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MANAGEMENT AND DISPOSAL OF INDUSTRIAL WASTE IN NIGERIA

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ABSTRACT

This paper examines the management and disposal of industrial waste in Nigeria. Four categories of industries were selected to give a cross-section of industrial life of the country with respect to the existing manner in which wastes are managed and disposed. The analysis of pollutants in the effluents from selected industries showed that larger proportion of the pollutants are suspended solid, dissolved solid, which can be easily treated and separated. Also, the average composition analysis of solid wastes from industries showed that, paper is by far the most abundant of these wastes, followed by plastic, metal, glass and wood in that order. This work reveals that most industries in Nigeria place little emphasis on proper wastes management, preferring the cheapest methods of wastes disposal to the most appropriate methods.

Keywords: Industrial wastes, management, disposal, industrial effluents and solid waste.

1. INTRODUCTION

Nigeria has witnessed rapid urban growth, increased economic and technological development in the past few years and these have also brought about increasing industrial development coupled with various forms of environmental pollution [1]. Since the production of wastes is an integral part of industrial activities, it is obvious therefore, that industrial growth apparently leads to an increase in the production of industrial wastes. These wastes are produced in the form of solids, liquids, gases and air-borne particulate matter, which are emitted into the environment.

The issue of industrial wastes has become one of the most crucial matters confronting society in general and industries in particular. Public concern on these issues continued to be expressed daily through the media, such as the newspapers, radio and the television. Advocates of environmental protection have drawn the attention of the national policy-makers to the health hazards and potential dangers to natural resources caused by the inadequate management of wastes [1, 2]. Waste is defined [3] as anything unused or not used to full advantage or in excess of what is required or garbage, rubbish or trash. There is a wide variation in both the physical and chemical nature of wastes as one goes from one industry to the other. The method of production or simply the types of manufacturing technology employed also play a significant role in the nature and type of wastes produced by an industry.

Waste management is a serious environmental problem that has been the subjects of several studies, conferences, strategic meetings and debates. Its importance lies in its visibility and clear intrusion in the daily lives of people, as well as the numerous secondary result of its negligence, which account for the global and national attempts to improve waste management.

According to Tanaka [4], the waste disposal and public cleansing law (referred to as the waste disposal law), which regulates waste management in Japan, state that the purpose of waste management is to preserve the living environment and to improve public health through the restriction of waste discharge, appropriate sorting, storage, collection, transport, recycling, etc. of wastes and conservation of a clean living environment. Thus waste management is expected to contribute significantly to the conservation of the living environment and maintenance of a high standard of public hygiene.

Waste management is a problem in urban and industrialized areas of the country. Many industrialized cities in Nigeria still have inadequate waste management; poorly controlled open dumps and illegal roadside dumping remain a problem. Such dumping spoils scenic resources, pollutes soil and water resources, and people. This situation is probably a social problem as much as a physical one; many people apparently are simply disposing their wastes as inexpensively and as quickly as possible. Many, in fact, may not see dumping their garbage as an environmental problem. If nothing else, this is a tremendous waste of resources; much of what is dumped could be recycled or reused.

The scientist has spent much time to analyse various stages of waste control system, which is applicable to today's waste generation and disposal means. Waste can not be eliminated totally from environment as long as production and other engineering activities continue. Waste has been a result of man's activities from his earliest civilization, made more prominent during the industrial revolution, intensified by technology developments of the twentieth century and given political and economic exposure by the passage of solid waste Act of 1965. Waste must be properly managed in a way that minimises risk to human health and reduce its negative impact on the environment. Just as a botanist regards a weed as a plant in a wrong place, so also waste is a resource in wrong place [5]. Waste is a resource in the sense that if properly managed, can serve as raw material for some industries e.g. Aluminium Industries, rubber and plastic making industries etc. Putting waste in holes for burial as a sanitary landfill has been said that is tantamount to inefficient management of materials [6].

