Global Scientific JOURNALS

GSJ: Volume 12, Issue 3, March 2024, Online: ISSN 2320-9186

www.globalscientificjournal.com

Assessment of Spatial Levels of Organic and Inorganic Toxins Associated with Municipal Solid Waste (Including; Bacteria, Fungi and Coliforms) In Bayelsa State

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Abstract

The soil toxicity of municipal solid wastes (MSWs) have become a threat to the ecosystem and public health. Both organic and inorganic toxicants of top soil (0 – 15 cm) and Sub soil (15 - 30cm) associated with MSW were assessed in Bayelsa State using Standard methods. Inorganic toxicants (Heavy Metals) were assessed using Atomic Absorption Spectrophotometer (AAS). Organic contaminants like bacterial and fungal count were assessed using standard aerobic pour plate technique, while coliforms were assessed using Most Probable Number (MPN) Technique. Results on the spatial and temporal average levels of heavy metals showed that besides Copper (Cu) and Lead (Pb), other heavy metals like; Arsenic (As), Cadmium (Cd), Chromium (Cr), Mercury (Hg) were either very low or below detection limit (<0.001 mg/kg). Average levels of total bacterial counts were in the range of; 4.562 – 8.403 x 10^5 cfu/g for top soil, and 3.939 – 7.183 x 10^5 cfu/g for subsoil. Fungal counts ranged from 4.006 – 5.918 x 10^3 cfu/g for top soil, and 3.733 – 5.482 x 10^3 cfu/g for subsoil. I therefore recommend that government and stakeholders should adopt policies to treat, reduce, reuse and recycle waste, as well as ensure effective legislation to minimize the health risk associate with waste.

KEYWORDS: Soil Toxicity, Organic Compound, Inorganic Compound.

1.0 Introduction

According to the United States Environmental Protection Agency (USEPA, 2012) constituents or characters of Municipal Solid Wastes (MSWs) are plastic, paper, vegetable matter, rubber, textile, bottles, appliances, paint, batteries and metals. The problems posed by improper and ineffective management of Municipal Solid wastes (WSWs) has become an issue of global concern over the past decades. The incidence of adequate management of wastes has infringed on vital environmental constituents; such as air, water and especially soil quality, which are toxicants. In Agricultural, soil provides food, fiber and fuel, and at the same time, interacts with other environmental media, supports biodiversity and protects cultural heritage (Chatterjee, 2011; Asthana & Asthana, 2010). It also acts as a biochemical or nutrient reactor which absorbs releases or transforms anthropogenic compounds like pesticides, heavy metals and other numerous compounds (USDA, & NRCCA, 2010).

Waste is seen as any substance to be discarded, due to their invaluable importance or possibly deleterious effects to the environment or human health (Angaye, Konmeze, Obodo & Ubi, 2019). It is something for which we have no further use and which we wish to get rid of (Douglas 1992; Barrow, 1993); or as any damaged, defective or superfluous materials that may end up being hazardous (Barrow, 1993). It can be defined as an unwanted or underserved materials or substances (Olayiwola, 2006). It is also referred to as rubbish, trash, garbage or junk depending upon the type of material and the regional terminology. Ogunyi and Folasade (2003) defined wastes as an unwanted material or substance that is no longer required as such it is discarded. However, it can exist in gaseous, liquid and most abundantly in solid forms. Nevertheless, United Nations Environmental programme, define wastes as substance of no further use for consumption, application, production and transformation (UNEP, 2006). This means substance or material of no economic value and is as well no more important for human use.

Of recent, man has been ravaged by plagues and epidemic visited on him by soil degradation, poor environmental sanitation, contamination/pollution of water, air and land, water eutrophication and low agricultural productivity; sequel to soil toxicants associated with municipal solid wastes indiscriminately dumped on soil. There is no doubt that, the need to drastically prevent pollution, soil degradation, low agricultural productivity, extinction of essential microorganisms and maintenance of environmental sanitation at stemming rate is at decline in our environment today. The inhabitants of Bayelsa state, whose state Capital is Yenagoa, South South of the Niger Delta, Nigeria, have for years live with this menace of indiscriminate dumping of municipal solid wastes on soil and with a conceptual thinking, that it is normal, as they pay no attention on the ecological or environmental degradation. There is no doubt also, that soil toxicity is as a result of indiscriminate dumping of municipal wastes on soil without proper management. Even scavengers who tend to make livelihood out of municipal solid wastes are still engaged in informal wastes management; which process of waste collection and recycling networks is backward, unhygienic and generally incompatible with modern management system.

