

1 **Physicochemical assessment of soils from selected metal scrap dumpsites in**
2 **Anambra State, Nigeria**

3

4 **Abstract**

5 Soils are prone to pollution due to the influence of climate change, globalization and
6 industrialization. Soil samples used in this research were collected from two different metal
7 scrap dumpsites while the controls were taken 500m away from sampling sites all in Anambra
8 state, Nigeria. The physico-chemical parameters analyzed were pH, electrical conductivity, total
9 organic carbon (TOC), moisture content, nitrate, phosphate and heavy metals. Heavy metals viz:
10 Cd, Co, Fe, Mn, Pb and Zn concentrations (mg/kg) were determined using Varian AA240 model
11 of atomic absorption spectrophotometer (AAS). The pH and electrical conductivity
12 determinations were done in situ using Searchtech, PHS-7010 multimeter scale. Moisture
13 content of the samples were determined in DHG-9053A oven. The soil samples in the studied
14 areas contained Cd, Co, Fe, Mn, Pb and Zn. The analysed heavy metals concentrations were
15 attributed to anthropogenic sources and geological formation of the areas since the control
16 samples equally had appreciable concentrations of some of these heavy metals. The pH, EC,
17 salinity, nitrate and phosphate values obtained in this study pose no harm on the soils yet.
18 However, the concentrations of some heavy metals assayed are significantly higher than WHO
19 permissible limit for heavy metals on soils. Therefore, good management of metal scrap
20 activities is highly recommended in Anambra State since metal scrappers occupy most large
21 vacant lands near farm lands, water bodies and human settlements thereby increasing the
22 potency of toxic chemicals in the ecosystem.

23

24 **Key words:** soil, metal scrap dumpsites, pollution, heavy metals, AAS, WHO.

25

114

137

138 **Introduction**

139 Soils are exposed to pollution due to the influence of climate change, globalization and
140 industrialization [1]. With rapid urbanization and industrialization, the environment is severely
141 contaminated by heavy metals and their rates of transfer in the soil, water and air have

1 continued to increase till date [2]. Crude oil which contains both inorganic and organic
2 compounds is known to cause environmental pollution through its exploration, production,
3 transportation and oil spillage activities. Soil contamination with high concentration of
4 pollutants may affect the microorganisms living in the soil [3].

5 Soil is a major component of agricultural food production and it serves as the source and/ or
6 sink for toxic substances [4].

7 One of the major challenges confronting Nigeria as a country is solid waste management [5].
8 Municipal solid wastes are routinely deposited on the roads, drains, water bodies and
9 uninhabited lands. Metal scrap is one of the municipal solid wastes (MSW), which have
10 monetary value in Nigeria [6]. The scrapyards are haphazardly sited in rural and urban centres
11 in Nigeria where all kinds of scraps from abandoned automobiles, machineries and electrical
12 appliances are disassembled [7]. Many of these scrap materials contain contaminants such as
13 heavy metals, polycyclic aromatic hydrocarbon and other toxic substances that adversely affect
14 the ecosystem [8]. Human beings may be exposed to these toxic substances through inhalation,
15 ingestion or dermal contact [9]. Heavy metals present in solid municipal wastes via interaction
16 with soil components, bio-accumulate and persist in soil and consequently go into the food
17 chain and consumed by human [10].

18 The increased level of metals that accumulate in the soil and affect nearby ecosystems primarily
19 originates from anthropogenic activities such as discharge of industrial and domestic wastes,
20 mining, smelting operations and vehicular emission [11]. Weathering of the natural rock is
21 another known source of heavy metal pollution in soils. However, input of metals from human
22 sources in soils is higher than the input from natural sources [12].

23 Heavy metals are released into the environment from metal smelting and refining industries,
24 scrap metals, plastic and rubber industries, various consumer products and from burning of
25 waste containing these elements. The metals volatilize on burning and is released into the air.
26 These volatilized metals become mobile and travel long distances to deposit on the soil,
27 vegetation and water depending on their density [13]. The deposited metals are non-
28 degradable and persistent in the environment and pose severe poisoning on humans through
29 inhalation, ingestion and skin absorption. Acute exposure to these toxic metals leads to nausea,
30 anorexia, vomiting, gastrointestinal abnormalities, dermatitis and many fatalities. The
31 contamination of the ecosystem by heavy metals is a serious problem in the society because the
32 environment is a direct receptacle for waste products generated in the space within the
33 environment [14]. Meanwhile, zinc and copper are some essential nutrients to humans and
34 animals for biochemical activities [15]. Waste from municipal dumpsites bear soils that are
35 satisfactorily rich in organic matter that would be acceptable for surface feeder plants [16]. It
36 was reported that open dump sites perform a twofold purposes of a safe disposal of waste and

1 simultaneously improve chemical properties of soils that constitute productive agricultural
2 fields [13].

