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RECYCLABLE POTENTIAL OF WASTES FROM A CHEMICAL FERTILIZER INDUSTRY AT ONNE, NIGERIA

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ABSTRACT

The nature of solid wastes and their leachates from a chemical fertilizer industry located in Onne, Nigeria was assessed to determine its recyclable potential and possible management options in the industry. The study was descriptive and exploratory in design. It involved collection of composite sample of solid wastes from the temporary dumpsite of the industrial complex as well as leachate samples around the same vicinity. The solid waste was characterized physically and chemically into combustible rubbish, garbage, carbon, nitrogen, potassium and phosphorus. Similarly, the leachate was characterized chemically according to standard methods into pH, conductivity, chloride, nitrate, zinc, and phosphate. The results indicated that the waste with a density of 89,1 kg/m^3 is richer in combustible matter (45.8 %) and has more organic carbon (2.68 ±0.17 g/100g) and potassium (2.15 ±0.57 g/100g) contents while the leachates recorded very high concentrations of conductivity (1.97 x 10^8 µs), phosphate (4.88 x 10^3 mg/l) and zinc (74.9 mg/l). This study reveals that the industrial wastes and their leachates have inorganic elements such as potassium, phosphate and zinc, which could be properly harnessed and recycled as a veritable waste management option in the industry.

Key words: Recycle, Leachates, Industry, Solid waste and Potassium.

INTRODUCTION

Solid waste and its associated problems remains one of the most recalcitrant environmental management problems confronting major urban cities in the developing countries of the world. Although a greater contribution of the worlds waste burden are from domestic and municipal sources, the gravity of the problem caused by wastes generated from various industries poses a very serious threat to the sustainability of ecosystems.

In Nigeria, solid waste management is certainly one of the major environmental problems confronting the country especially in the major cities. In some of these cities where there are increased industrial activities the problem becomes more compounded as these industrial wastes add to the overall waste burden in the community.

Waste recycling can only be feasible and effective after a proper characterization is carried out For instance, studies on the characteristics of refuse in developed countries like Britain indicated that its average density was 290 kg/m^3 while in certain parts of United States of America between 1920 and 1970, the quantity of refuse produced per person varied from 2.7 kg to 4.5 kg as against 0.87 to 0.9 kg in London between 1965 and 1969.

On the physical characteristics of solid wastes, Lund (1971) reported that a typical municipal refuse in the United States of America comprise old newspaper, waste paper, bottles, tin, cans, garbage, junk cars, old refrigerators, bicycles, automobile tyres, plastic toys and construction materials with all their total weights accumulating at a rate of 165 million tons/year. For chemical characteristics, investigations carried out in different parts of the developed countries have shown that domestic refuse generally contain levels of nitrogen, phosphorus and potash between 0.5 and 10 percent (Department of Environment, UK 1971). Studies from the developing countries such as India also indicate certain average figures for chemical composition such as Nitrogen (0.5 %), Phosphorus (0.65 %) and Potash (0.82 %) (CPHERI, 1971). Similarly studies carried out in SouthWestern Nigeria by Sridhar et al (1985) indicated a higher Nitrogen and Phosphorus content in the higher socio economic group as against a higher Carbon and volatile substances in low and medium socio economic group.

The characteristics of leachates emanating from wastes especially those from municipal sources have been studied extensively. Osibanjo et al (1997) showed that fresh waste leachates had higher values for certain physicochemical parameters as against lower values for old abandom dumpsite leachates. Sridhar and Aluko (2000) also indicated certain characteristics for leachates from some dumpsites in Ibadan, Nigeria.

Interestingly, while information appears to be replete on the characteristics of solid wastes and their leachates from domestic and municipal sources from both the developed and developing countries, the same is not true for industrial wastes and their leachates. This seeming paucity of information on this subject especially here in Nigeria for a wide range of industrial plants forms the basis of this investigation.

The objective of this study, therefore, is to characterize both the solid waste and its leachates from the foremost chemical fertilizer plant in Nigeria with the view to using its outcome in recommending more cost effective and environmentally sustainable management methods for the industrial wastes and its leachates.

