POLLUTION STATUS OF BREWERY SEWAGE SLUDGE IN LAGOS, NIGERIA

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ABSTRACT

This study was conducted to examine the concentrations of heavy metals in sludge from a brewery plant in order to asses the pollution extent of the sludge before be use as a cheap soil fertilizer. Sludge samples were collected from different points of the plant weekly for six weeks, and analyzed for Pb , Cu Cd Cr and Co. The highest concentration of Cu, Cr and Pb were observed in the sludges samples compared to Cd and Co respectively. The mean concentration of heavy metals ranged from 22.00±9.03-34.42± 1.87 µg/g Pb, 79.83±27.49-100.75±28.06 µg/g Cu, 0.58± 1.86-1.30± 0.40 µg/g Cd ,29.33±12.62-47.92±22.13 µg/g Cr and 5.92± 0.97-9.10±4.18 µg/g Co. The pH analysis for each of the sampling points were found to ranged between 7.12±0.47-7.17±0.35 indicating the suitability of the brewery sludge as a sources of fertilizer since most crops grow best when the soil pH is between 6.5-7.0 and a high moisture content was obtained. The mean concentration of the analyzed metal in the sludge do not exceed the allowed permissible level in sludge sample set by European Union (EU) and United state environmental protection agency (USEPA) standards.

Keywords : *Sludge, optimum pH ,brewery, bioaccumulation, toxic.*

1. INTRODUCTION

Lagos State in Nigeria has a population of over 40 million and generates a large amount of wastes water from both domestic and industrial waste. Increasing urbanization and industrialization has culminated in a dramatic growth in the volume of municipal wastewater produced worldwide. This wastewater when treated produces a huge amount of sludge which is a residual semi-solid material which poses a serious disposal problem [1-2]. Sewage or wastewater sludge is a rich source of organic matter and nutrients, this wastewater contains all the substances that enter in human metabolism, such as food, beverages, pharmaceuticals, a great variety of household chemicals and the substances discharged from trade and industry to the sewer system [1,3-4]. Utilization of sludge for agricultural applications is increasing instead of the conventional disposal option as it recycles nutrients [5]. However, agricultural utilization of this material is limited by excessive quantities of heavy metals [1,4]. Moreover, rain water and its contact materials also contribute to this composition. As a result, the components of the municipal wastewater discharged into the sewer system are a mirror of our civilization and of human and urban metabolism. The administration of raw and post-fermentation sewage sludge from municipal treatment plants is a difficult task due to epidemiological hazards and the occurrence of heavy metals. The key sources of heavy metals in sewage sludge are industrial wastewater and surface flows containing large amount of zinc, which originate from phosphate fertilizers and plant protection chemicals. The main hindrance in this respect is the steadily increasing concentration of heavy metals, resulting in their accumulation in soil and plants [6].

The prospects for sewage sludge to be used in agriculture have been reported [7-8]. In sewage sludge, metals occur in inorganic forms or organic complexes. In order to assess their mobility (especially the extremely toxic ones such as lead, cadmium and zinc). Ogbonna et al [9] reported that the wastes from the leather industry consist of tanned and untanned solids, waste waters (effluent) including the sludge and waste gases. Common mineral elements such as Al, Fe, Ca, Na, K and Si are present in significant quantities in sludge. Trace elements and heavy metals such as Cd, Pb, Hg, As, Cr, Cu, Ni, Zn, B, Se, Mo reported to bioaccumulate and cause a lot of adverse effect in human when ingested [10] as well as N and P in both organic and inorganic forms may also be present [11]. Heavy metal Utilization of sludge for agricultural applications is increasing instead of the conventional disposal option as it recycles nutrients. Breweries which produces beer, generates sludge as waste and it is known to be one of the most interesting bio-sludge as it has significantly high plant nutrients especially phosphorus and nitrogen, and less heavy metal concentration which is good for digestion. Sewage sludge from wastewater treatment plants and brewery sludge represent a source of energy, biogas, as a by-product of anaerobic digestion. It has been reported that about 25 million people in China employed biogas for cooking and illumination for more than 8 months within a year [12].

China also has reliable experience of running diesel and gasoline engines with biogas [13]. This possibly will save on the non-renewable source of energy such as fossil fuels that are diminishing rapidly, and at the same time the sludge can be used to supply nutrients to agricultural soil as well as for soil amendment. However, if improperly managed, it may pose potential risks to both environment and public health from the accumulation of heavy metals and organic compounds as well as pathogen contamination.

The present work is geared toward assessing the of heavy metal status of the wastewater sludge from brewery in Nigeria for proper management of the generated sludge for sustainable development.

