International Journal of Scientific & Engineering Research Volume 9, Issue 11, November-2018 577
ISSN 2229-5518

ASSESSMENT OF THE QUALITY OF SOIL AT SOME ABANDONED WASTE-DUMP SITES IN AMASSOMA AND ALONG TOMBIA-AMASSOMA ROAD IN BAYELSA STATE

Lewis Igo*, Erepamowei Young** and Timi Tarawou***

*Department of Chemical Sciences, Niger Delta University, Wilberforce Island, P. M. B. 071, Bayelsa State, Nigeria
**Department of Chemical Sciences, Niger Delta University, Wilberforce Island, P. M. B. 071, Bayelsa State, Nigeria
***Department of Chemical Sciences, Niger Delta University, Wilberforce Island, P. M. B. 071, Bayelsa State, Nigeria

** Corresponding author**:** Erepamowei Young; Telephone # +234 (0) 8065591763; E-mail address: erekomu2004@yahoo.co.uk.

Abstract

It is a common practice in Bayelsa State to use abandoned waste dump sites for farming for a host of reasons. However, such dump sites are big reservoirs of heavy metals and heavy metal pollution largely affects the quality of soil for farming activities. Hence, it is of great importance that such sites are assessed for their level of pollution. Soil samples (15 cm depth) were collected from abandoned waste-dump sites in Amassoma and along Tombia-Amassoma Road in Bayelsa State. Samples were analyzed using atomic absorption spectrometer and pollution indices (contamination factor (CF), degrees of ecological risk, potential contamination index, modified degree of contamination, enrichment factor, geo-accumulation index, Nemerow multi-factor value) were computed from concentration values. Concentrations ranged (0.036 mg/kg – 1.874 mg/kg, except Fe), contamination factor (0.881 – 2.764), pollution load index (1.335 – 1.833), ecological risk index (93.84 – 150.80), ecological risk coefficient (0.71 – 120.27), geo-accumulation (0.120 – 1.382), Nemerow multi-factor (0.27 – 4.44), pollution contamination indices (0.29 – 4.34), modified degree indices (1.30 – 2.31), contamination degree indices (10.91 – 13.89), enrichment factor (0.681 – 9.572). Generally, these values indicate that the abandoned waste dump sites are only minimally polluted and may not pose any health threat to man if sites are used for farming activities.

Keywords: Abandoned, Bayelsa, dumpsite, index, pollution, waste

1 INTRODUCTION

ISSN 2229-5518
The rapid industrialization, population and economic development lead to the heavy metals accumulation in sediment through various ways including fertilization, irrigation, rivers run-off, atmospheric deposition, and point sources as a metal mining. Sediments are usually regarded as the ultimate sink for heavy metals discharged into environment **[1],** and can be sensitive indicators for monitoring contaminations in aquatic environments [2]. Therefore the environmental problem of sediment pollution by heavy metals has received increasing attention in the last few decades in both developing and developed countries through the world [3]. Heavy metals occur naturally in the soil environment from the pedogenetic processes of weathering of parent material at trace (<1000mgkg^{-1}) and rarely toxic [4]. Due to the disturbance and acceleration of nutrients slowly occurring geochemical circle of metals by man, most soils of rural and urban environment, may accumulate one or more of heavy metals which are high enough to cause risks to human health, plants, animals , ecosystem or other medium [5]. The heavy metals essentially become contaminants in the soil environment because their rate of generation via man-made cycles rapid relative to natural ones, they become transferred from mines to random environmental location where higher potentials of direct exposure occur; the concentration of the metals in discarded products are relatively high compared to those in the receiving environment, and the chemical (species) in which a metal is found in the receiving environmental system may render it more bioavailable **[5]**. Some of these heavy metals i.e. As, Cd, Hg, Pb, or Se are not essential for plant growth, since they do not perform any known physiological function in plants. Other i.e. Co, Cu, Fe, Mn, Mo, Ni and Zn are essential elements required for normal growth and metabolism of plants, but these elements can be easily lead to poisoning when their concentration is greater than optimal values [6]. The use of compost to improve agricultural yield without caring with possible negative effects might be a problem since the waste composts are most applied to improve soils used to grow vegetables. Considering the edible part of the plant in most vegetable species, the rick of transference of heavy metals from soil to humans should be a matter of concern [7].

Uptake of heavy metals by plants and subsequent accumulation along the food chain is a potential threat to animal and human health. The absorption by plant rots is one of the main routes of entrance of heavy metals in food chain [7].

Heavy metal accumulation in plants depends upon plant species and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil to plant transfer factors of the metals [8]. Heavy metals are potentially toxic and phytoxicity for plants resulting in chlorosis, weak plant growth, yield depression, and may even be accompanied by reduced nutrient uptake, disorders in plant metabolism and reduced ability to fixate molecule nitrogen in leguminous plants [9].