3 Nigeria has a comparatively very poor waste management approach[17]. Indiscriminate waste
4 dumps and scrap dumpsites occupy almost every vacant plot of land especially along major
5 roads and streets. It is suspected that these activities contaminate and degrade the soil by
6 causing substantial alteration of the physical and chemical composition of the soil hence
7 compromise efficient and quality plant growth.

8 Thus, the inadequate waste management approach has the potential of increasing soil metal
9 concentration in and around Anaocha and Njikoka major scrap dumpsites. The mobility of heavy
10 metals, bioavailability and related bio-toxicity to organisms depend on their specific chemical
11 forms or ways of binding and the total metal concentration obtained after strong acid digestion.

12 Presently, there is no information regarding the assessment of inorganic and organic
13 compounds in soil around the metal dumpsites in the studied areas. It is hoped that the present
14 study would produce a new framework for assessment of environmental risks associated with
15 metal scrap dumpsite activities. Therefore, this study seeks to assess the physicochemical
16 properties and heavy metals (Cd, Co, Fe, Mn, Pb and Zn) in the vicinity of open waste dumpsite
17 at Adazi-ani (Anaocha) and Abagana (Njikoka) areas in Anambra state, Nigeria. Assessment of
18 these soils followed a thorough soil chemistry as well as comprehensive laboratory work to fully
19 comprehend the extent of contamination of the environment and the potential risk to the
20 ecosystem.

21 **Materials and Methods**

22 **Description of Study Area**

23 Adazi-ani is a community in Anaocha local government area while Oyeaguis situated at
24 Abagana, in Njikoka local government area, both in Anambra state, Nigeria. They are in
25 between Awka and Nnewi metropolis. The areas are located in the Niger Delta Basin. Adazi-ani
26 metal scrap dump site lies on latitude 6.07304°N and longitude 6.982019°E while Abagana metal
27 scrap dumpsite lies on the latitude 6.18502°N and longitude 6.95646°E . Adazi-ani control
28 coordinates at 6.080008°N and 6.987892°E while that of Abagana at 6.187943°N and
29 6.970761°E .

