.23±12.34 cmol/kg and 164.39 cmol/kg in Dead sea sediment and it ranged from 3.64 cmol/kg at Egbema – 7.88 cmol/kg at Ozuzu with a mean of 5.94±0.93 cmol/kg in Nigeria.

In the soils from Israel and Nigeria the highest levels of Ca (40.20 meq/100 g), Mg (16.60 meq/100 g), Ex. Acidity (0.72 cmol/kg), Ex. Al (0.35 cmol/kg) and ECEC (61.71 cmol/kg) were at Tabor while Na (2.72 meq/100 g) and K (2.31 meq/100 g) were at Galilee.

High levels of exchangeable bases Ca (50.80 mg/kg), Mg (67.60 mg/kg), Na (39.35 mg/kg), K (5.74 mg/kg), exchangeable acidity (0.80 cmol/kg), Ex. Al (0.40 cmol/kg), ECEC (164.39 cmol/kg), Cl^- (9798 ppm), SO_4^{2-} (184.61 ppm) and NO_3^- (14.0 ppm) were measured in the Dead sea sediment. This implies high level of mineralization in the sediment which serves as sink for environment and hence the use of the Dead sea sediment in the manufacture of various cosmetic products.

The textural classes of the soils and sediment were sand at Jordan and Dead sea in Israel and Ozuzu and Port Harcourt in Nigeria while soils at Umuola and Egbema in Nigeria were loamy sand. The soils at Mt.Tabor and Galilee were found to be clay loam and sandy clay loam respectively. This indicate that the soils and sediment from Jordan, Dead sea in Israel and Ozuzu and Port Harcourt in Nigeria have low fertility, permeable and high nutrient leaching. The soils from Mt. Tabor, Galilee, Umuola and Egbema could be rated more fertile with high nutrient holding capacity. The light and/or pale colour of the soils and sediment from Jordan, Dead sea, Ozuzu and Port Harcourt could be responsible for their high sand contents while the soils at Galilee, Mt. Tabor and Egbema have shades of red due to their clay and iron contents.

The C:N ratio ranged from 2.65 – 65.25 with a mean of 40.52±19.23 in soils and 0.4 in Deadsea sediment in Israel while it ranged from 11.2 – 13.89 with a mean of 12.26±0.67 in Nigeria. Carbon to Nitrogen ratio is an indicator of nitrogen mineralization and accumulation in soils. [41,42] reported low range of C:N ratios for soils in the Niger Delta region of Nigeria. According to [2] C/N ratio in the Topsoil is commonly between 10 and 12 in humid regions. The low range in Nigeria implies high decomposition and mineralization in the area. If the ratio is below 20, mineralization will be higher than immobilization [2].

A t-test showed significant difference ($p<0.05$) in the mean levels of the parameters measured between Israel and Nigeria.

Manganese ranged from 20.77 ppm at Jordan – 31.69 ppm at Dead sea in Israel with mean soil level of 23.25±1.28 ppm and 0.01 ppm at Egbema – 170.40 ppm at Ozuzu in Nigeria with a mean of 49.66±40.44 ppm.

Chromium ranged from 1.461ppm at Dead sea – 1.736 ppm at Galilee in Israel with a mean of 2.0±0.37 ppm in soil and 0.16 at Port Harcourt – 0,178 ppm at Umuola in Nigeria with a mean of 0.22±0.03 ppm.

Iron ranged from 78.284 ppm at Dead sea – 816.75 ppm at Galilee in Israel with a mean of 439.14±189.95 ppm in soil and 1.065ppm at Ozuzu – 402.37 ppm at Egbema in Nigeria with a mean of 108.06±98.28 ppm.

Nickel ranged from 0.931 ppm at Dead sea – 3.054 ppm at Galilee in Israel with a mean of 2.7±0.30 ppm in soil and 0.03 ppm at Egbema – 0.35 ppm at Port Harcourt in Nigeria with a mean of 0.13±0.07 ppm.

Cadmium in Israel ranged from 0.042 ppm at Tabor – 1.108 ppm at Jordan with a mean of 0.70±0.34 ppm and 0.008 ppm at Umuola – 0.72

ppm at Port Harcourt with a mean of 0.19±0.18 ppm in Nigeria.

Lead ranged from 0.045 ppm at Dead sea – 7.776 ppm at Jordan with a mean of 5.13± 2.53 ppm in soil at Israel and 0.01 ppm at Egbema – 12.30 ppm at Ozuzu with a mean of 6.21±2.81 ppm in Nigeria.

Zinc ranged from 1.954 ppm at Tabor – 5.049 ppm at Galilee with a mean of 3.23± 0.93 ppm in soil at Israel and 1.80 ppm at Egbema – 36.30 ppm at Ozuzu with a mean of 23.41 ppm in Nigeria.

Copper ranged from 0.516 ppm at Dead sea – 0.845 ppm at Mt. Tabor with a mean of 0.73±0.08 ppm in soil at Israel and 0.90 ppm at Egbema – 12.601 ppm at Umuola with a mean of 7.17± 2.45 ppm in Nigeria.

Low pH (below 5.5) makes metals such as Zn, Cu, Cr, Mn, Co, Fe and Al more soluble for plant uptake [43,5,3]. With the low pH values obtained in Nigeria, the Fe and Mn values obtained show that the acidic condition of the soils in Nigeria increased the solubility and availability of these metals. This situation encourages leaching of nutrient elements.

The results of Pearson's correlation coefficients and their significant levels ($P < 0.01$) are presented in Tables 5 – 9.