ISSN 2229-5518

Greater quantity of heavy metals in soils has been testified to prevent plant's progress in growth, uptake of nutrients, physiological as well as metabolic processes. This also affects chlorosis, harm to root tips minimized water and uptake of nutrients and impairment to enzymes[9]. Heavy metals, similar to other ecological stressors, also encourage amplified antioxidant enzymes processes in plants [10]. Heavy metal poisonousness is the product of multifaceted interation of chief noxious ions with other vital or non-essential ions. The metals can be a source of decrease in the hydrolysis products viz., α-amylase, phosphatase, RNAs and proteins. This disturbs the enzyme activities by substituting metal in from the metalo-enzymes and prevent various physiological developments of plant [11]. Different rare metals are crucial for plants, showing main roles in plant anabolism, catabolism and biosynthesis, together as cofactors for enzymes and metabolic yields [12]. For example, Zn, Fe, Cu, Cr and Co is critical nutrient which mention above, but conversion to toxic elements at greater amounts. Comparatively, lead (Pb) and cadmium (Cd) have no recognized favorable effects in plants and are solely lethal [13]. The threshold lead level allowed for fruits and small fruits are 0.10 and 0.20 mg/kg respectively [14]. Plants grown in the Zn and Cu-polluted soil store abundant portion of metals in roots [12]. Copper (Cu) is known to be important and poisonous for numerous biological systems. Living organisms require varying amounts of heavy metals. Iron, cobalt, copper, manganese, molybdenum, and zinc are required by humans. **[15]** all metals are toxic in higher concentration. Excessive levels can be demanding to the organism. Other heavy metals such as mercury, plutonium and lead are toxic metals that have no known vital or beneficial effect on organisms and their accumulation over time in the bodies of animals can cause serious illness. Certain elements that are normally toxic are for certain organisms or under certain conditions beneficial.

The aim of this research work was to assess the quality of soil in terms of heavy metal pollution levels for agro-purposes; pollution levels were assessed using pollution indices such as contamination factor (CF), degrees of ecological risk, potential contamination index, modified degree of contamination, enrichment factor, geo-accumulation index, Nemerow multi-factor value.

2 MATERIALS AND METHODS

2.1 Study Area

Yenagoa is geographically located between latitude 4^o47^1 and 5^o11^1 N and Longitude $6^o01^{\ 1}$ and 6^o24^1 and lies within 31 and 32N of World Geodetic System 1984 "WGS84" (Ndiwarri, 2004). The town is located in a humid tropical wetland area with mean annual rainfall of about 2539 mm and an average temperature of 26.2^oC.

2.2 Sampling, sample description, and preparation

2.2.1 Sampling

Three replicates soil samples (20 cm depth) were collected from three abandoned waste dump sites; two from Tombia-Amassoma Road (waste dumpsites 1 and 2) and the other from Amassoma community, all in Yenagoa (Bayelsa State). For each site, a control sample was also collected, a 100 meters away from each ump site. The soil samples were collected in February 2017 at depths of 0 to 20 cm using soil Auger. Samples were put in polyethylene bags, sealed and labeled properly.

2.2.2 Sample description

In most samples, the soil pH fluctuated in the range from 6.13 to 7.84 (Table 1). The percentage organic matter and percentage organic carbon ranged from 2.19 - 7.57, and 2.20 -6.30 for the sites under investigation.

Table 1. pH values of the soil samples from waste dump sites

Sites	1	2	3	Mean
Tombia-Yen.1	7.14	7.10	7.04	7.09
Tombia-Yen.2	6.24	7.84	7.30	7.13
Amassoma	7.04	6.61	7.21	6.95

Measurement of Conductivity

The mean conductivity values ranged between 1.14 to 1.22µScm^{-1} in the soil samples (Table 2).

Table 2. Conductivity (µScm^{-1}) values of the soil from the waste dumps sites

Sites	1	2	3	Mean (µScm^{-1})
Tombia-Yen.1	1.12	1.16	1.14	1.14
Tombia-Yen.2	1.21	1.17	1.24	1.21
Amassoma	1.22	1.26	1.18	1.22

2.2.3 Sample preparation and AAS analysis

Samples were put in polyethylene bags, sealed and labeled properly. The samples were spread out and placed in a designed air-dried special room in the laboratory for two weeks three days (17 days). Then the samples were ground using mortar and pestle in the laboratory and sieved through a 2 mm sieve to get fine powdered samples and stored in plastic cover plate at room temperature.

The soil samples were digested; 2.0 g of sample was mixed with 30 mL of Aqua regia (3:1 of HNO_3: H_2SO_4), heated on a hot plate inside fume cupboard. The digested samples were filtered through Watchman filter paper; the filtrate was diluted with 50 mL of distilled water. The diluted samples were taken for heavy metal determination using Atomic Absorption Spectrophotometer (AAS).

2.3 METHODS OF ASSESSING SOIL QUALITY (POLLUTION INDICES)

In order to assess the pollution levels of soils and sediments, various methods were put forward by different scholars: contamination factor, Potential Ecological Risk Coefficient, Potential Ecological Index, Contamination Degree **"[16], [9]"**; Potential Contamination Index **"[17], [9]**; Modified degree of contamination **"[18], [9]**; Geo-accumulation index **[19]**. Others include The Nemerow multi-factor index and Enrichment Factor. All the indices are fashioned to assess the level of pollution caused by anthropogenic sources. Classification based on contamination factor (CF), degrees of ecological risk, Potential Contamination index, Modified degree of contamination, Enrichment factor are shown in Table 3 and Classification based geo-accumulation index, Nemerow multi-factor value are shown in Table 4.