30

31

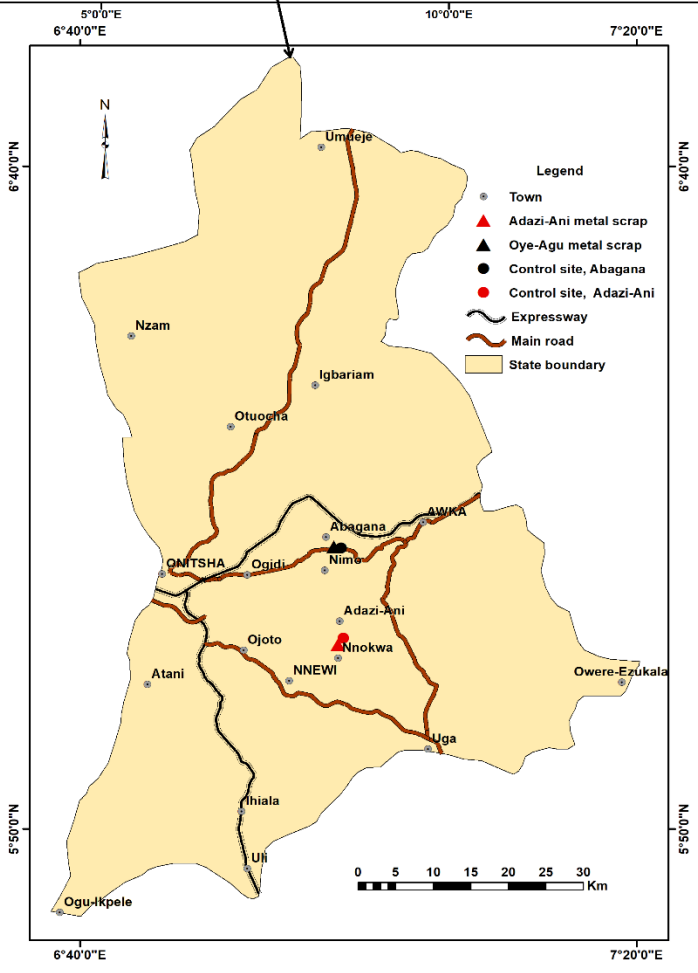
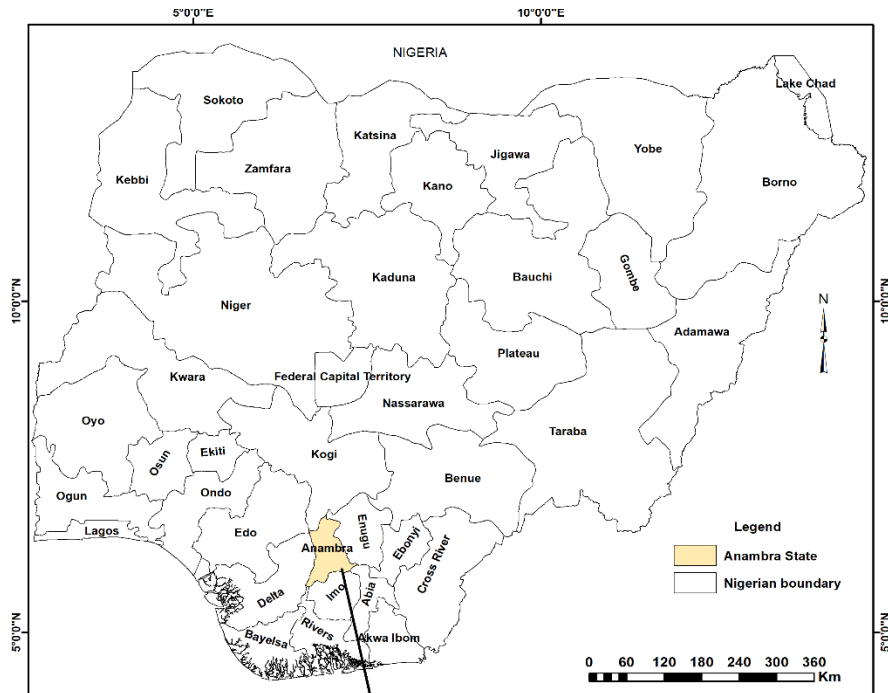
32

33

1

2

UNDER PEER REVIEW



1
2 **Fig. 1: Map of Anambra State, Showing the Study Areas**

1 **Soil sampling and analysis**

2 Total of eight(8) soil samples were used in this study. Soil samples used in this research were
3 collected with a soil auger at 0-15cm depth and 15-30 cm depth from the metal scrap
4 dumpsites and controls collected 500m away from sampling sites. The pH was determined in -
5 situ using pH meter. The samples were put in sealed plastic bags, labelled and conveyed to the
6 laboratory. After moisture content determination, the soil samples were air dried, crushed and
7 passed through a 2mm sieve prior to other analysis. Samples for heavy metals were digested
8 using aqua regia method and finally analysed using Varian AA240 atomic absorption
9 spectrometer(AAS) at Spring Board Research Laboratories, Awka, Anambra state, Nigeria. The
10 average and standard deviation obtained from duplicate analysis of the samples were
11 compared with WHO permissible limits.

12 **Soil pH and conductivity determination.**

13 The soils pH and conductivity were determined using a calibrated Searchtech, PHS-7010
14 multimeter by adopting the method described by AOAC 2012 [18]. The meter was first
15 standardized against standard buffer solutions of known pH values according to the
16 manufacturer's instruction. The electrodes of the meter were then washed with distilled water
17 and then immersed in the samples contained in a beaker. The pH and electrical conductivity of
18 the samples were then read on the multimeter scale and noted.

19 **Moisture content determination**

20 By adopting the modified method described by AOAC 2012 [18], 2g of each sample was
21 weighed into Petri dishes that were washed and dried in an oven. The weight of the Petri dishes
22 and samples were noted before drying. The Petri dishes and samples were transferred into
23 DHG-9053A oven and heated at 105⁰C for 3hrs, cooled in desiccators and the weight was noted.
24 The drying procedure continued until constant weights were obtained.

$$25 \text{ \% moisture content} = \frac{W2 - W3}{W2 - W1} \times 100 / 1$$

26 Where:

27 W1= weight of the crucible

28 W2= weight of the crucible+ sample before drying

29 W3= weight of the crucible+ sample after drying.

30 **Nitrate and phosphate determination**

31 Nitrate and phosphate concentrations of the soils were determined following the procedure
32 used by Onoyima and Okide [19].