Egunjobi [7] noted that the best and most suitable strategy is to device ways and methods of improving the efficiency of the system in order to reduce wastes to a level that can be easily disposed without creating immediate or long-term pollution problems. In other words, the strategy should be aimed at achieving a "zero-waste", and secondly, the disposal of the remaining waste in a way and manner that will not create immediate or long-term pollution problems. This does not however, imply that production processes in the industries must run at 100% efficiency, which is practically not possible in every case, but simply denotes that all wastes generated must be consumed or destroyed within the process.

In support of Egunjobi's statement, all waste generated could be consumed, by serving as raw materials either in the same process or other processes. That is the waste must be recycled or simply used or converts to useable products by another industrial set-up as source of raw material. In destruction however, the wastes simply have to be got rid of in a way that will, as much as possible, of good use to humanity and its environment.

Many factories in Nigeria are located on the river banks and use the rivers as open sewers for their effluents. A recent study of effluents from two breweries on Ikpoba rivers in Benin City shows increase in pH, dissolved oxygen, biological oxygen demand (BOD) and massive increase in a total suspended solids [8]. The open dump method of solid disposal is considered as both naïve and dangerous [9]. This is because leachate effect (i.e. chemical and biological contaminants in wastes) will constitute a direct risk to human health. Though, cheap as generally believed, it is in the long run the costliest. As primitives as open dump method of solid waste disposal is, Johnnessen and Boyer [10] observed that it remains the predominant means in developing countries.

While disposal through incineration has some basic advantage, it is regarded as one of the most expensive solid waste management options. This is because it requires capital intensive plants, highly skilled personnel and careful maintenance [11]. Solid waste disposal methods such

as burning on opening ground or city streets, dumping into drains, water bodies (streams, lakes, oceans) and all other forms of indiscriminate dumping are regarded as environmentally unfriendly and therefore constitute threats to the health of resident, either directly or indirectly.

All industries produce solid wastes and wastewater in varying quantities and conditions and the accumulation of these solid wastes in heaps at dumping sites or discharge of wastewater on the soil or streams create pollution in a very short time. Therefore, industries join municipalities in contributing to the cultural pollution of the landscape, streams and other bodies of water. As these wastes are necessary end product of industries, the only solution to abating their nuisance effects is satisfactory waste management treatment and disposal methods.

This paper examines waste management and disposal in some Nigerian industries. It analyses the nature and composition of wastes generated in various industries and it also recommends necessary steps that could be taken to improve the industrial waste management and disposal in the country, so that the environment will be free from pollution, congestion and accidents.

2. SOURCES OF INDUSTRIAL WASTES

Wastes originating in business activities of the industrial world are referred to as industrial waste. These wastes are generally produced in-line with the end-products or during the processing procedure of each of the industries. In carrying out this research, four categories of industries were selected for study to give a cross-section of industrial life of the country with respect to the existing manner in which wastes are managed and disposed. The industries are breweries, textiles, paper industries and plastic industries. The wastes produced in these industries are heterogeneous and each category of industries differs in the amount and type of waste produced, but within each category, the generation and composition are fairly the same. Industrial wastes include solids, liquids and gases, but in the context of this research, only solids and liquids wastes are considered.

2.1 LIQUID WASTES IN INDUSTRY

All industries use water to various extents, some take in a greater quantity of water than raw materials (e.g. breweries). Some need comparatively large amounts in their finishing operations than in the manufacturing process. Very little of the water needed in industry forms part of the finished product and as very little of the water evaporates or sinks into the ground, the bulk of the water is discharged into the environment as wastewater containing various dissolved and suspended matter.

Liquid wastes from industry generally exhibit considerable variation in viscosity and heat. Examples are spent cooling waters content which are principally contaminated by heat, rinse waters which are usually contaminated by soil, oils, chemicals and other liquids they intended to remove. Others are process waters and effluents from workmen's washrooms. The pollution strength of wastewater is measured in terms of its biological oxygen demand (BOD), chemical oxygen demand (COD) and its suspended solids (SS) [12]. The BOD is the total oxygen that will be consumed in a biological oxidation of the organic content, initially present in the waste. The COD is a measure of the oxygen taken up in the chemical oxidation of the organic content so the total oxygen demand (TOD) is the sum of BOD and COD.