2.0 Materials and Methods

a. Management of Waste and Toxins

Apart from other strategies employed for the disposal of municipal solid wastes in developing nations, the conventional application of sanitary landfill is however, below global standard (Nartey, Hayford & Ametsi, 2012; Mangizvo, 2010; Adewole, 2009). The indiscriminate dumping of municipal solid waste without adequate management, resulting to environmental pollution is a burning topic of the day. The soil which is the universal sink bears the greatest burden (Muhammad, Maah & Ismail, 2014).

Anthropogenic activities from homes, industries, hospitals, school, markets, manufacturing industries, construction firms, Agricultural farms, cooking recreation and business areas are the most source of MSW pollutants or toxicants on soil and living organisms (Ahove *et al.*, 2006; Lamb, Ming, Megharaj & Naidu, 2009). The Chemical, Physical and Biological transformation of these wastes over a period of time form toxic substance like leachate and other toxicants impair the components of the ecosystem such as water, air and especially soil (Al sabahi, Rahim, Wan Zuhairi, Al Nozaily and Alshaebi, 2009; Oyelami, Aladejana & Agbede, 2013). When toxicants impair on soil, it alter the ecosystem, because soil is the easiest media of pollution. Some microorganisms are of great importance to the soil ecosystem, as they render services such as soil aggregation; improve soil structure, recycling of soil nutrients, formation of soil, decomposing of organic residues, water recycling etc. When toxicants or pollutants are allowed to depletes the soil, such soil loses its fertility and value which is the index of the wealth of a nation (Usman, Kundiri & Nzamouhe, 2017; Usman, Muhammad & Chiroman, 2016; Usman & Kundiri, 2016; Brady & Weil, 2017; Li, Ma, Van der Kuip, Yuan, & Huang, 2014; Coleman, 2005; Castro, Lopez de Romafia, Bedregal & Chirinos, 2013; Castro & Chirinos, 2016).

b. Municipal Solid Wastes Dumpsites in Bayelsa State

Dumpsites according to Ahove *et al.,* (2006) is a land arena where Municipal Solid Wastes generated are dumped and allowed opened without care or concern for soil and water pollution effects, control of scavengers, air pollution, nature and environmental beauty as well as diseases. From the above definition, it is also an open area of land, deposited with solid waste materials or by-products produced as a result of anthropogenic activities and left unsafe with no recourse to environmental pollution and effect on flora fauna, land, water, air and human.

The inhabitants of Bayelsa State and the society at large takes the advantage of its simplest, limited time and cheap to operate in disposing Municipal Solid Waste (MSW) indiscriminately on land, not taking into cognizance that, the leachate from these dumpsites contaminate soil, surface and groundwater, causes vector-borne diseases, air pollution, causes soil toxicants such as pathogenic micro-organisms and Heavy metals; which affects soil, flora fauna, human, air pollution and water eutrophication. Generated Municipal Solid Waste (MSW) transported to dumpsite or open dumpsite stations comprise of both biodegradable and non-biodegradable materials base on their physical, chemical and biological proportions as well as their nature of existence.

The biodegradable materials are domestic sewage and natural organic compound materials that can get decompose by decomposer or saprotrophs such as bacteria, fungi, warms etc; the decomposers and scavengers breakdown dead plants and animals, they also breakdown the wastes (poops) of organisms. Decomposers are very important for any ecosystem because if they were not in the ecosystem the plants would not get essential nutrients and dead matters to feed on and these open wastes dumpsites would have piled up (Ahove, 2006).