Table 3. Classification based on contamination factor (CF), degrees of ecological risk, Potential Contamination index, Modified degree of contamination, Enrichment factor

Contamination scale based on contamination factor (CF) value	
CFs value Scale	**Classification**
1 and less	No contamination
1-2.0	Suspected
2-3.5	Slight
3.5-8	Moderate
8-27.0	Severe
27 and above	Extremely
Criteria for degrees of ecological risk cause by heavy metals in sediment	
Ri or E_r^i	**Ecological Pollution degree**
$E_r^i < 40$ or Ri < 150	Low ecological risk for the sediment
$40 \leq E_r^i < 80$ or $150 \leq$ Ri < 300	Moderate ecological risk for the soil
$80 \leq E_r^i < 160$ or $300 \leq$ Ri < 600	Considerable ecological risk for the soil

$160 \leq E_r^i < 320$ or $600 \leq Ri$	Very high ecological risk for the soil

Potential Contamination index value criteria for soil assessment

Grade division	Cp value	**Pollution level**
1	Cp ≤ 1	Low pollution
2	1 < Cp ≤ 3	Moderate pollution
3	Cp > 3	Severe or very severe pollution

Modified degree of contamination

mCd < 1.5	nil to a very low degree of pollution
1.5 ≤ mCd < 2	indicates a low degree of pollution
2 ≤ mCd < 4	indicates a moderate degree of pollution
4 ≤ mCd < 8	indicates a high degree of pollution
8 ≤ mCd < 16	indicates a very high degree of pollution
16 ≤ mCd < 32	indicates an extremely high degree of pollution
mCd ≤ 32	indicates an ultra-high degree of pollution

Level of contaminant based on Enrichment factor (EF) value

EF value	**Contamination degree**
< 1	No enrichment
< 2	Deficiency to minimal enrichment
2-5	Moderate enrichment
5-20	Significant enrichment
20-40	Very high enrichment
>40	Extremely high enrichment

Table 4. Classification based geo-accumulation index, Nemerow multi-factor value

Classification for the geo-accumulation index

Class	**Sediment Quality**
0	Unpolluted
1	From unpolluted to Moderate polluted
2	Moderate polluted
3	From moderate to Strongly polluted
4	Strongly polluted
5	From strongly to extremely polluted
6	Extremely polluted

Classification criteria for Nemerow multi-factor value

Grade division	**Pc**	**Contamination level**	**Contamination degree**
1	Pc ≤ 0.7	Save	Clean
2	0.7 ≤ Pc ≤ 1	Alert	Still clean
3	1 < Pc ≤ 2	light	Soil slightly contaminated;
4	2 < Pc ≤ 3	moderate	Moderately contaminated
5	Pc > 3	Severely	Severely contaminated

ISSN 2229-5518

3 RESULTS AND DISCUSSION

Concentration of Heavy Metals in Tombia/Yenagoa Road Abundant Waste Dumpsite

The mean concentrations of metals in the soil samples are shown in Table 5. Metal concentrations (mg/kg) ranged over the following intervals: Cd, 0.044 - 0.069; Cu, 0.064 - 0.139; Pb, 0.704 - 1.506; Ni, 0.507 - 0.741; Cr, 1.065 - 1.106; Zn, 0.407 - 0.614; Fe, 297.181 - 311.425. The average concentrations of the metals were: Cd, 0.055; Cu, 0.091; Pb, 1.043; Ni, 0.599; Cr, 1.197; Zn, 0.50 and Fe, 304.046, and the trend in these average values follows: **Cr > Pb > Ni > Zn > Cu > Cd.**

The concentration of heavy metals in Tombia-Yenagoa road waste-dumpsite 2

The heavy metal concentrations, ranges and averages in the soil samples are given in Table 5. Metal contents were found in the following ranges, Cd (0.1-0.124 mg/kg), Cu (0.263-0.318 mg/kg), Pb (0.229-0.389 mg /kg), Ni (0.119-0.388 mg /kg), Cr (1.885-2.048 mg/kg), Zn (0.337-0.414 mg/kg), and Fe (229.714-246.136 mg/kg), while mean concentration were 0.110, 0.289, 0.294, 0.366, 1.952, 0.382 and 237.047 mg/kg for Cd, Cu, Pb, Ni, Cr, Zn and Fe respectively. The average concentrations define the following trend: **Cr > Zn > Ni > Pb > Cu > Cd.**

Concentration of Heavy Metals in Amassoma Waste Dump Site

The metal concentrations for each sampling point are shown in Table 5. Metal concentrations ranged over the following intervals: Cd (0.12-0.133 mg/kg); Cu (0.268-0.326 mg/kg); Pb (0.342-0.379 mg/kg); Ni (0.284-0.523 mg/kg); Cr (1.756-1.97 mg/kg) and Zn (1.081- 1.308 mg/kg). The mean concentrations of the metals were 0.125, 0.296, 0.359, 0.435, 1.883 and 1.22 for Cd, Cu, Pb, Ni, Cr and Zn, trending as follows: Cr > Zn > Ni > Pb > Cu > Cd.