2. MATERIALS AND METHODS

Sampling collection and sample preparation

The soil samples were collected randomly from sampling points using soil auger . After collection of the 5-6 individual samples from various points, they were mixed together and one average was compiled for the analysis. The samples were collected once weekly for six week between the month of October and November 2008.

Sample Preparation and Determination of Moisture Content

The solid sludge was dried for two days in an oven set at 105°C. The samples were then cooled in a desiccators having silica gel as a drying agent before re-weighing. The moisture content of the sample was then determined as a percentage of the dry mass. To have homogeneity, the sample was then crushed into a semi-fine powder and sieved using a set of stainless steel (2 mm) and brass coated Endecott sieves [14].

Determination of pH of the sludge samples

The pH for solid sludge was determined as follows:2 5 g of sludge dried at 105°C was transferred to 150 ml stoppered conical flask (alternatively graduated cylinder) and ultra pure deionized MilliQ water was added to make the total volume of 100 ml. The solution was shaken on a magnetic stirrer for approximately 15 minutes until the sample was thoroughly dispersed. Finally, the pH meter (Crison micro pH 2000 microprocessor controlled pH meter) was set up and pH was measured according to the manufacturer's instructions.

Mineral analysis

Samples for mineral determination, the samples were digested in HNO_3/HCl. The elements, Pb , Cu Cd Cr and Co., were measured by atomic absorption spectrophotometry (AAS), using a Varian Spectra atomic absorption spectrophotometer, Buck Scientific 210 GVP model. All determination was done in triplicates and a spike sample was used to verify the accuracy of the procedure.

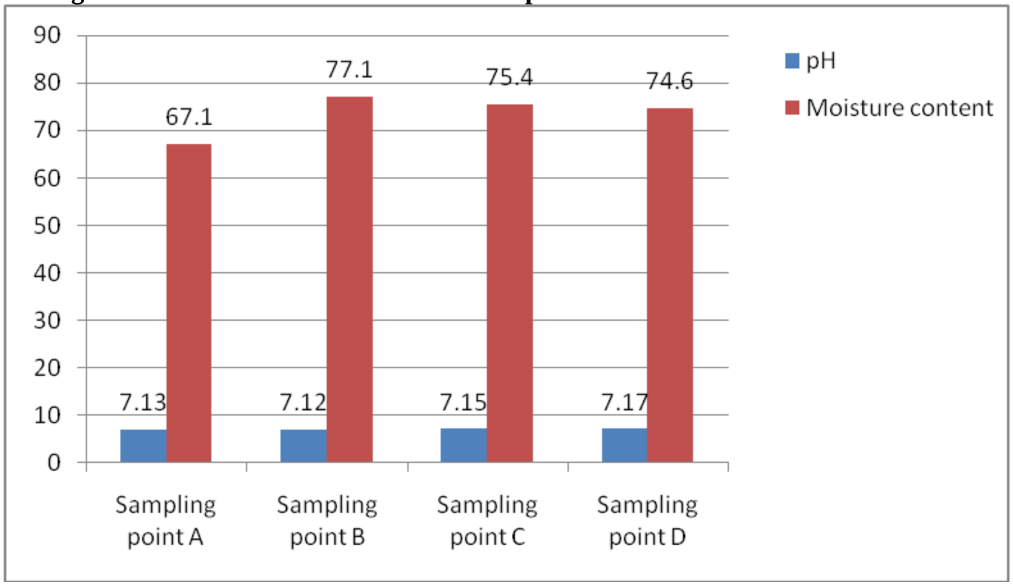
3. RESULTS AND DISCUSSION

The determination of pH of sewage sludge is very important because it determines the fate of the metals present in the sludge when the material is disposed off in the environment as a source of cheap fertilizer. It is important to note that the pH of sludge need to be regulated before if it to be use as fertilizer. The optimum pH for adsorption of all metals, except gold, has been determined to be between 4 and 5.2. This means that any sludge within this pH range are likely to be hazardous to the environment due to the fact that the heavy metal in them can readily be leached into ground water or any water stream[15-17]. It also means that they can readily be taken up by plants which end up being consumed by both man and animals. The mean value of pH and the moisture content of the analyzed sludge with their standard deviation are presented in table 1.