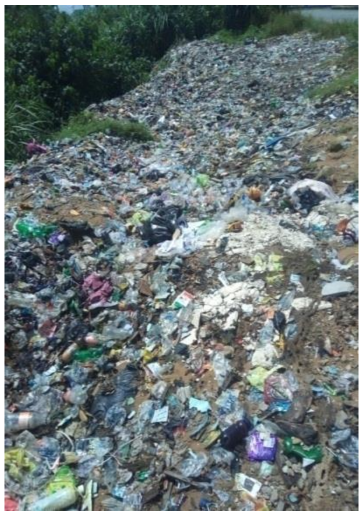
These types of wastes are produced in food processing units, cotton Mills, paper mill, sugar mills, textile factories and sewage of slaughter houses; Such as food, paper, human waste, manure, sewage, sewage sludge, death animal, death plants etc. The biological process of decomposers and scavengers on these dumpsites enable biodegradable materials to be recycled and use as organic manure. Though, most of the wastes from these industries are reused but when these wastes are in excess or above threshold they act as pollutants and they take much time for decomposition.

Non-Biodegradable materials are wastes materials that do not degrade easily. Natural agent or organisms does not decompose them easily upon their action. As the name implies non-degradable, these wastes stays for several years without decomposition. These wastes are not environmentally friendly as they hardly decompose or dissolve. They are dangerous to human health, soil, flora fauna, water and air. Example of these wastes are bottles, cans, plastics, irons, steel, metals, leather etc., with pollutants such as Mercury Hg, Arsenic As, Lead Pb, Copper Cu, Nickel Ni, Cadmium Cd, Chromium Cr and Iron Fe, Aluminum Al, Mercury Hg, Sodium Na, Silver Ag, Gold Au etc as well as other chemicals that react and release chemicals into the soil thereby contaminating it by hydrological cycle of solution, solvent and chemical (Asthana and Asthana, 2010; Partha, Murthya, Saxena, 2011),

The excessive generation of Municipal Solid Waste (MSW) stream attributes to inadequate management of waste disposal leading to indiscriminate dumping of solid wastes on soil. Gandy, (1994) and Gandy, (1993) attributes excessive waste generation as a result of cheaper consumer products, demand for convenience products, proliferation of packaging and pattern of taste. The modification of the natural environment is also a factor, when natural environment which is untampered and there is insignificant change or human alteration and is tampered with; without impact assessment in building of homes, companies, industries, infrastructural facilities etc., more wastes are generated.

These wastes are not only generated and dumped at the preferred temporal dumpsites if any, for onward transportation to permanent dumpsites as at when due or adequately but littered on the streets and roads across Bayelsa State, which has practically blocked the streets and roads thereby defacing the aesthetics environment of the State. Below are open dumpsites in Bayelsa State in Plate 2.1.

Yenagoa Metropolis Wastes Dump Site, Yenagoa LGA



Amassoma Town Wastes Dump Site Southern Ijaw LGA

Nembe-Bassambiri Wastes Dump Site Nembe LGA

Ogbia Town Wastes Dump Site Ogbia LGA

Twon-Brass Town Wastes Dump Site, Brass LGA

Ekeremour Town Wastes Dump Site, Ekeremour LGA

Kaiama Town Wastes Dump Site Kolokuma/Opokuma LGA

Sagbama Wastes Dump Site Sagbama LGA

Plate 2.1: Photographs of spatial distributionof wastes dumpsites across the Local Governments in the Study area

3.0 Study Area

The study area is located in Bayelsa State, covering the three (3) Senatoral Districts, namely; Bayelsa Central (Yenagoa / Southern Ijaw & Kolokuma Opokuma LGA), Bayelsa East (Ogbia / Nembe & Brass LGA) and Bayelsa West (Sagbama & Ekeremor LGA). The study areas comprise of dumpsites in the six (6) Local Government Areas (Figure 3.1). The State is located in the Southern part of Nigeria, covers 21, 100 square kilometers with its Capital at Yenagoa. It is bounded by Delta State on the North, Rivers State on the East and Atlantic Ocean on the West and Southern axis of the Niger Delta, Nigeria.