2.2 SOLID WASTES IN INDUSTRY

Solid wastes are more specific and more easily handled. Their composition depends on the type of industry. Solid wastes produced in plastic processing are mainly thermoplastic materials. In the textile industry, the bulk of the solid wastes are natural and/or synthetic fibres and fabrics produced from the fibres. Undigested wood constitute the main solid wastes in the paper and pulp industry while in brewery they are spent malted barley and broken bottles. Table 1 shows the compilation of types of wastes and the generating sources in the various industries visited for the research study.

Table 1: Compilation of the sources and types of waste.

Industries	Sources	Types of Wastes
Plastics	Manufacture (injection-blow and compression moulding) of plastic products	Plastic materials (e.g. Polypropylene, polyethylene, polyvinyl-chloride), curing compounds, pigments, filter powder.
Textile	Weaving, processing (e.g. Scouring, sizing, bleaching and printing/and dyeing.	Cloth and fibre residue, desizing wastes, caustic solutions, scouring waste, cloth, yarns fibre dust, tenrides, solvents, oxidizing and reducing agents.
Paper	Paper manufacture, conversion of paper and paper board, manufactory of paper board boxes and containers.	Paper and fibre residues, chemicals (e.g sulphite liquors), paper coating and fillers, inks and gives
Brewery	Fermentation, filtration, storage, packaging, processing machine of malted barley	Spent grams, spent hops, sludge residue, yeast, and broken bottle.

Source: Field survey June, 2004

3. METHODOLOGY.

In carrying out this research, relevant data were gathered about four categories of industries which include breweries, textiles, paper industries and plastic industries. The data were gathered through reconnaissance survey, interview granted by workers of the industries and tests carried out on the wastes samples obtained from the industries. The industries visited are: Nigerian Breweries Limited, Iganmu, Lagos; Guinness Limited, Ikeja; Nigerian Paper Mill Jebba; Crikaton Manufacturing Ventures Limited, Ufuma; Black Horse Plastics Industry Limited, Lagos; Nigerian Carton and Packaging Limited, Ilupeju, Lagos; Nichemtex Plc, Ikorodu; and Nitol Textile Limited, Lagos.

3.1 HANDLING OF INDUSTRIAL WASTES

3.1.1 Treatment and Disposal of Industrial Wastewater

The biological oxygen demand (BOD), chemical oxygen demand (COD) and its suspended solids (SS) are three functional parameters most regularly monitored and most often used to evaluate the performance efficiency of wastewater treatment plant. The performance of the treatment plant is measured in terms of the reduction in the treatment process of SS, BOD and COD of the effluent. There are three practical methods of industrial wastewater disposal, these are waste stabilisation ponds, activated sludge and trickling flitters.

Waste stabilisation ponds are earthen ponds designed for a daily organic loading. This secondary treatment is based on biological processes.

Activated sludge processes involve the industrial wastes being fed into an aeration tank. Within the tank flocs of microorganisms are kept in suspension by the aeration process. The flocs then feed on the organic matter of the industrial wastes after which they are separated from the wastes during sedimentation. They are returned to the tank to continue oxidation of wastes while the stabilized wastes are disposed.

Trickling flitters operations involve the filtration of the wastes. The filter is the contact media which may be a bed of broken stones, or any other material that can be used as a filter. Within the filter, the microorganism matters react with wastes. The filter is kept aerobic by natural ventilation.

3.1.2 Solid Waste Management and Disposal

The concept of solid waste management involves total inventory of all waste streams categorization of the wastes, recycling or reuse of waste, waste treatments to reduce the risks and safe disposal of the waste. Pyramid depicting the solid waste management hierarchy is shown in Fig. 1. *Source reduction* is at the top of the pyramid, followed by *reuse*, *recycling/composting*, *incineration*, and then *sanitary land filling*. The solid waste management hierarchy ranks the most preferable ways to address solid waste. Source reduction or waste prevention, which includes reuse, is the best approach to manage solid waste. This means reducing the amount of trash discarded by making maximum use of raw materials. Once waste is created, recycling which includes composting is one of the most effective methods of reducing the amount of material in the waste stream. If waste cannot be recycled, incineration and sanitary land filling are the next preferred methods of treatment.