METHODOLOGY

Description of the Study Area

This study was conducted within the premises of the foremost and most complex chemical fertilizer industry in Nigeria, which is owned and operated by the National Fertilizer Company of Nigeria (NAFCON) Limited, Onne, Rivers State. The fertilizer complex with a work force of 3000 is located in southern Nigeria between latitudes 4.49º and 4.5º north and between longitudes 6.59º and 7.00º east of the Greenwich Meridian on 115 hectares of arable land about 30 km from Port Harcourt.

The industrial products include: ammonia (1000 tons), urea (1500 tons), and NPK formulations (1000 tons) through series of processes that begin with the production of ammonia using the Haber process. This involves desulfurization, reforming, carbon dioxide purification, synthesis and refrigeration stages with the major raw materials being natural gas, atmospheric nitrogen and steam where hydrogen reacts with nitrogen at temperatures over 800^{o}C. The production of urea involves reaction between the raw materials: ammonia(as feed) and carbon dioxide through an exothermic (synthesis) and endothermic (granulation) stages. The production of NPK and other complex fertilizers involve the reaction between ammonia, urea, other additives and sand (as filler material) at various proportions. Within the entire plant complex, there are different plant units such as the Ammonia, Urea, Utilities, NPK, Bulk blending plants and the warehouse as well as the laboratories and offices where different kinds of solid wastes are generated. These solid wastes particularly rich in phosphorous and nitrogenous substances are disposed of into dumpsites located within the plant complex.

The fertilizer complex is bound on the west by Okrika Creek which is the main receiving water body for the industrial effluents. The Creek takes its course from the Bonny River, which empties into the Atlantic Ocean. It measures 68.5 km long, 5 km wide, and 9 m deep. The complex is also bound on the west by Okrika communities who are traditional fishermen and a characteristic wetland ecosystem, consisting mainly of mangrove swamps. On the east, the complex is surrounded by farmlands, owned by Onne communities who are traditional fishermen and farmers. On the south, the complex is bound by the Federal Ocean terminal and smaller communities such as Ele and Owuogono. Farming activities, which are mostly carried out on the hinterland around the Okrika Creek are on the mangrove swamp soils. These soils are brown to black due to organic decay of leaf and dead woods. They are rich in organic matter in their top layers but may contain excessive salt especially during the dry season.

Materials

The materials used for solid waste characterization include a tape (metre rule), weighing balance, an oven as well as glasswares and spectrophotometer. While those used for leachate analysis include leachate sampler, conductivity meter, pH meter, and spectrophotometer.

(i) *Solid Waste Samples*

Grab solid waste samples totaling ten were collected from the solid waste temporary dumpsite in the plant complex and made up to a single composite sample. Samples for chemical characterization were taken out from the composite sample after physical characterization.

(ii) *Leachate Samples*

Grab leachate samples totaling 3were collected from the base of the dumpsite and made up to composite sample for physical and chemical analyses.

Methods

Characterization of Solid wastes

(i). Physical characteristics of solid wastes

Physical characteristics of solid wastes from NAFCON were determined by standard methods according to Anon (1978) with modifications by isolating and grouping the different solid waste component as follows: Grab samples from about 10 different spots taken at random where solid wastes are deposited on the dump site were collected and a composite sample of 1 m^3 volumes made. From this composite sample, the solid wastes were segregated into different components viz garbage, combustible rubbish, non-combustible rubbish, bulky waste, special waste and operational waste. The weights of these component parts were weighed using standard laboratory chemical balance.

(ii). Chemical Characterization of solid waste

Chemical characteristics of the solid wastes was carried out by taking a representative quantity (500g) of the composite sample after oven drying and grinding to powdery form and further processing before measuring parameters such as total carbon (C), total Nitrogen (N), Phosphorus (P) and Potassium. The carbon content of solid waste was measured according to method of Walkley and Black (1934). Determination of total Nitrogen in solid waste was done using Kjelhal distillation and titrimetric method .Total phosphorus (as P_20_5) in the solid waste samples was determined spectrophotometrically using molybdo vanadate method. Potassium (as K_20) content of solid waste was determined titrimetrically using sodium tetraphenylboron volumetric method. All methods for these parameters were as described by AOAC (1980).