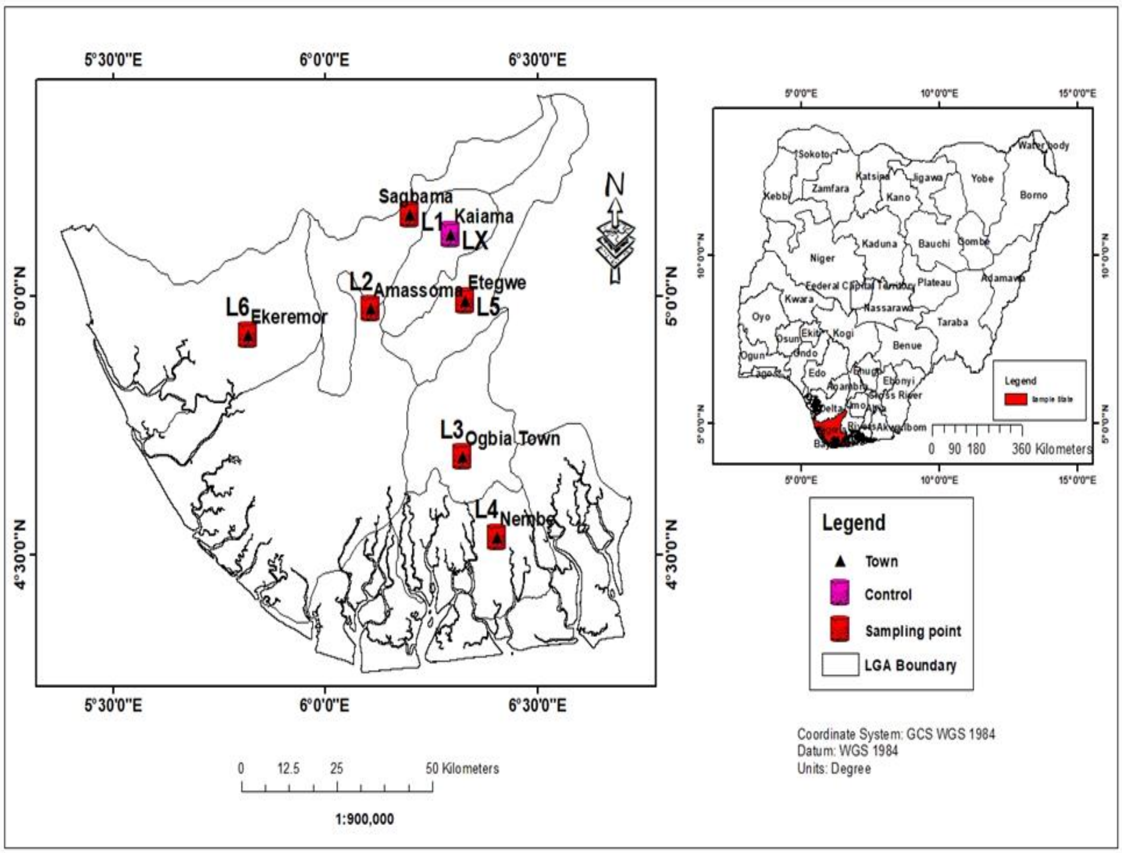


Figure 3.1: Location of Research Study

4.0 Results

Spatial levels of organic and inorganic toxins

The spatial level of concentrations of organic and inorganic toxins in the soil regarding the top soil (0-15cm) and sub soil (15-30cm) is displayed in Table 4.1.

Generally, result on the levels of arsenic from both top soil and sub soil collected from seven dumpsite locations (L1 – L6), including a control station (LX). The results on the average level of arsenic from soil samples collected across the different dumpsite locations showed that the measured level of arsenic from both surface and sub soil strata were below detection limit (<0.001 mg/kg) across all locations including the control station. Therefore, there is no difference in the levels of arsenic among the locations. Similarly, the results on the average level of Cadmium across the different locations showed that the measured spatial level of cadmium was 0.0171 mg/kg at the topsoil and 0.0100 mg/kg in the subsoil. This shows that Cd concentration was slightly higher in the topsoil than the subsoil. The same result was found in the control.

The result of average levels of chromium was 0.0168 mg/kg at the topsoil while 0.0100 mg/kg at the subsoil. This shows that the concentrations of Cr was higher than the subsoil. The analysis also showed that Cr was below detection limits (<0.001 mg/kg) across all locations with the exception of chromium in surface soil of Location L2 (0.029 mg/kg). In addition, the chromium level soil strata in the control station was also below detection limit (<0.001 mg/kg).