Table 5. The concentration of heavy metals in abandoned waste dump sites

Sampling location	**Elements**						
	Cd	Cu	Pb	Ni	Cr	Zn	Fe*
Tombia/Yenagoa waste dump 1							
Max	0.069	0.139	1.506	0.741	1.42	0.614	311.425
Min	0.044	0.064	0.704	0.507	1.065	0.407	297.181

Mean	0.055	0.091	1.043	0.599	1.197	0.5	304.046
Tombia/Yenagoa waste dump 2							
Mean	0.110	0.289	0.294	0.366	1.952	0.382	237.047
Max	0.124	0.318	0.389	0.388	2.048	0.414	246.136
Min	0.100	0.263	0.229	0.119	1.885	0.337	229.714
Amassoma							
Mean	0.125	0.296	0.359	0.435	1.883	1.220	347.884
Max	0.133	0.326	0.379	0.523	1.970	1.308	374.642
Min	0.120	0.268	0.342	0.284	1.756	1.081	327.984

The Concentration of Heavy Metal in Background Study

The heavy metal concentrations for the background study are shown in Table 6. The metal content was found in the following intervals: Cd (0.027-0.04 mg/kg); Cu (0.061-0.109 mg/kg); Pb (0.938-1.239 mg/kg); Ni (0.327-0.459 mg/kg); Cr (0.79-0.99 mg/kg); Zn (0.358-0.68 mg/kg); and Fe (504.448-521.626 mg/kg). The mean background value concentrations were 0.032, 0.092, 1.071, 0.41, 0.907, 0.523 and 514.287 for Cd, Cu, Pb, Ni, Cr, Zn and Fe respectively. The background concentration decreases as follows: Pb > Cr > Zn > Ni > Cu > Cd.

Table 6. The Background concentration

Sampling Point	Elements						
	Cd	Cu	Pb	Ni	Cr	Zn	Fe*
UPL 1	0.03	0.109	0.938	0.327	0.99	0.532	521.626
UPL 2	0.027	0.108	1.036	0.459	0.973	0.68	516.789
UPL 3	0.04	0.061	1.239	0.444	0.76	0.358	504.448
Mean	0.032	0.092	1.071	0.41	0.907	0.523	514.287

Replicates sampling sites: UPL 1, UPL 2, and UPL 3

CONTAMINATION FACTOR

Contamination Factor (CF) In Tombia-Yenagoa Road Abundant Waste Dump Site 1

The average contamination factors of Cd, Ni and Cr, as shown in Table 7, are 1.718, 1.461 and 1.319 respectively, which indicate contamination in the soil of the waste dump site. The average contamination factors of the other elements (Cu, Pb, and Zn) indicate no contamination in the soil. The order of contamination factor of the 6 heavy metals are Cd > Ni > Cr > Cu > Pb > Zn.

Contamination Factor (CF) In Tombia-Yenagoa Road Waste Dump Site 2

Cd has the highest average contamination factor of 3.416 (Table 7), which indicates slight contamination in the soil. Cu and Cr have average values of 3.140 and 2.151 respectively, which indicate slight contamination. The average contamination factors of Ni, Zn, and Pb indicate no contamination in the soil. The order of contamination factors is: Cd > Zn > Cu > Cr > Ni > Pb

Contamination Factor (CF) In Amassoma Waste Dump Site

The highest average value of the contamination factor is 4.604 in Cd (Table 7), which indicates moderate contamination, Cu has an average value of 3.220, which indicates slight contamination, Zn and Cr have the values of 2.333 and 2.076 respectively, which indicate slight contamination. Ni has the value of 1.06, which indicates suspected contamination in the soil; Pb has a value of 0

Table 7. The contamination factor (CF) in abandoned waste dump sites

Sampling Point	**Elements**					
	Cd	Cu	Pb	Ni	Cr	Zn
Tombia-Yenagoa 1						
Mean	1.718	0.989	0.973	1.461	1.319	0.956
Tombia-Yenagoa 2						
Mean	3.416	3.14	0.274	0.893	2.151	0.729
Amassoma						
Mean	4.604	3.220	0.335	1.060	2.076	2.333

POLLUTION LOAD INDEX

Pollution Load index in Tombia-Yenagoa road side abundance open waste dump side 1

A pollution load index (PLI) value higher than 1, indicates pollution, while a PLI value less than 1 indicates no pollution. Based on Table 8 on Tombia-Yenagoa road abandoned open waste dump site 1, value range of 1.06 to 1.33 on different sampling points with the average of 1.24, indicates that pollution has occurred on the soil.

Pollution Load index in Tombia-Yenagoa road open waste dump site 2

The PLI values in Table 8 ranged from 1.045 to 1.341 and with an average of 1.22, indicating that the soil is polluted.

Pollution Load Index in Amassoma Waste Dump Site

The calculated PLI values are shown in Table 8. The values are higher than 1, indicating pollution on Amassoma dump site.

Table 8. Pollution Load indices in abandoned waste dump sites

Sampling Point	Element Cd	Cu	Pb	Ni	Cr	Zn	PLI	Pollution evaluation
Tombia-Yenagoa road abundance open waste dump site 1								
PL1	1.593	1.510	1.406	1.236	1.219	1.174	1.33	polluted
PL2	2.156	0.657	0.657	1.807	1.174	0.917	1.33	polluted
PL3	1.375	0.760	0.857	1.341	1.565	0.917	1.06	polluted
Tombia-Yenagoa road open waste dump site 2								
TY 1	3.25	2.858	0.363	0.29	2.078	0.644	1.045	Polluted
TY 2	3.125	3.108	0.246	1.443	2.257	0.753	1.341	Polluted
TY 3	3.875	3.456	0.213	0.946	2.12	0.791	1.284	Polluted
Amassoma waste dump site								
AM1	3.75	3.543	0.334	1.214	2.121	2.066	1.69	Polluted
AM2	4.156	3.206	0.353	1.275	1.936	2.434	1.741	Polluted
AM3	5.906	2.913	0.319	0.692	2.171	2.5	1.652	Polluted