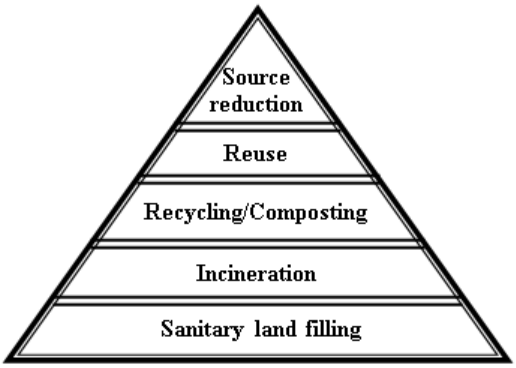

Fig. 1: Solid waste management hierarchy

(a) ***Source reduction*****:** Source reduction is generally perceived as being the highest rung on the waste minimization ladder with the greatest potential for avoiding energy and raw materials consumption as well as waste production. Technology changes for source reduction include changes to the design of the production process, the purchase of new equipment, changes in operating conditions and changes in process controls.

(b) ***Reuse*****:** Waste materials generated during the production process can be reused both on-site and off-site. "Reuse" means reusing a waste material directly either for its original purpose or in a new role without any major modification to the material before it is reused.

(c) ***Recycling*****:** A large percentage of the wastes generated are either paper, plastics, packaging materials, metals, cans or biodegradable waste most of which are recyclable. These types of waste from industries can be recycled at the recycling centres. This will not only reduced the amount of wastes available for disposal, but it will also reduce the cost of recycled material, as recycled products are cheaper. Recycling schemes such as converting waste paper into tissue paper, using broken glass wares as feedstock for glass production, treatment of spent oil for re-use, using waste plastics as feedstock for plastic production can be practiced.

(d) ***Composting*****:** Composting is the process by which solid organic waste is degraded by aerobic, mesophilic and thermophilic microorganisms. It converts organic waste into stable, sanitary and humus like product, which can be used for soil improvement. The establishment of a composting centre will be a means of transforming a lot of the waste generally to composts, which if successfully managed, would reduce the consumption of inorganic fertilizer and results in an enormous savings for the economy.

(e) ***Incineration*****:** Incinerators are capable of reducing the volume of waste to the barest minimum since they involve the efficient and controlled burning of wastes. Controlled incineration is a reliable and environmentally acceptable technology for treatment of wastes. Incineration can transform even toxic waste into non-hazardous ashes prior to disposal. Incineration has the advantage of combusting the liquid and gaseous along with the solid waste.

(f) ***Sanitary land filling*:** The simplest and least expensive way to dispose of solid waste is to place it in landfill. A sanitary landfill is created on a piece of land that has minimal estate value into which organic and inorganic solid wastes are dumped. Each day's waste deposit is covered with layer of soil to minimize aesthetic, odour and fire hazard. Covering the waste is what makes the landfill sanitary. It isolates the refuse, minimizing the amount of surface-water entering into the waste and gas escaping from the waste.

3.2 WASTE MANAGEMENT AND DISPOSAL IN THE SELECTED INDUSTRIES

3.2.1 Breweries

The brewery industry is a food industry, which is working with pure culture microorganism (the yeast). This implies vigorous cleaning efforts and furthermore, it is essential to have effective disinfection. The brewery is a batch industry that makes separate brews which are treated successively until they are cold and standardized. Next, are different fermenting vessels and storage tanks, where the brews are transformed into beer. The beer has to be filtered and finally passed through a bright beer tank (Cellar) before it is put into bottles, cans or Kegs.

The sources of wastes to disposed of at the various sections of production (e.g. for beer production) are:

(a) ***The brew house*:** Loses of raw material, wort and last runnings from the spent grains and 'trub' or 'sludge'.

(b) ***The fermenting and storage department***: Excess yeast, tank bottoms (gelager).

(c) ***Filtration*:** First and last runnings.

(d) ***Packaging*:**

(i) Cleaning of new/returned bottles.
(ii) Beer loses due to over foaming, breaking bottles.
(iii) Returned "remnant beer' in the bottles.
(iv) Starting and stopping of the shift (Beer losses).
(v) General cleaning at the end of the week.