Table 1 The mean value of pH and the moisture content of the analyzed brewery sludge

	Sampling point A	Sampling point B	Sampling point C	Sampling point D
pH	7.13±0.41	7.12±0.44	7.15±0.36	7.17±0.39
Moisture content	67.10±0.90	77.10±0.60	75.40±1.07	74.60±1.16

Figure 1 showing the bar chart of the mean value of the pH and the moisture content of the brewery sludge



The pH value obtained for sampling point A ranged 6.68-8.02 with a mean value of 7.13±0.41 while sampling point B ranged from 6.88-8.06 with a mean value of 7.12±0.41. Conversely, for sampling point C the value ranged from 6.87-7.92 with a mean value of 7.15±0.36 and that of sampling point D has a value ranging from 6.85-8.01 with a mean value of 7.15±0.36 as shown in figure 1 respectively. The observed pH mean values from each of the sampling points were found to be slightly alkaline and ranged between 7.12±0.47-7.17±0.35 indicating the suitability of the brewery sludge as a source of fertilizer since most crops grow best when the soil pH is between 6.5-7.0 [18].

The moisture content of the solid sludge was determined following the procedure of AOAC 1995. The moisture content of the sludge from each of the sampling point was calculated and the results summarized in terms of the sampling points are tabulated in Table 1. The standard deviation included with the data represents the variation of the mean. As presented in the Table1 there exists a slight variation in the moisture contents. The collected fresh samples at each sampling points give an indication as to how much water is impeded in the sludge just after its production in the plant with the results showing that water makes up 65-80% of the fresh wet sludge. An overall look at the moisture content of the solid sludges sampled reveals that the minimum moisture content was 75.40% while the maximum was 78.40% with a mean value of 77.10% at sampling point A. At sampling point B the minimum and maximum value were 60.20% and 75.30 with a mean value of 67.70%. However, the minimum value obtained for sampling point C was 74.30% recorded at week 3 while the maximum of 77.40% was recorded in week 1 with a mean value of 75.80%. The moisture content of the brewery solid sludges sample at sampling point D reveals that the minimum moisture content was 73 .40% with a maximum of 76.40% and a mean value of 76.60% respectively. The obtained value were relatively high which may be attributed to high volume of wastewater present in the sludge tank during sampling which are yet to be treated. Although there are no specific regulations on the amount of moisture content for sludges, the evidence is that some of the sludge samples had high moisture content but this also needs to be monitored if the sludge is to be use as a cheap fertilizer.

Among the numerous groups of elements present in sewage sludge, heavy metals are undoubtedly the most crucial and at the same time the most controversial ones as those responsible for pollution cadmium, zinc, copper, chromium and nickel are of primarily concern. The concentrations of heavy metals investigated in the sludge samples from four different sampling points from a brewery in Nigeria are presented in Table 2,3,4,and 5 respectively.

Table 2: Physiochemical parameter and concentration heavy metals in brewery sludge at sampling point A

week	pH	Moisture content	Pb (µg/g)	Cu (µg/g)	Cd (µg/g)	Cr (µg/g)	Co (µg/g)
1	6.84	75.40	32.50	108.50	1.50	39.50	10.01
2	7.02	77.40	27.00	69.50	2.00	32.00	16.50
3	7.01	78.40	23.00	83.00	1.01	41.50	4.01
4	7.08	77.40	25.00	71.50`	-	31.50	-
5	6.83	76.80	49.00	132.00	1.02	50.00	7.01
6	8.02	77.20	50.00	140.00	1.03	50.00	8.01
∑x	42.80	462.60	206.50	604.5	6.50	244.50	45.50
X	7.13	77.10	34.42	100.75	1.31	40.75	9.11
S.D	0.41	0.9	12.11	30.74	0.44	7.48	8.1

Table 3:Physiochemical parameter and concentration heavy metals in brewery sludge at sampling point B

week	pH	Moisture content	Pb (µg/g)	Cu (µg/g)	Cd (µg/g)	Cr (µg/g)	Co (µg/g)
1	6.68	75.20	11.50	39.50	0.50	5.50	8.50
2	6.92	75.30	22.50	62.50	0.49	26.00	1.01
3	7.00	63.30	24.50	86.00	0.51	41.00	6.00
4	7.13	62.20	16.00	63.50	1.01	29.50	1.02
5	6.92	60.20	33.50	112.50	0.52	37.00	11.50
6	8.06	70.10	40.00	114.00	0.503	43.00	14.00
∑x	42.71	406.4	148.00	479.00	3.50	182.00	42.00
X	7.12	67.70	24.67	79.67	0.59	30.33	7.00
S.D	0.44	6.12	10.64	29.89	0-21	13.82	4.67