1 **Heavy metals assay**

2 The samples for heavy metals analysis were digested using aquaregia method and the digests
 3 were assayed using Varian AA240 atomic absorption spectrometer(AAS)and the duplicate data
 4 obtained were subjected to statistical calculations.

5 **Results and Discussion**

6 **Table 1. Results of physicochemical parameters of the soil.**

Samples ID	pH	EC.(dS/m)	Moist cont (%)	TOC (mg/kg)	Salinity (dS/m)	Nitrate (mg/kg)	P(mg/kg)
AD0	8.23	-54.00	3.50	14.58±0.12	0.20±0.01	6.62±0.17	2.32±0.03
AD15	8.30	-57.00	2.50	26.52±0.25	0.28±0.05	6.45±0.02	3.28±0.76
AC0	8.43	-43.00	3.00	14.31±0.12	0.86±0.82	4.55±0.36	2.29±0.04
AC15	7.78	-8.00	2.00	9.39±0.53	0.40±0.03	8.43±0.20	3.07±0.93
OD0	8.07	-42.00	1.00	23.66±0.43	0.60±0.06	5.86±0.60	2.38±0.06
OD15	8.48	6.70	52.00	28.45±0.24	0.24±0.27	5.44±0.57	2.05±0.06
OC0	8.53	-57.00	4.50	14.07±0.06	0.36±0.05	6.14±0.32	2.30±0.13
OC15	8.42	-62.00	2.50	9.39±0.53	0.41±0.02	6.51±0.04	2.91±0.77

7
 8 AD0 and D15 =Adazi-ani dumpsite 0-15cm and15-30 cm respectively, AC0 and C15=Adazi-ani
 9 control 0-15cm and15-30 cm respectively, OD0 and D15= Oyeagu dumpsite 0-15cm and 15-
 10 30cm respectively, OC0 and C15 =Oyeagu control 0-15cm and 15-30cm respectively, ID=
 11 identity,EC. =electrical conductivity, moist cont= moisture content, TOC=total organic carbon, P
 12 = phosphate.

13
 14
 15
 16
 17
 18

19 **Table 2. concentrations(mg/kg) of metals from all depths(cm) and locations**

Samples ID	Lead	Cadmium	Zinc	Manganese	Cobalt	Iron
------------	------	---------	------	-----------	--------	------

AD0-15cm	0.103±0.017	0.154±0.036	1.940±0.005	0.021±0.014	0.006±0.006	8.158±9.421
AD15-30cm	0.057±0.012	0.062±0.014	1.842±0.007	0.007±0.000	0.005±0.007	1.151±0.035
AC0-15cm	0.369±0.132	0.413±0.077	1.517±0.158	0.013±0.000	0.011±0.004	0.192±0.098
AC15-30cm	0.013±0.012	0.027±0.001	0.301±0.010	0.004±0.006	0.006±0.008	0.320±0.010
OD0-15cm	0.028±0.003	0.015±0.002	1.480±0.016	0.011±0.007	0.014±0.002	0.747±0.044
OD15-30cm	0.046±0.009	0.021±0.000	1.843±0.008	0.009±0.002	0.000	1.109±0.064
OC0-15cm	0.010±0.003	0.020±0.004	0.101±0.115	0.010±0.002	0.000	0.244±0.004
OC15-30cm	0.008±0.009	0.012±0.001	0.149±0.000	0.007±0.003	0.006±0.000	0.295±0.016
WHO limit	0.01	0.003	3.00	0.50	0.03	3.00

1
2 AD0 and D15 =Adazi-ani dumpsite 0-15cm and15-30 cm respectively, AC0andC15=Adazi-ani
3 control 0-15cm and15-30 cm respectively, OD0 and D15= Oyeagu dumpsite0-15cm and 15-30cm
4 respectively, OC0 and C15 =Oyeagu control 0-15cm and 15-30cm respectively, WHO limit= world
5 health organization limit.