(e) ***General losses*:** Dripping spent grains silo, and oil grease and other lubricating agents leaking from mechanical equipment and cars.

***Waste Disposal Methods*:** In breweries, waste disposal methods employed are similar; spent grains are stored in storage silos and loaded at interval into contract lorries for disposal into suppose approved dumping site. The liquid wastes from all sources pass through a network of drains within the factory into a main channel, where they are discharges untreated into the streams or water bodies.

2.2 Textile Wastes

Textile factories generally have two divisions, namely the grey mill where the grey cloth is woven and finishing mill where the grey cloth is dyed, printed or embroidered. Chemical used in bleaching are those containing active chlorine, such as sodium or calcium hypochlorite, bleaching lime and sodium chlorite. Hydrogen peroxide is also used for bleaching. Many other chemicals are employed for different purpose.

Wastes emanating from textile industries (Table 1) are various bits and pieces of cotton and other solids, easily biodegradable substances like starch, non-biodegradable organic substances like oils, greases, waxes and a number of process chemicals, organic anions like sulphides and cyanides and other organics e.g. phenols, pesticides used in proofing. There are also phosphates, sulphur and nitrogen compound acids, bases, and suspended solids.

***Waste Disposal Methods*:** The textile industries at Lagos discharge their liquid wastes into the environment (or water bodies) untreated, except one where their liquid wastes are always treated before they are discharged into public drains. Most of these industries employed the services of private contractors for the disposal of their solid wastes.

2.3 Paper Industry Wastes

The paper industries are mainly concerned with the manufacture of pulp and paper from wood. A general over-view of the processes involved in the manufacture of pulp and paper shows that after milling the chips obtained are sent into the digester where they are treated mainly with NaOH and Na_2S. The end products from the digester is milled and screened. Paper making industries are famous for high volumes of waste materials consisting of wood wastes, waste water, fibre residue and used sulphite liquor.

***Waste Disposal Methods*:** In the paper industry visited in the northern part of the country, solid wastes from the processes are dumped openly outside the factories. All categories of solid wastes are piled up behind the factory to form an unsanitary and un-aesthetic landfill. The liquid wastes from the industry is discharged into nearby river untreated.

Although a typical paper mill effluent–treatment system demands a relatively large commitment in plants (and funds), a well-designed one will greatly improves the economics of the entire industry through re-circulation of water and re-use of chemicals.

2.4 Plastic Industry Wastes.

Plastic processing is concerned mainly with the operation carried out on this group of materials to form them into useful products. In the case of thermoplastics the main step in any process involve melting/softening, moulding/shaping and cooling. Investigation carried out in some plastic industries show that two types of wastes (Unavoidable and avoidable) are produced during the processing of thermoplastic material (Fig. 2).