Table 4: Physiochemical parameter and concentration heavy metals in brewery sludge at sampling point C

week	pH	Moisture content	Pb (µg/g)	Cu (µg/g)	Cd (µg/g)	Cr (µg/g)	Co (µg/g)
1	6.87	77.40	11.00	43.00	1.51	10.00	4.00
2	7.06	75.30	12.50	60.00	1.50	12.50	5.00
3	7.01	74.30	19.00	79.50	0.99	30.50	9.50
4	7.12	75.30	22.50	104.49	2.00	26.00	5.50
5	6.91	74.20	32.00	104.50	2.51	48.00	6.50
6	7.92	75.40	35.00	100.50	2.50	49.00	7.50
∑x	42.89	452.30	132.00	492.00	11.01	176.00	38.00
X	7.15	75.40	22.00	82.00	1.84	29.33	6.33
S.D	0.35	1.07	9.89	25.94	0.61	16.76	1.97

Table 5: Physiochemical parameter and concentration heavy metals in brewery sludge at sampling point D

week	pH	Moisture content	Pb (µg/g)	Cu (µg/g)	Cd (µg/g)	Cr (µg/g)	Co (µg/g)
1	6.85	73.40	20.00	45.00	0.50	29.00	4.50
2	7.11	75.80	22.50	60.00	0.50	32.50	6.00
3	7.02	74.80	28.00	76.00	1.50	39.00	7.50
4	7.16	73.80	30.00	101.50	1.50	41.50	6.00
5	6.89	73.50	46.00	158.50	1.50	50.50	6.01
6	8.01	76.40	47.50	160.50	1.50	95.00	5.92
∑x	43.04	447.70	194.50	601.00	7.00	287.50	35.50
X	7.17	74.60	32.33	100.25	1.17	47.92	5.98
S.D	0.39	1.16	11.74	49.56	0.52	24.23	0.94

Table 6 showed the mean value (mean ± SD) of the heavy metal concentration in the analyzed samples at different sampling points. Cadmium (Cd) and cobalt (Co) concentration were observed to be the lowest for the samples from all the points while the concentration level of copper (Cu) chromium and lead were higher with copper being the most abundant. The order of abundant of this metal in the sludge at all the sampling points was Cu>Cr>Pb>Co>Cd. as shown in figure 2

Figure 2 showing the bar chart of the mean concentration of heavy metals in the brewery

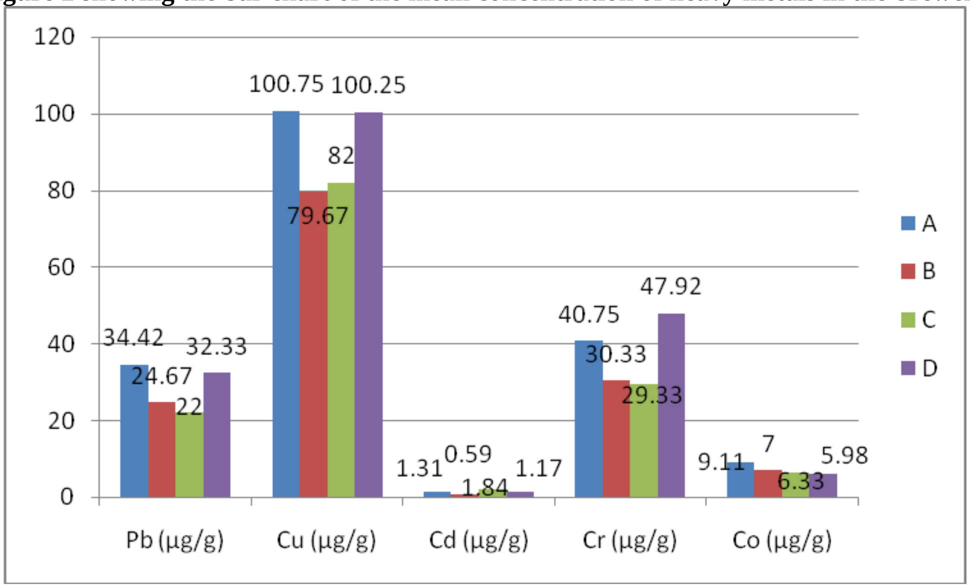


Table 6 Mean concentration of the brewery sewage sludge at different sampling points Sludge