A correlation coefficient > 0.7 is interpreted as a strong relationship between two parameters, whereas values between 0.5 and 0.7 represent a moderate relationship [44]. Correlation analysis provides an effective way to reveal the relationships between multiple variable and thus have been helpful for understanding the influencing factors as well as the sources of chemical components [45]. The relationship between heavy metals can provide important information on heavy metal sources and pathways [46].

In Israel, the concentrations of Mn showed a strong negative relationship with Ni (-0.9360), Cd (-0.7677) and Pb (-0.7666); Cr showed strong positive relationship with Fe (0.9873) and Zn (0.9809) but moderate positive relationship with Ni (0.6483), Cd (0.5292) and Pb (0.6269); Fe has strong positive relationship with Zn (0.9418) but moderate positive relationship with Ni (0.6784), Pb (0.5784) and Cu (0.5346). Pb has strong positive relationship with only Zn (0.7306). Ni has strong positive relationship with Cd (0.8434) and Pb (0.8759) but moderate positive relationship with Zn (0.6668). Cd showed strong positive relationship with Pb (0.9926) but moderate positive relationship with Zn (0.6480). The metal concentrations showed strong positive relationship (> 0.9) between all the stations.

In Rivers State, Nigeria, Mn showed strong positive relationship with Cr (0.7610) and Pb (0.7385) but moderate positive relationship with Zn (0.5983). Cr has moderate negative relationship with Ni (-0.6056) and Cd (-0.6481). Fe showed strong negative relationship with Pb (-0.7264), Zn (-0.9648) and Cu (-0.8236). Ni has strong positive relationship with Cd (0.9885) but moderate positive relationship with Zn (0.5268). Pb showed strong positive relationship with Zn (0.7008) while Zn showed moderate positive relationship with Cu (0.6729). The concentrations of metals at Umuola showed moderate positive relationship with those at Egbema (0.6362) and Port Harcourt (0.5262). Similar observation was made between Ozuzu and Port Harcourt (0.5567).

The observed relationships suggest that the metals concerned come from similar sources. The concentrations of Pb and Cu showed weak correlations with other metals suggesting that they were from different sources than the other metals.

Generally the SMI values obtained were below 100% suggesting that the soils of the study areas though contaminated are unpolluted with heavy metals. The spatial variation of SMI reflects effect of anthropogenic activities in the enrichment of heavy metals.

The enrichment factor (EF) was used to quantify the level of the potential anthropogenic effects in soils from the study areas. The EF values increase with the contributions of anthropogenic sources [47]. The EF > 1 indicates that the abundance of the heavy metals in the soil may not come from the local soil background but other natural and/or anthropogenic sources such as vehicle emissions, industrial emissions, etc [48]. The EF < 5 though not significant, indicates metal accumulation while EF > 5 indicate soil contamination for related metals. The values of EF are greater than 5 for Ni (13.77), Cd (87.87), Pb(18.15) at Jordan; Ni (7.30) at Mt Tabor; Cd (19.18) at Galilee; Mn (10.12), Cr (9.33), Ni (11.88), Cd (19.16) in Dead Sea; Mn (8.39), Cd (49.86), Pb (175.21), Zn (149.09), Cu (235.61) at

Umuola; Mn (3981.31), Cr (135.51), Ni (74.77), Cd (155.76), Pb (5747.66); Zn (5498.44), Cu (4093.46) at Ozuzu; Mn (234.76), Cr (39.02), Ni (170.73), Cd (5853.66), Pb (768.29), Zn (2652.85), Cu (1565.85) at Port Harcourt.

The results showed significant enrichment with Ni and Pb at Jordan, Ni at Mt Tabor, Cd at Galilee, Mn, Cr, Ni, Cd in Dead Sea and Mn at Umuola. It showed very high enrichment with Cr at Port Harcourt. The results showed extremely high enrichment with Cd at Jordan, Umuola, Ozuzu, Port Harcourt; Pb, Zn, Cu at Umuola, Ozuzu, Port Harcourt; Mn, Ni, at Ozuzu, and Port Harcourt and Cr at Ozuzu. This implies that the metals showed extremely high enrichment in Nigeria than Israel. Only Cd showed extremely high enrichment in Jordan while all the metals determined showed extremely high enrichment in Ozuzu and Port Harcourt except for Cr at Port Harcourt. This observation could be attributed to the use of heavy farming implements and machinery in Port Harcourt (Rivers State University teaching farm) and Ozuzu in Etche, a major farming area in Rivers State, Nigeria. The highest enrichment of Cd and Pb in Port Harcourt and Ozuzu respectively indicate the importance of industrial and traffic emissions from fossil fuel and other anthropogenic sources as contributors to the metals concentrations.

4. CONCLUSION

The findings from this study have shown that the soils in Nigeria are acidic and nutrient-deficient as most of the values were below permissible limits while soils from Israel are alkaline. The observed soil pH can influence nutrient absorption and plant growth through its influence on nutrient availability and the presence of toxic ions. The concentrations of heavy metals especially the high Fe and Mn values obtained show that the acidic condition of the soils increased the solubility and availability of these metals.

The soils in Nigeria need application of land amendment materials such as organic wastes (from plants and animals) than soils in Israel as the soil physicochemical properties show that all the soils of the study areas in Nigeria are acidic and low in Organic Matter, Total Nitrogen, Available Phosphorus and Exchangeable Bases while those in Galilee and Mt. Tabor in Israel are moderate. The levels of exchangeable bases, exchangeable acidity and ECEC were higher in soils from Israel than Nigeria and highest in Dead sea sediment than soil from both countries.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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