Results on the average level of copper in soil strata (i.e surface and subsoil) across the different dumpsite locations of copper ranging from 0.134– 0.356 mg/kg for topsoil (0-15 cm) (Table 4.7), the highest and lowest value were recorded in locations L5 and L2 respectively. Meanwhile, values for the subsoil (15 – 30 cm) ranged from 0.144 – 0.256 mg/kg with highest and lowest values in locations L6 and L1 respectively (Table 4.7). Comparatively, the copper levels in both soil strata of the control station (LX) recorded the lowest values. There is significant difference in the spatial levels of copper across the locations and the soil strata. On average, in Table 4.1, the concentrations of Cu in the surface soil was 0.2794 mg/kg while 0.2007 mg/kg was for the sub soil. It is also known that at the control plot, the Cu was 0.0767 mg/kg at the topsoil and 0.0595 mg/kg at the subsoil. This shows that the Cu concentrations at the dumpsites were higher than that of the control plot at both topsoil and subsoil.

Results on the Pb in soil strata (i.e surface and subsoil) across the different dumpsite locations showed that the concentration of Pb ranged from 2.908– 4.610 mg/kg for topsoil and, the highest and lowest value were recorded in locations L1 and L4 respectively. Meanwhile, values of the subsoil for lead ranged from 1.794 – 4.430 mg/kg with highest and lowest values in locations L1 and L4 respectively (Table 4.8). Comparatively, the lead levels in both soil strata of the control station (LX) recorded the lowest values. The levels of lead varied amongst the locations. Nonetheless, it was found that the average Pb concentrations at the topsoil was 4.078 mg/kg while that of the subsoil was 3.3493 mg/kg in the entire Bayelsa State. The concentrations at the control plot was 0.4478 mg/kg at the topsoil and 0.1122 at the subsoil. This suggested that the concentrations of Pb were higher at the experimental plot (dumpsites) than the control plot. Among all the toxins, Pb was extremely high at both soil strata.

Results on the concentrations of mercury in soil strata (i.e surface and subsoil) across the different dumpsite locations showed that the average levels of mercury was 0.018 mg/kg in the topsoil and 0.0100 mg/kg at the subsoil. At the control plot, the concentrations at the topsoil and sub soil were the same (0.01 mg/kg) which was lower than the Hg concentrations at the topsoil in the experimental site. Thus, the concentrations were below detection limit across all locations.

The result recorded average levels of total bacterial count ranging from 4.562– 8.403 x 10^5 cfu/g for top soil and 3.939 –7.183 x 10^5 cfu/g for subsoil. The highest and lowest total bacterial counts of top soil were recorded in locations L5 and L6 respectively, while, the highest and lowest bacterial count of subsoil (15 – 30 cm) were recorded in locations L5 and L3 respectively. In addition, the bacterial counts in the control station (LX) were 5.773 x 10^5 cfu/g for top soil and 4.879– 8.403 X10^5 cfu/g for subsoil. There was significant difference in the levels of bacterial count across the locations (Table 4.9). The mean bacterial count at the topsoil (5.8315 x 10^5) was higher than that in the subsoil (5.1156 x 10^5). However, in the control plot, it is discovered that bacterial count was 5.7739 x 10^5 at the topsoil and 4.8794 x 10^5.

The average level of total fungal count in soil strata (i.e surface and subsoil) across the different dumpsite locations showed that total fungal count ranged from 4.006 – 5.918 x10^3 cfu/g for top soil, and 3.733 – 5.482 x 10^3 cfu/g for subsoil. The highest and lowest total fungal counts of top soil and subsoil were recorded in locations L5 and L3 respectively. In addition, the fungal counts in the control station (LX) were 1.832 x 10^3 cfu/g for top soil and 1.582 x10^3 cfu/g for subsoil. There is no significant difference in the spatial levels of fungal count across the location.