6
7 According to **Table 1**, the results showed that the pH values of the soils are alkaline except for
8 AC15 which has a neutral value of 7.78. The pH values obtained in this study is higher than the
9 prescribed limits of 6.5-7.5 [19].Plants may not thrive in acidic (low pH) soils. Salinity values of
10 the analysed soils were within the limit. Salts reduce the soils water holding capacity. A soil that
11 is salty can be wet and yet lack water for plant growth. This is because salts have a strong
12 attraction for water molecules that the roots cannot overcome it. The salt content of a soil can
13 be estimated from the electrical conductivity of the soil measured in a saturated soil paste
14 [20].Soil salinity occurs when the electrical conductivity(EC) of the saturation extract(ECe) in the
15 root zone exceeds 4dS/m at 25⁰C [21].Moisture content of all the soil samples were within the
16 range of 2-4% but OD015 significantly have 52%. Higher moisture content of 20-40% shows
17 poor soil aeration.It was observed that the dumpsite recorded the highest value (28.455) while
18 the least value (9.390) occurred in a control sample. The organic carbon content (TOC) of the
19 soils were greater than 0.7% and thus revealed that the soil would be fertile for agriculture in
20 case if the scrap activities discontinued [22]. The nitrate and phosphate content of the soils
21 were higher than the values obtained in the literature [19].

1 From **Table 2**, the heavy metal analysis revealed that AD0, AD15, OD0, OD15, OC15 have higher
2 concentration of lead, AC15 has the value (0.008mg/kg) which is lower than WHO
3 recommended limit while OC0 and AC15 values are within WHO permissible limit of
4 (0.01mg/kg). The average values of Cd in all the soil samples exceeded 0.003mg/kg
5 recommended by world health organization standard for agricultural soils [23, 24]. The mean
6 concentrations of zinc, manganese and cobalt in all samples were found to be within the WHO
7 permissible limit. The concentration of iron in all the soil samples were within the threshold
8 except for AD0 whose value (8.1580mg/kg) is far above the WHO permissible limit [25, 26].

9 10 **Conclusion**

11 The soil samples in the studied areas contained Cd, Co, Fe, Mn, Pb and Zn. The analysed heavy
12 metals concentrations were attributed to anthropogenic sources and geological formation of
13 the areas since the control samples equally had appreciable concentrations of some of these
14 heavy metals. The pH, EC, salinity, nitrate and phosphate values obtained in this study pose no
15 harm on the soils yet. However, the concentrations of some heavy metals assayed are
16 significantly higher than WHO permissible limit for heavy metals on soils. Therefore, good
17 management of metal scrap activities is highly recommended in Anambra State since metal
18 scrappers occupy most large vacant lands near farm lands, water bodies and human settlements
19 thereby increasing the potency of toxic chemicals in the ecosystem.

20 21 **REFERENCES**

- 22 1. Tamboli PM and NeneYL. Modernizing higher Agricultural Education system in India to
23 meet the challenges of 21st century. Asian Agric-History foundation. 2013; 17(3): 251-
24 264.
- 25 2. Ali H, Khan E and Ilahi I. Environmental Chemistry and ecotoxicology of Hazardous Heavy
26 Metals: Environmental Persistence, Toxicity and Bioaccumulation. Journal of Chemistry.
27 2019; Article ID 6730305.
- 28 3. Salam LB, Ilori MO, Amund OO, Liimien Y, Nojiri H. Characterization of bacterial
29 community structure in a hydrocarbon-contaminated tropical African soil. Environmental
30 technology. 2018; 39(7):939-951.
- 31 4. Sarkar B, Mukhopadhyay R, Ramanayaka S, Bolan N, Yong SO. The role of soils in the
32 disposition, sequestration and decontamination of environmental contaminants. Phil.
33 Trans. R. Soc. 2021; B 376: 20200177. 20200177.