Replicates sampling sites of Amassoma-Tombia Road abandoned waste dump sites 1: PL 1, PL2, and PL 3; replicates sampling sites of Amassoma-Tombia Road abandoned waste dump sites 2: TY1 1, TY 2, and TY 3; Replicates sampling sites of Amassoma abandoned waste dump sites : AM 1, AM 2, and AM 3

POTENTIAL ECOLOGICAL RISK COEFFICIENT AND POTENTIAL ECOLOGICAL INDEX

Heavy metal Potential Ecological Risk coefficient and Potential Ecological Index in Tombia-Yenagoa abandoned open waste dump site

The potential ecological risk (R_i) posed by heavy metals in soil was estimated by using the method developed by (**Hakanson 1980**). The criteria for assessment is tabulated in Table 3. The calculated average ecological risk coefficient (E_r^i) for Cd was 51.21 (Table 9), which is higher than 40, indicating moderate ecological risk level. The E_r^i of Cu, Pb, Ni, Cr and Zn are 15.67, 1.36, 4.46, 4.30 and 0.72 indicating no ecological risk to the soil.

Heavy metal Potential Ecological Risk Coefficient (E_r^i) and Potential Ecological Index in Tombia-Yenagoa road open waste dump site 2

The potential ecological risk coefficient (E_r^i), for Tombia-Yenagoa road open waste dump site 2 is given in Table 9. Cd has an average value of 102.50, indicating a considerable ecological risk for the soil. Cu, Pb, Ni, Cr, and Zn have average values of 15.67, 1.36, 4.46, 4.30 and 0.72 respectively, indicating no ecological risk to the soil. The potential ecological index for the Tombia-Yenagoa open waste dump site 2 of heavy metals was 129.03 indicating a low ecological risk in the soil.

Heavy Metal Potential Ecological Risk Coefficient (E_r^i) and Potential Ecological Index in Amassoma Waste Dump

The potential ecological risk coefficient were found in the following order; Cr > Cu > Ni > Cr > Zn > Pb (Table 9). The E_r^i, average value of Cd was 138.12, indicating considerable ecological risk level in the dump site. The E_r^i, average value for Cu, Ni, Cr, Pb and Zn were 16.10, 5.30, 4.15, 2.33 and 1.67 respectively indicating low ecological (see risk classification in Table 3). The R_i value in AM 1 sampling point is 14.25 (low ecological risk), but R_i have an average value of 167.67 in the soil waste dump, which indicates moderate ecological risk level.

Table 9: Heavy metal Potential Ecological Risk coefficient and Potential Ecological Index in abandoned waste dump sites

Sampling Point	E_r^i						**Ri**
	Cd	Cu	Pb	Ni	Cr	Zn	
Tombia-Yenagoa 1							
Mean	51.21	4.67	4.86	7.27	2.63	0.956	71.61
Tombia-Yenagoa 2							
Mean	102.50	15.67	1.36	4.46	4.30	0.72	129.03
Amassoma							
Mean	138.12	16.10	1.67	5.30	4.15	2.33	167.67

GEO-ACCUMULATION INDEX, I_{geo}

Geo-Accumulation Index in Tombia-Yenagoa Road Abandoned Open Waste Dump Site

The geo-accumulation index is classified in seven classes from unpolluted to extremely pollute (Table 10). The result of the geo-accumulation index (I_{geo}) studies are shown in Tables 10. The value of geo-accumulation

ISSN 2229-5518
index of Cd in sampling points PL1 and PL2 ranged from 0.087 - 0.523 showing that the soils were polluted to moderately polluted. The I_{geo} for Cd was negative; showing unpollution. The values for Cu, Pb, Ni, Cr, and Zn were found negative indicating unpolluted soil.

Geo-Accumulation Index in Tombia-Yenagoa Road Waste Dump Site 2

The results of the geo-accumulation index study of Tombia-Yenagoa road waste dump site 2 are shown in Table 10. The geo-accumulation index for Cd ranged from 1.058 -1.369 with an average value of 1.181 indicating the soil can be classified unpolluted to moderately polluted. The soil is either unpolluted or moderately polluted with Cu because Cu has an average geo-accumulation index of 1.061. The average geo-accumulation indices for Pb, Ni, and Zn were found to be negative (-1.031 to -2.447); indicating un-pollution. The average geo-accumulation index for Cr were found to be 0.519, indicating un-pollution to minimal pollution.

Geo-Accumulation Index in Amassoma Waste Dump Site

The average geo-accumulation index values of Cd, Cu, Cr and Zn were 1.387, 1.098, 0.467 and 0.633 respectively (Table 10), indicating that the soil is unpolluted or minimally polluted with these metals. The values of Pb and Ni are less than 0, meaning the soil is not polluted with these metals.

Table 10. Geo-accumulation index in abandoned waste dump sites

Sampling Point	**Igeo**					
	Cd	Cu	Pb	Ni	Cr	Zn
Tombia-Yenagoa 1 mean	0.161	- 0.692	- 0.697	- 0.057	- 0.237	- 0.670
Tombia-Yenagoa 2 Mean	1.181	1.061	- 2.447	- 1.031	0.519	- 1.045
Amassoma Mean	1.387	1.098	- 2.159	- 0.550	0.467	0.633

NEMEROW MULTI-FACTOR VALUE

Nemerow Multi-Factor Value For Tombia-Yenagoa Road Abandoned Waste Dump Site

Nemerow Multi-factor values for Tombia-Yenagoa road abandoned waste dump site are shown in Table 11. The average Nemerow-multifactor is 1.46 and shows that the soil is only lightly polluted. The soil is lightly polluted with respect to all six metals except Zn, which shows no pollution level (Nemerow Multi-factor value of 1.07).