The average level of coliform count in soil strata (i.e surface and subsoil) across the different dumpsite locations for total coliform across the locations was 131.11 - 167.78 MPN/100ml for top soil, and 101.11 - 152.22 MPN/100ml for sub soil. Meanwhile the levels of fecal coliform ranged from 84.61 - 121.11 MPN/100ml for top soil, and 79.44 - 111.67 MPN/100ml for sub soil. Generally, the top soil had higher levels of coliform than sub soil, location L5 and L6 had the highest and lowest levels of coliforms respectively. In addition, the results showed that the control station had the lowest level of coliform for both top and subsoils. Incidentally, there is was significant difference in the spatial levels of coliform count.

It is thus discovered that the total coliform at the topsoil was 136.99 x 10^3 and 116.99 MPN/100ml while in the control plot the total coliform was reduced at the topsoil while higher 117.23 MPN/100ml at the higher at the subsoil. The mean fecal coliform was 108.10 x 10^3 MPN/100ml at the topsoil and 95.000 MPN/100ml at the subsoil in the entire study area. The control plot area was lower at the topsoil compared to the experimental plot while in the subsoil, the fecal coliform was higher than the experimental plot.

It is revealed in Table 4.2 that Pb was significantly varied among the study locations regarding the soil strata (topsoil and subsoil) (F=2.528, p=0.037). similarly, Cr (F=4.799, p=0.001), bacterial count (F=2.651, p=0.030) and total coliform (F=3.627, p=0.006). Considering the variation in the soil organic and inorganic toxins, it is observed the pairwise t test in Table 4.3 showed that Pb (t=5.339, p=0.000), Cu (t=3.038, p=0.004), bacterial count (t=3.663, p=0.001), total coliform (t=6.342; p=0.000) and fecal coliform (t= 4.423, p=0.000) are significantly varied between the topsoil and subsoil.

Table 4.1: Spatial levels of organic and inorganic toxins in Different Soil Strata

Organic and Inorganic Toxins	**Experimental Plot**		**Control Plot**	
	0-15cm	**15-30cm**	**0-15cm**	**15-30cm**
	Mean±SD	**Mean±SD**	**Mean±SD**	**Mean±SD**
Hg (mg/kg)	.0168±0.03	0.0100±0.00	0.01±0.01	0.01±0.01
As (mg/kg)	0.01±0.01	0.01±0.01	0.01±0.01	0.01±0.01

Pb (mg/kg)	4.078±1.66	3.3493±1.38	0.4478±0.4	0.1122±0.1
Cu (mg/kg)	0.2794±0.2	0.2007±0.1	0.0767±0.1	0.0595±0.1
Cd (mg/kg)	0.0171±.02117	.0100±0.00	.0100±0.00	.0100±0.00
Cr (mg/kg)	0.0168±0.02	0.010±0.00	.0100±0.00	.0100±0.00
Bacterial Count	5.8315±2.3	5.1156±1.6	5.7739±1.0	4.8794±0.3
Fungal Count	4.3545±1.8	4.2024±1.7	5.5256±1.2	5.0067±0.8
Total Coliform	136.9906±25.7	116.9901±23.6	136.1117±14.2	117.2217±17.6
Fecal Coliform	108.1019±28.1	95.0003±25.8	105.5567±7.2	97.7783±18.5

Source: Researcher's Analysis, 2022; n=36 (Experimental Plot); n=6 (Control plot)

5.0 Conclusion

This study investigated the levels of top and sub soil samples collected from different dumpsite locations across the different Local Government areas in Bayelsa State. Unfortunately, results of this study showed some level of heavy metal and microbiological contaminations of the soil. This contamination is due to the high levels of anthropogenic activities caused by the reckless disposal of untreated and unsegregated waste in the catchment area. Effective waste management is very essential in minimizing environmental pollution. This level of environmental pollution is a major concern due to the environmental and public health problem they pose.

6.0 Recommendations

Based on the findings of this study and other established literatures I therefore make the following recommendations:

- Government policies to reduce, reuse and recycle waste should be formulated without further delay.
- Incinerators and thermal desorption units should be constructed around waste dumpsite in order to minimize the open burning and pollution of the environment.
- Government should do more to enacts functional laws should be enacted and enforced to deter the reckless disposal of waste by the populace of the study area.

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