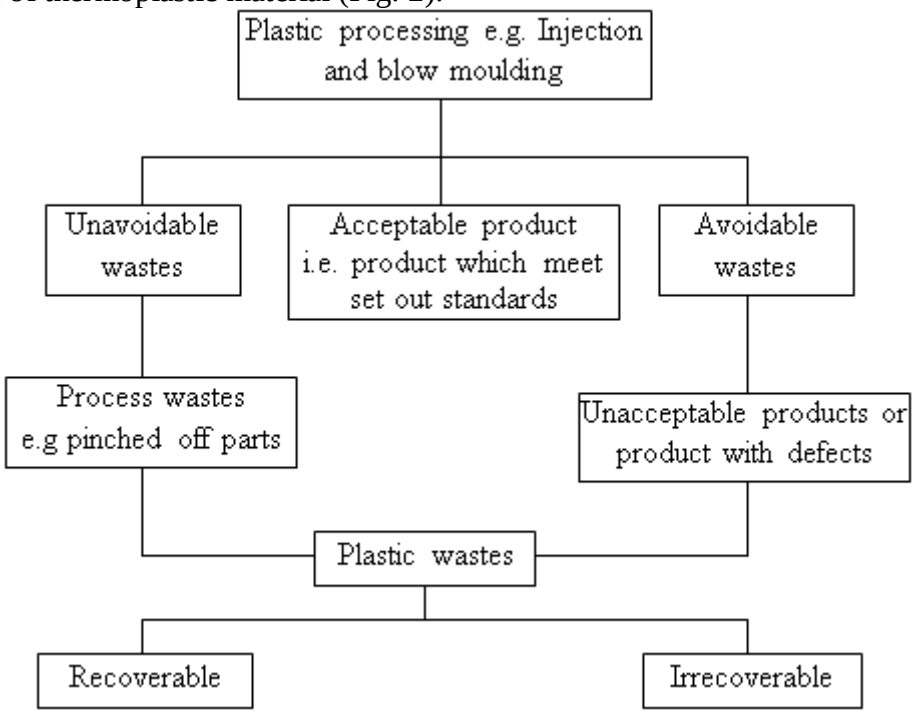

Fig. 2: Sources and types of waste in plastic processing.

***Waste Disposal Methods*:** The solid waste generated by the plastic industries visited were claimed to have been disposed-off through the services of private contractors whose vehicles visit their factories periodically to collect their wastes. In Lagos and other urban centres, it is often the practice of some private enterprises to collect wastes from various industries and discharge them along roads in the outskirts of the cities, which is environmentally unacceptable. Also, the wastewaters from these industries are discharged without any treatment through public drains directly into the lagoon.

4. RESULTS AND DISCUSSION

4.1 Results.

Industries consume large volumes of water, about 90% of which go out as wastewater. Unfortunately industries in Nigeria discharged their untreated wastewater into the nearest surface water. The nature of industrial wastewater is complex containing high oxygen demanding organic pollutant, suspended solids, dissolved solids and other inorganic and organic chemicals, which could be harmful to aquatic living resource.

Samples of industrial effluents were collected from four of the industries visited, one industry each from paper, brewery, textile and plastic industries. Tests were carried out on the samples to determine the level of pollution in terms of physico-chemical properties (BOD, COD, suspended solid, dissolved solid and pH) of the effluents. The results together with recommended effluent standards [1] are shown in Table 2. Samples of solid waste were also collected from a tipping site located at Isolo, Lagos. This site is chosen because it is meant only for the disposal of industrial wastes. Tipping sites are area set aside for the disposal of solid wastes. Sometimes, such sites are located in an area suffering from some physical deficiencies such as being slightly swampy. The sampled solid wastes were separated into six groups (paper, plastics, metal, glass, wood and others) and the results of their percentage composition by weight are shown in Table 3.

Table 2: Physico-chemical properties of industrial effluents from selected industries and the recommended standards

No	Parameter	Paper Industry	Brewery Industry	Textile Industry	Plastic Industry	Recommended Level
1.	pH	5.2	4.8	5.8	6.8	6.0 – 9.0
2.	Suspended solid (mg/litre)	486	2,287	220	375	30
3.	Dissolved solid (mg/litre)	217	581	320	480	2,000
4.	B.O.D (mg/litre)	89	1,340	148	92	50
5.	C.O.D (mg/litre)	260	760	150	180	80

Table 3: Composition of sampled industrial solid wastes from a tipping site located at Isolo, Lagos

Type of Waste	Percentage Composition (%)
Paper	37.5
Plastic	15.9
Metal	14.6
Glass	13.4
Wood	10.3
Others	8.3

3.2 Discussion of Results

Table 2 shows physico-chemical properties of industrial effluents from selected industries and the recommended standards. The characteristics of industrial effluents vary with the type of industry. This can be seen when the wastes are discharged into the environment. Examples are white water from paper mills and coloured wastes from textiles industries.

Two of the parameters used to evaluate the level of pollution in the industrial effluents are BOD and COD. They are used to express the oxygen demand of microorganisms, which stabilize the waste and thus give an estimate of the concentration of organic waste. Other important parameters are the pH and the suspended solids.