Sampling points	**Pb (µg/g)**	**Cu (µg/g)**	**Cd (µg/g)**	**Cr (µg/g)**	**Co (µg/g)**
A	**34.42±12.11**	**100.75±30.74**	**1.31±0.44**	**40.75±7.48**	**9.11±8.10**
B	**24.67±10.64**	**79.67 ±29.89**	**0.59 ±0.21**	**30.33±13.82**	**7.00 ±4.67**
C	**22.00±9.89**	**82.00±25.94**	**1.84±0.61**	**29.33±16.76**	**6.33 ±1.97**
D	**32.33±11.74**	**100.25±49.56**	**1.17± 0.52**	**47.92±24.23**	**5.98±0.94**
USEPA Limit	**300**	**1500**	**39**	**1200**	**-**
European Union (EU) limit	**750-1200**	**1000-1750**	**20-40**	**200-1200**	**-**
South Africa	**50.5**	**50.5**	**15.5**	**1750**	**100**

These results suggest that the samples from brewery are highly contaminated with copper, chromium and lead when compared with the cadmium and chromium analyzed. The mean concentration ranging from 22.00±9.03-34.42±1.87 µg/g Pb, 79.83±27.49-100.75±28.06 µg/g Cu, 0.58± 1.86-1.30± 0.40 µg/g Cd, 29.33±12.62-47.92±22.13 µg/g Cr and 5.92± 0.97-9.10±4.18 µg/g Co were obtained respectively for the brewery sludge samples. The mean value obtained for the Cr, Co and Pb were below what was reported earlier [19-20] and are within the normal range of the allowed established guidelines in several countries. Conversely, the concentration of copper obtained in this study were below what was reported for copper in paddy soil by Luo et al 2003 [21] but higher than the South Africa permissible level (Table 5). Copper concentration levels above normal range are highly unsafe and pose health risks to the environment [22]. Cadmium was detected in all the samples [Table 6]. Based on the assessment made above, it motivates to compare the current results with the limits of other countries. Therefore, the results obtained in this study were compared with USA and EU limits as shown in Table 6. With reference to the tabulated information, it is clear that mean value in this study are much lower compared to USA and EU limits. For instance the obtained value for cadmium is within normal range of 0.1 – 7 µg/g [11] as well as within the range of the allowed permissible level in United State of America , European union (EU) and some countries allowed permissible level [23-26].

The statistical data (Table 7) showed no significant difference at 95% level of confidence in the concentration of Pb, Cu, Cr and Co in the sludge sample. However, the Pearson correlation coefficient analysis at 99% level of confidence showed a strong correlation between Pb and Cu, Pb and Cr as well as Cu and Cr in the brewery sludge sampled with r value of 0.919, 0.822 and 0.821 respectively. This shows that there is as common source of these metals in the study sludge.

Table 7 Duncan's one way analysis of variance the heavy metal concentration in the sludge sample

	Pb	Cu	Cd	Cr	Co
t-test (95% confidence level	0.090^{a}	0.354^{a}	0.092^{a}	$0.014^{a,b}$	0.202^{a}

Table 8 Correlations of variation between the heavy metal in the sludge sample

		Pb	Cu	Cd	Cr	Co
Pb	Pearson Correlation	1	.919**	.150	.822**	.305
	Sig. (2-tailed)		.000	.493	.000	.157
	N		24	23	24	23
Cu	Pearson Correlation		1	.247	.821**	.211
	Sig. (2-tailed)			.255	.000	.334
	N			23	24	23
Cd	Pearson Correlation			1	.218	.087
	Sig. (2-tailed)				.317	.692
	N				23	23
Cr	Pearson Correlation				1	.097
	Sig. (2-tailed)					.661
	N					23
Co	Pearson Correlation					1
	Sig. (2-tailed)					
	N					

**. Correlation is significant at the 0.01 level (2-tailed).

Cadmium is very hazardous and at certain concentrations, it is toxic to humans and other living organisms especially when present in the aqueous medium [27]. The source of cadmium in the sludge may be attributed to paint pigment used in coating the sludge tank as well as oils used in lubrication of the machine before or after production. The high levels of Pb in the sludge may due to emission from exhaust pipe of the generating plant used to power the machines during production but it is interesting to note that the values are below the allowed permissible level corroborating earlier statement that this brewery sludge can be utilized as a source of cheap fertilizer and with no lead pollution. It can thus be said that sludge is good for agricultural application.

4. CONCLUSION

We assessed the pollution status of sludge from a brewery in Nigeria and the obtained result indicated that the obtained levels of the heavy metal fell within the allowed permissible level set by European union and united state of America. The study revealed that the sludge from this brewery is unpolluted and can be utilized as source of cheap fertilizer for soil. However, all environmental machinery must be set in place to constantly monitored the sludges generated by most of this breweries in Nigeria so as to be sure that the sludge discharge are within the acceptable standard before they are introduce into the environment in order to keep the environment safe.

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