Nemerow Multi-Factor Value For Tombia-Yenagoa Road Waste Dump Site 2

The Nemerow multifactors tabulated in Table 11 shows that the soil collected from Tombia-Yenagoa road waste dump site 2 is severely contaminated with Cd, Cu; moderately contaminated with Cr; and slightly contaminated with Ni. The Nemerow multifactors shows that the soil is contaminated with Pb at save level and Zn at alert level. The average Nemerow multifactor of 1.90 indicates light pollution of the soil.

Nemerow Multi-Factor Values For Amassoma Waste Dump Site

The P_C values in Table 11 show that the soil from Amassoma dump site is seriously contaminated with Cd (P_C, 5.29) and Cu (P_C, 3.38); moderately contaminated with Zn (P_C, 2.41) and Cr (P_C, 2.12); slightly contaminated with Ni (P_C, 1.17). Contamination is at save level with Pb (P_C, 0.34). The overall average value of P_C in the Amassoma waste dump soil is 2.45, which shows that it is moderately contaminated.

Table 11.Nemerow Multi-factor values in abandoned waste dump sites

Elements	Pc	Contamination level	Contamination degree
Tombia-Yenagoa road waste dump site 1			
Cd	1.94	Lightly Polluted	Slightly Contaminated
Cu	1.28	Lightly Polluted	Slightly Contaminated
Pb	1.21	Lightly Polluted	Slightly Contaminated
Ni	1.64	Lightly Polluted	Slightly Contaminated
Cr	1.45	Lightly Polluted	Slightly Contaminated
Zn	1.07	alert	Still clean
Average	1.43	Lightly Polluted	Slightly Contaminated
Tombia-Yenagoa road waste dump site 2			
Cd	3.65	Severely	Severely contaminated
Cu	3.30	Severely Contaminated	Severely Contaminated
Pb	0.32	Save	Clean
Ni	1.19	Light contamination	Soil slightly contaminated;

Cr	2.20	Moderate	Moderate contaminated
Zn	0.76	Alert	Still clean
Average	1.90	Light	Slightly
Amassoma waste dump sites			
Cd	5.29	Severe	Seriously contaminated
Cu	3.38	Severe	Seriously contaminated
Pb	0.34	Save	Clean
Ni	1.17	light	Slightly contaminated
Cr	2.12	Moderate	Soil Moderately contaminated
Zn	2.41	Moderate	Soil moderately contaminated
Average	2.45	Moderate	Soil moderately contaminated

POLLUTION CONTAMINATION INDEX, Cp

Pollution Contamination Index in Tombia-Yenagoa Road Abandoned Waste Dump Site

The pollution contamination indices, Cp for heavy metals in the Tombia-Yenagoa road abandoned waste dump site are given in Table 12. The values show that the soil is moderately polluted with Cd (Cp, 2.16), Ni (Cp,1.81), Cr (Cp,1.57) and Cu (Cp,1.51); and the values for Zn (Cp,1.17) and Pb (Cp,1.41) show low pollution level. However, the order of contamination indices for the 6 heavy metals is; Cu > Cd > Cr > Ni > Zn > Pb. According to the overall assessment result, the comprehensive pollution contamination index of soil heavy metal at Tombia-Yenagoa road abandoned waste site was 1.61, indicating a low level of pollution..

Pollution Contamination Index in Tombia-Yenagoa Road Waste Dump Site 2

The overall assessment result for the pollution contamination index on the surface soil show an average value of 2.02 (Table 12), indicating a moderate pollution. For individual heavy metals, the soil is severely polluted with Cd (Cp, 3.87) and Cu (Cp, 3.45); moderately polluted with Cr (Cp, 2.25) and Ni (Cp, 1.44), but the Cp values of Pb (Cp, 0.36) and Zn (Cp, 0.79) show no pollution with these metals. The order of pollution contamination indices is: Cd > Cu > Cr > Ni > Zn > Pb.

Pollution Contamination Index in Amassoma Waste Dump

The pollution contamination index assessment of metals in Amassoma waste dump site showed an average value of 2.33 (Table 12), indicating moderate level of pollution. For individual metals, the site is severely

ISSN 2229-5518
polluted with Cd and Cu with Cp values of 4.15 and 3.54 respectively; moderately polluted with Zn (Cp, 2.54), Cr (Cp, 2.17) with Cp values falling between this range, $1 < Cp \leq 3$. Soil is not polluted with Pb (0.35) while polluted with Ni at low level. The order of pollution is: Cd > Cu > Zn > Cr > Ni > Pb.