- 1 5. Adewuyi GO, Opasina MA. Physicochemical and Heavy Metals Assessments of Leachates
2 from Aperin Abandoned Dumpsite in Ibadan City, Nigeria E-Journal of Chemistry. 2010;
3 7(4), 1278-1283.
- 4 6. Ejiogu BC, Opara AI, Nwosu EI, Nwofor OK, Onyema JC, Chinaka JC. Estimates of aquifer
5 geo-hydraulic and vulnerability characteristics of Imo State and environs, Southeastern
6 Nigeria, using electrical conductivity data. Environ Monit Assess. 2019; 191 (4):238.
- 7 7. Ejiogu BC, Opara AI, Nwofor OK, Nwosu EI. Geochemical and bacteriological analyses of
8 water resources prone to contamination from solid waste dumpsites in Imo State,
9 SoutheasternNigeria. J Environ Sci Technol.2017; 10(6):325 -343.
- 10 8. Okere KJ, Abu GO, Ndukwu B. Estimation and characterization of municipal solid waste in
11 Nekede landfill, Owerri metropolis, Nigeria. Int J EngAppl Sci. 2018; 5(3): 93-100.
- 12 9. Odika IM, Nwanisobi GC, Nwankwo NV, Mmaduakor EC, Ikeh OA. Polycyclic
13 Aromatic Hydrocarbons, PAHs Contamination Levels and Health Risks in Foods
14 Consumed in Nigeria: A Review. Asian journal of Food Research and Nutrition. 2023;
15 2(4):558-570.
- 16 10. Ogoko EC. Physicochemical properties and heavy metal concentration of groundwater in
17 Owerri Metropolis, Nigeria. Curr J ApplSci Technol. 2017; 23(1):1–10.
- 18 11. Arukwe A, Eggen T, Möder M. Solid waste deposits as a significant source of
19 contaminants of emerging concern to the aquatic and terrestrial environments—a
20 developing country case study from Owerri, Nigeria. Sci Total Environ. 2021; 438 :94–
21 102.
- 22 12. Obasi IA, Nnachi EE, Igwe OE, Obasi NP (2015). Evaluation of pollution status of heavy
23 metals in the groundwater system around open dumpsites in Abakaliki urban,
24 Southeastern Nigeria. Afr J Environ Sci Technol. 2015; 9(7):600–609.
- 25 13. Salam A. Environmental and health impact of solid waste disposal at Manawaneni
26 dumpsites in Manzini Swaziland: Journal of Sustainable Development in Africa. 2010;
27 12(7).
- 28 14. Ahukaemere CM. Vertical Distribution of Organic Matter in Relation to Land Use Types in
29 Soils of Similar Geological History of Central Southern Nigeria. Nigeria Journal of Soil and
30 Environmental Research. 2012; 10: 71- 75.
- 31 15. Hosea PI, OlowokereJA, Odineze MC. Comparative Assessment of Heavy Metal
32 Concentration in Some Edible Spinach (*Amaranthushybridus*) inSouthern Taraba (Ibi,
33 Wukari and Donga), Nigeria. Asian Journal of applied chemistry research. 2023; 14(3):10-
34 16.
- 35 16. Amadi AN, Olasehinde PI, Okosun EA, Okoye NO, Okunlola I A, Alkali YB, Dan-Hassan MA.
36 A Comparative Study on the Impact of Avu and IhieDumpsites on Soil Quality in
37 Southeastern Nigeria. American Journal of Chemistry. 2012; 2(1) :17-23.

- 1 17. Angaye TCN, Abowei JFN. Review on the environmental impacts of municipal solid waste
2 in Nigeria: challenges and prospects. Greener journal of environmental management
3 and public safety.2017; 6(2): 018-033.
- 4 18. AOAC. Official Method of Analysis: Association of Analytical Chemists. 19th edition,
5 Washington DC. 2012; 121-130.
- 6 19. Onoyima CC, Okibe FG. Multivariate analysis of the physico-chemical properties of soils
7 in selected locations of the floodplain of River Kaduna in Niger state, Nigeria. Global
8 journal of pure and applied sciences. 2021; 27(3):279-288.
- 9 20. FAO and IIASA. Harmonized world soil database version 2.0. Rome and Laxenburg.2023.
- 10 21. Shrivastava P, Kumar R. Soil Salinity: A serious environmental issue and plant growth
11 promoting bacteria as one of the tools for its alleviation. Saudi journal of biological
12 sciences. 2015; 22(2): 123-131.
- 13 22. FAO (food and agricultural organization). Soil organic carbon: the hidden potential. Food
14 and agricultural organization of the united Nation. Rome, Italy. 2017.
- 15 23. Kinuthia GK, Ngure V, Beti D, Lugalia R, Wangila A, Kamau L. Levels of heavy metals n
16 wastewater and soil samples from open drainage channels in Nairobi, Kenya: community
17 health implication. Scientific reports.2020; 10:8434.
- 18 24. Ebong GA, Moses EA, Akpabio OA, Udombeh RB. Physicochemical properties, total
19 concentration, geochemical fractions and health risks of trace metals in oil-bearing soils
20 of Akwalbom state, Nigeria. Journal of Materials and Environmental Sustainability
21 Research. 2022; 2(4):1-18.
- 22 25. Momoh A, Opuwari M, Osaji EP, Imagbe OL, Ajadi J. Multivariate statistical appraisal of
23 trace elements in shallow groundwater of Keana, Nigeria. Environment Asia. 2020;
24 13(1):67-74.
- 25 26. Zaki Z, Ismail EA, Mohamed WS, Ali AK.Impact of surface water and groundwater
26 pollutions on irrigated soil, El Minia Province, Northern upper Egypt. Journal of water
27 resource and protection. 2015; 7(17).
- 28
- 29
- 30