Characterization of Leachates

(i). Physico-chemical characterization of leachates.

The physical parameters that were determined are colour, odour and temperature. Colour and odour were determined qualitatively.Temperature was measured using a standard laboratory thermometer graduated in degrees Celsius.

(ii). Chemical Characterization of Leachates

The chemical parameters that were measured were pH, conductivity, Dissolved oxygen (DO), urea, free ammonia (NH_3), phosphate, chloride, iron and zinc. The measurement of pH was done by probe method using a pH meter model 3020 made by Jenway, U.K. Conductivity measurement was carried out by probe method using a calibrated conductivity meter model 4010 made by Jenway, U.K. Dissolved oxygen was determined by probe method using a calibrated, standard. Do meter, model 50B made by YSI incorporated, U.K and result expressed in mg/l. Urea was measured spectrophotometrically according to standard methods described by Dutch State Mines (1979). Free ammonia determination was carried out using the distillation and titration technique according to standard methods. Phosphate determination was made using the per-sulphate digestion method and results expressed in mg/l. Chloride determination was made by the mercunic nitrate method and result expressed in mg/l. The iron content of the leachate was measured by the phenanthroline method and result expressed in mg/l. Zinc was measured using the zincon method as described by standard methods and result expressed in mg/l. The methods for all these parameters were as described by APHA (1992).

RESULTS

Characteristics of Solid wastes

The characterization of solid wastes from the designated dumpsite showed that it has a density of 89.1 kg/m^3. Combustible rubbish had the highest composition of 45.8 ± 3.5 kg/100kg (45.8 %) while special waste had the least, 5.79 ± 3.46 kg/100kg (5,79 %). Results of chemical analysis indicate that carbon recorded the highest concentration of 2.68 ± 0.17 g/100g while phosphorous had the least 0.34 ± 0.09 g/100g. See details in figures 1 and 2.

Characteristics of Leachates

The characteristics of leachates arising from the solid wastes at the temporary dump site showed that it had dark brown colour and very high values for urea (2.05 x 10^5 mg/l); chloride (4.54 x 10^4); and phosphate (4.88 x 10^3 mg/l). See details in Tables I and II

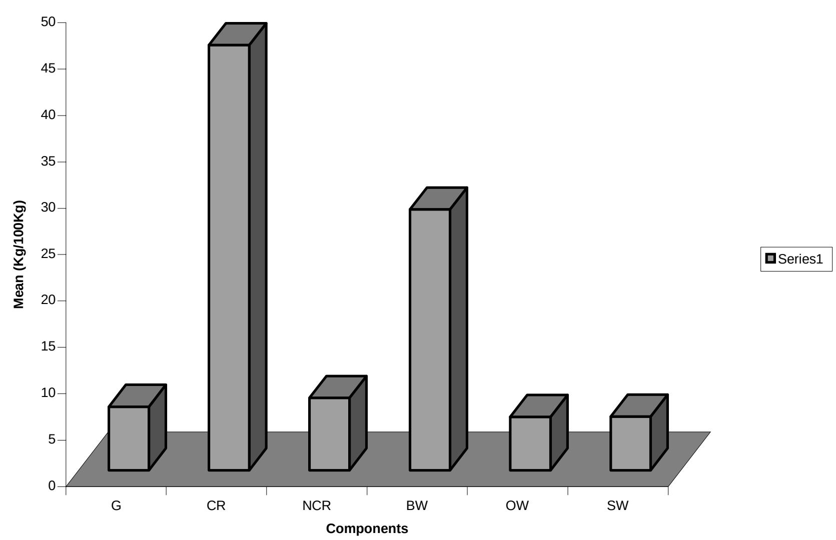

Figure 1.: Physical characteristics of solid waste

Key:

G = Garbage (garden and kitchen waste)

CR = Combustible Rubbish (office paper, plastic, rubber, cloth)
NCR = Non-combustible Rubbish (metal, tin, cans, glass)
BW = Bulky Waste (larger appliances, auto parts, furniture woodwork, filler sand)
OW = Operation Waste (solid and semi-solid lubricants, spent oil)
SW = Special Waste (asbestos, explosives, hazardous and radioactive substances)