Fig. 3 shows the quantities of most pollutants in wastewater from the selected industries are far above the recommended levels. Except the quantities of dissolved solids, which were found to be within the recommended level in all the selected industries. Also, it is clearly shown in Fig. 3

that wastewater from breweries contain the highest quantity of all categories of pollutants. Ideally, before discharging industrial effluents into the environment, they should be treated and detoxified with the installation of pollution abatement equipment based on the best practical technology (BPT) or best available technology (BAT). The percentage composition by weight of sampled industrial solid waste from a tipping site (Table 3) shows that the paper is by far most abundant of these wastes. However, this is just a sample from one site; considerable variation can be expected later on this site or on the other tipping sites depending on factors such as industrial activities around the site location, climate and season of the year.

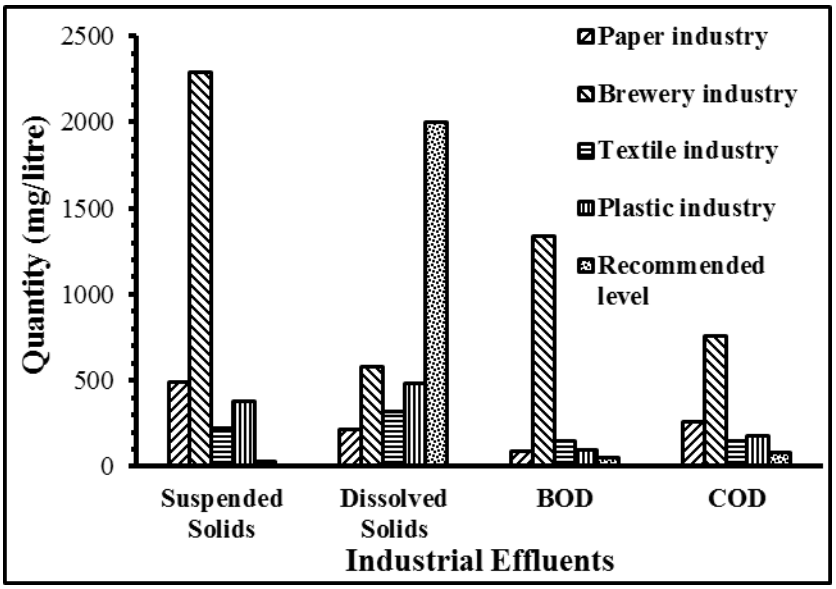

Fig. 3: The quantity of the pollutants in the effluents from selected industries

5. CONCLUSIONS AND RECOMMENDATIONS.

5.1 Conclusions

Wastes generally, are an inherent part of the manufacturing processes. Other causes of waste are manufacturing defects. It is necessary to avoid generating waste, which can be achieved if all the raw materials entering the process are thoroughly tested to ensure firstly, that they meet the required quality standard and secondly, are free of contaminants.

The four groups of industries discussed have been selected to give a cross-section of the industrial life of the country with the existing manner in which wastes are managed and disposed. Observation shows that these industries place little emphasis on proper waste management, preferring the cheapest methods to the most appropriate methods. In some cases they contract out the solid waste disposal and subsequently feel innocent, pretending that no further problems exist.

The analysis of quantity of pollutants in wastewater discharged from selected industries shows that larger proportion of the pollutants are total solid, suspended solid, dissolved solid, which can be easily treated and separated. It also shows that wastewater from breweries contained the highest quantities of all categories of pollutants. Most industries discharge their effluents in to the environment untreated. This act is environmentally unacceptable and it poses serious threats to public health. The percentage composition by weight of solid wastes from industries shows that, paper is by far the most abundant of these solid wastes, followed by plastic, metal, glass and wood in that order. If appropriate waste management is employed, these discarded solid wastes can be recycled and turned into valuable resources.

5.2 Recommendations

The following are the recommendations for the improvement of the industrial waste management and disposal in the country:

(i) Process conditions may often be adjusted either to recycle products or reduce the quantity of effluent produced or by suitable treatment on site to convert the waste products to a form suitable for subsequent treatment and disposal.

(ii) Environmental considerations must be integrated into the planning and design processes of all large projects.

(iii) In the design and establishment of future industrial estates, attention should be given to possible collective handling of industrial wastes so as to minimize costs and to ensure effective handling industrial wastes so as to minimize costs and to ensure effective handling.

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