Table 12.Pollution Contamination indices in abandoned waste dump sites

Elements	Cp value	Pollution level
Tombia-Yenagoa road waste dump site 1		
Cd	2.16	Moderate pollution
Cu	1.51	Moderate pollution
Pb	1.41	Low pollution
Ni	1.81	Moderate pollution
Cr	1.57	Moderate pollution
Zn	1.17	Low pollution
Average	1.61	Moderate pollution
Tombia-Yenagoa road waste dump site 2		
Cd	3.87	Severe pollution
Cu	3.45	Severe pollution
Pb	0.36	Not polluted
Ni	1.44	Moderate pollution
Cr	2.25	Moderate pollution
Zn	0.79	Not polluted
Average	2.02	Moderate pollution
Amassoma Road waste dump site		
Cd	4.15	Severe / very severe pollution
Cu	3.54	Severe pollution
Pb	0.35	Not polluted
Ni	1.27	Low pollution
Cr	2.17	Moderate pollution
Zn	2.50	Moderate pollution
Average	2.33	Moderate pollution

Table 13. The Concentration of the Elements

Elements:	Cd	Cu	Pb	Ni	Cr	Zn
Max.	0.069	0.139	1.506	0.741	1.420	0.614
reference	0.032	0.092	1.071	0.410	0.907	0.523

ISSN 2229-5518

MODIFIED DEGREES OF CONTAMINATION (mCdi) AND CONTAMINATION DEGREE INDEX (Cdi)

The modified degrees of contamination and contamination degree index values for heavy metals in the sites under investigation are given in Table 14.

Modified Degrees of Contamination And Contamination Degree Index In Tombia-Yenagoa Road Abandoned Open Waste Dump Site

The study results for Tombia-Yenagoa road abandoned open waste dump site are given in Table 14. The Cdi values varied from 6.67 to 8.13 with an average value of 7.4, indicating that the site is moderately polluted. The mCdi values of the metals (Cd, Cu, Pb, Ni, Cr and Zn) vary from 1.11 to 1.36 with an average 1.23, representing a low degree of pollution to no pollution of the site.

Modified Degree of Contamination and Contamination Degree Index in Tombia-Yenagoa Road Waste Dump Site 2

The Cdi values of metals in Tombia-Yenagoa road waste dump site 2 varied from 9.48 to 11.40 (Table 14) with an average value of 10.60 representing moderate pollution of the site while the mCdi varied from 1.58 to 1.90 with an average of 1.77, representing low degree of pollution.

Modified Degree of Contamination and Contamination Degree Index in Amassoma Waste Dump Site

The contamination degree index value shown in Table 14 varies from 13.02 to 14.50 with an average value of 13.62, indicating that the site is polluted considerably. The modified degree of contamination index for all the metals (Cd, Cu, Pb, Ni, Cr and Zn) varied from 2.17 to 2.41 with an average value of 2.26, indicating a moderate degree of pollution of the soil due to anthropogenic source.

Table 14. Modified degree of contamination and contamination degree index in abandoned waste dump sites

Sampling Point	**Element**						**Cdi**	**mCdi**
	Cd	Cu	Pb	Ni	Cr	Zn		
Tombia-Yenagoa road waste dump site 1								

PL 1	1.592	1.510	1.406	1.236	1.219	1.174	8.13	1.36
PL 2	2.156	0.695	0.657	1.807	1.174	0.917	7.40	1.23
PL 3	1.375	0.760	0.857	1.341	1.565	0.778	6.67	1.11
Tombia-Yenagoa road waste dump site 2								
TY 1	3.25	2.85	0.36	0.29	2.07	0.64	9.48	1.58
TY 2	3.12	3.10	0.24	1.44	2.25	0.75	10.93	1.82
TY 3	3.87	3.45	0.21	0.94	2.12	0.79	11.40	1.90
Amassoma Road waste dump site								
AM 1	3.75	3.54	0.33	1.21	2.12	2.06	13.02	2.17
AM 2	4.15	3.20	0.35	1.27	1.93	2.43	13.36	2.22
AM 3	5.90	2.91	0.31	0.69	2.17	2.50	14.50	2.41

Replicates sampling sites of Amassoma-Tombia Road abandoned waste dump sites 1: PL 1, PL2, and PL 3; replicates sampling sites of Amassoma-Tombia Road abandoned waste dump sites 2: TY1 1, TY 2, and TY 3; Replicates sampling sites of Amassoma abandoned waste dump sites : AM 1, AM 2, and AM 3

ENRICHMENT FACTOR, EF

Enrichment Factor in Tombia-Yenagoa Road Abandoned Waste Dump Site

The results showed that the average EF values of Cd, Cu, Pb, Ni, and Zn were 2.895, 1.683, 1.656, 2.465, 2.201 and 1.621, respectively; the enrichment factors decreases from Cd to Zn as follows: Cd > Ni > Cr > Cu > Pb > Zn (Table 15). The mean EF values of Cd, Ni and Cr were greater than 2, suggesting relatively moderate enrichment. However, the mean EF values of Cu, Pb and Zn were higher than 1.5, but less than 2, showing deficient to minimal enrichment.

Enrichment Factor in Tombia-Yenagoa Road Waste Dump Site 2

The enrichment factors for the heavy metals of interest follows this pattern, Cd > Cu > Cr > Ni > Zn > Pb as it is evident in their average enrichment factors: Cd, 7.435; Cu, 6.826; Cr, 4.660; Ni, 1.922; Zn, 1.583; and Pb, 0.594 (Table 15). The values show that the soil is significantly enriched with Cd and Cu (EF values greater than 5); soil is moderately enriched with Cr; deficiently

Enrichment Factor in Amassoma Waste Dump Site

The average EF values of Cd, Cu, Pb, Ni, Cr and Zn in Amassoma waste dump site were 5.830, 4.755, 0.497, 1.558, 3.078 and 3.476 respectively (Table 15), indicating that the soil is not enriched with Pb; significantly enriched with Cd; moderately enriched with Cu, Cr and Zn; minimally enriched with Ni. The order of EF is: Cd > Cu > Zn > Cr > Ni > Pb.