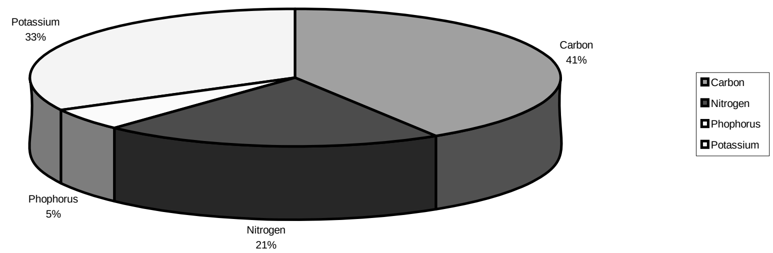

Figure 2.: Chemical characteristics of solid wastes

Table I.: Characteristics of Leachates from Solid wastes at the designated dump site in the Industry.

PARAMETER	VALUE
Colour	Dark Brown
Odour	Oily&Pungent
Temperature (^oC)	23.5
Conductivity (µs)	1.97 x10
pH value	6.86
DO (mg/l)	4,86
Urea (mg/l)	2.05x105
Cl(mg/l)l	$4.54x10^4$
PO_4 (mg/l)	$4.88x10^3$
Fe (mg/l)	4.05
Zn (mg/l)	74.9

DISCUSSION

With a density of 89.1 kg/m^3, it was found to be lower than that recorded for domestic solid wastes in most urban cities of the world such as Great Britain (Lund, 1971). This is an indication that the rate of refuse generation is much higher in the urban environments in comparison to the industrial environment. The critical difference in the physical composition of solid wastes between these two settings however lies in the increase presence of hazardous materials in the industrial solid wastes

The physical characteristics of solid wastes generated in NAFCON industrial complex indicated an increased proportion for two of the basic components of the wastes viz combustible rubbish (which is rich in office papers, cardboard materials and nylon bags used for packaging fertilizers) and bulky waste (which is basically rich in filler materials such as sand being utilized in making complex fertilizers, as well as logs of wood. It is glaring that, these materials posses very high recycling potentials of which if properly exploited could minimize the waste burden of the industry.

Also, the chemical composition of the industrial waste indicated that it was richer in organic carbon content and potassium. The increased carbon content could have been as a result of C-containing organic materials used in making complex fertilizers, while the high potassium content may have come from potash, which served as one of the basic ingredients used in complex fertilizer production processes. These two very rich components have clearly indicated enormous potentials as substances, which could be recycled, hence utilized within the industrial complex if properly harnessed. In addition, nitrogen and phosphorus were also identified as rich constituents of the solid wastes. Their values according to CPHER1 (1971) were not considerably different from that recorded for domestic refuse in some developing countries such as India

Leachates from solid wastes generated in the industry at the temporary dump site showed intense colour, which could be attributed to the presence of various pigments that are of organic origin. The extremely high conductivity value recorded could also be attributed to the presence of metal ions at the dumpsite, which again has a promising recycling potential. Although free ammonia and nitrate determinations were not carried out, the high urea level indicated that the leachates were rich in nitrogenous substances in addition to high zinc and phosphate concentration as supported by the characteristics by leachates from a dump site illustrated by Jackson et al (1989).

It is pertinent to mention that the studied dumpsite was more than 1km away from drinking water sources located within the vicinity. The implication of this is that the quality of the ground water within these boundaries was really not under any serious threat.

CONCLUSIONS

From this study, it could be deduced that:

1. The solid wastes from the industry have a density, which may be considered lower than that of domestic refuse from urban centres.

2. The solid wastes were rich in physical components viz combustible rubbish and bulky wastes which are themselves rich recycling materials for the industry.

3. The chemical compositions of the solid wastes comprised Carbon, Nitrogen and Potassium, which are rich recyclable substances for the industry if properly harnessed.

4. Leachates arising from the solid wastes contain extremely high concentrations of substances including, urea, phosphate, chloride, iron and zinc, which also have enormous recycling potentials and so could be reutilized by the industry.

5. Recycling of the wastes generated within the fertilizer industry therefore promises to be a veritable means of tackling the waste management problem in the factory.

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