Table 15. Enrichment factor in abandoned waste dump sites

Sample	EF					
Point	Cd	Cu	Pb	Ni	Cr	Zn
Tombia-Yenagoa 1						
Mean	2.895	1.683	1.656	2.465	2.201	1.621
Tombia-Yenagoa 2						
Mean	7.435	6.826	0.594	1.922	4.660	1.583
Amassoma						
Mean	5.830	4.755	0.497	1.558	3.07 8	3.476

4 Conclusion

The abandoned wastes dump sites (Tombia-Yen 1, Tombia-Yen 2, and Amassoma) under investigation are safe lands for agricultural activities: Although the concentrations of Cd, Cu, Pb, Ni, Cr, and Fe were above the background levels indicating pollution but below the soil environmental quality standard and USEPA guide line; the pollution indices (contamination factor, pollution load index, ecological risks, modified degree of contamination and contamination degree index, enrichment factor, and geo-accumulation) generally show minimal to moderate pollution, consistent with the level of industrialization in the state.

References

[1] Banat K.M., Howari F.M., and Al-Hamad A.A. (2005). Heavy metals in urban soils of Central Jordan: Should we worry about their environmental risk? *Environmental Research*, *97*: 258 - 273.

[2] Pekey H,. Karakas D., Ayberk S., Tolun L., Bakoglu M (2004). Ecological risk assessment using trace elements from surface sediments of Izmit Bay (Northeastern Marmara Sea), Turkey. *Marin Pollution Bulletin*, 48: 946 -953.

[3] Zhang L.P., Ye X., Liang R., Feng H., Jing Y., Ouyang T., Yu X., Gao CH., Chen C (2007) Heavy metal contamination in western Xiamen Bay sediments and its Vicinity, China. *Marine Pollution Bulletin*, 54 (7): 974 - 982.

[4] Kabata-Pendias A and Hendia (2001). Trace elements in soils and plants. 3rd Edition, CRC Press. Boca Raton, Florida, USA, P. 413.

[5] Amore D' J.J., Ai-Abed S.R., Scheckel K.G and Ryan J.A. (2005). Methods for speciation of metals in soils: a review, "*Journal of Environmental Quality, 34* (*5)*:1705 - 1745.

[6] Rascio N, Navari-Izzo F (2011) Heavy metal hyper-accumulating plants; how and what do they do it? And what makes them so interesting? Plant Sci. (Shannon Ireland), 180: 160 - 180.

[7] Jordao CP, Fialho LL, Neves JCL, Cecon PR, Mendonca ES and Fontes RLF (2007). Reduction of heavy metal contents in Liquid effluents by vermicomposts and the use of the metal-enriched vermicomposts in lettuce cultivation. *Bioresource Technology*. 98 (15): 2800 - 2813.

[8] Khan S, Cao O, Zheng Y.M, Huang Y.Z, and Zhu Y.G (2008). Health risk of heavy metals in contaminated soil and food crops irrigated with waste water in Beijing, China. Environmental Pollution Series, 152 9 (3): 686 - 692.

[9] Maanan M., Saddik M., Chaibi M., Assobhei O., Zourarah B (2014). Environmental and ecological risk assessment of heavy metals in sediments of Nador lagoon, Morocco. *Ecological Indicators, 48*: 616 - 626.

[10] Lannelli M.A., Pietrini F., Flore L, Patrilli L., Massaci A. (2002). Antioxidant response to cadmium in phragmitessau. Australia plants. *Plants Physiology and Biochemistry,* 40 (11): 977 - 982.

[11] Xue X., Xinwei L., Xiufeng H., Zhao N, (2015). Ecological and health risk assessment of metal in re-suspended particles in urban street dust from an industrial city in china. *Research articles*, 108(1): 72 - 79.

[12] Rattan R.K, Dalta S.P, Chhonka P.K, Suribabu K and Singh A.K (2005). Long-term impact of irrigation with waste water effluents on heavy metals content in soils, crops and groundwater: a case study. *Agr. Ecosyst. Environ*. 109: 310 - 322.

[13] Mohamed N, Abdel M.H (2016) Assessment of metals contamination and ecological risk in AIT Ammar abandoned iron mine soil, Morocco. De Gruyter Open. 35 (1): 32-49.

[14] EC (2006). Commission of the European communities. Commission regulation (EC). *No.1881/2006*. Regulation of setting maximum levels for certain contaminant in foodstuffs. Official J. European Union L346-5/L364-24.

[15] Riyad Al-Anbari, Abdul Hameed M.J., Obaidy A., Fatima H., Ali A. (2015). Pollution loads and ecological risk assessment of heavy metals in the urban soil affected by various anthropogenic activities. *International Journal of Advanced Research,* 3 (2): 104 - 110.

[16] Hakanson L. (1980). An ecological risk index for aquatic pollution control, a

sedimentological approach. *Water Research*. 14: 975 - 1001.

[17] Dauvalter V. and Rognerud S. (2011). Heavy metal pollution in sediments of the Pasvik River drainage. *Chemosphere*, 42: 9 - 18.

[18] Abrahim G.M.S and Parker R.J (2008). Assessment of heavy metals enrichment factor and the degree of contamination in marine sediments from Tamaki Estuary, Auckland, New Zealand. *Environ. Monit. Assess*. 136: 227 - 238.

[19] Taylor S.R and Mclennan S.M (1995). The geochemical evolution of the continental crust. Rev. Geophys., 33, 241 - 265.