International Journal of Chemical and Biomolecular Science
Vol. 1, No. 2, 2015, pp. 27-33
http://www.aiscience.org/journal/ijcbs

Colouration Industry Wastewater Treatments in Nigeria–Hazard and Treatment: A Review

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Abstract

Effective treatment of effluent discharged in colouration industry requires advanced treatment technologies such as adsorption for the removal of colorants or dyestuffs. Effluent is an out-flowing of water or gas from a natural body of water or from a human-made structure such as colouration industry. In the artificial sense, effluent is generally considered to be water pollution, such as the outflow from a sewage treatment facility or the wastewater discharge from industrial facilities into surface of water body. The complex organic framework of effluents and presence of heavy metals induce chronic toxicity and they may be mutagenic, tetratogenic and carcinogenic. Many researchers reported that, cases of tumors, cancer and effect on liver and kidney increased significantly after long-term exposure to effluent ($p<0.05$). Colouration industrial effluent treatment covers the mechanisms and processes used to treat waters that have been contaminated in some ways by anthropogenic industrial or commercial activities prior to its release into the environment or its reuse. Most colouration Industries in Nigeria produce some wet waste although recent trends in the developed world have been to minimize such production or recycle such waste within the production process by some regulated agencies such as United State's Environmental Protection Agency (EPA), National pollution Discharge Elimination System (NPDES) and Nigeria Federal Environmental Protection Agency (FEPA). The present review is aimed at assessing the effluent treatment status by Nigerian colouration industry with a view to highlight the necessary strategies that will guide the authorities concerned and also the Nigerian colouration industries to effectively discharge their social responsibilities to the concerned community.

Keywords

Colouration Industry, Industrial Effluents and Treatment of Effluents

Received: May 25, 2015 / Accepted: June 29, 2015 / Published online: July 15, 2015

1. Introduction

Colouration industry is the industry which consumes large amounts of water and produces large quantities or volumes of wastewater from different angles or steps in the colouration and finishing processes. It comprises a diverse and fragmented group of establishments that produce and/or process colour-related products for further processing into useful products. It involves a number of wet processes that may use solvents.

The wastewaters from colouration industries are often rich in colour containing residue of reactive dyes and chemicals. The toxic effects of dyestuffs and other organic compounds, as well as acidic and alkaline contaminants are widely noted (Ashoka, 2006).

The colouration effluents do not affect the peoples alone but also the environment through the hydrological cycle, such effluents can seep into the aquifer and pollute the underground water or where it discharged without proper treatment into water bodies. The pollutants cannot be confined within specific bomelaries and can therefore affect aquatic life in enormous ways (Glazer, 1997)

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In general, most aquatic organisms need light and air for respiration and growth in order to develop, so any deficit in this respect caused by coloured water lead to an imbalance of the ecosystem moreover, the water or river that are used for dyeing must not be coloured, as otherwise the treatment costs will be very high.

Many techniques have been developed to find an economic and efficient way to treat the colouration industry wastewater such as biotechnology, physicochemical, biochemical and combined treatment processes (FEPA, 1991).

Biotechnology is providing environmentally acceptable methods of modifying or destroying chemical wastes so that they are no longer toxic to the environment. Biotechnological decolourization has been employed under either aerobic or anaerobic environment. This usually involves finding bacteria or other microbes that can be genetically engineered to provide strains with better contaminant degrading potential than their natural counterparts (Melvin and John, 2006).

The residual dyes from different sources of colouration industry are considered wide variety of organic pollutants introduced into natural water resources or wastewater treatment system. One of the main sources with severe pollution problems worldwide is the colouration industry and its dye-containing wastewater or effluent. The dyes are natural and synthetic compounds that make the world more beautiful through coloured products. The dyes represent a category of organic compounds, generally considered as pollutants, presented into wastewaters resulting mainly from processes of chemical textile finishing (Vannede-vivera and Branchhi, 1998).

The term “effluent” is normally regarded or refers to as an out flowing, emanating outpouring of water or gas from a natural body of water, or from a human-made structure such as colouration industry (Babbit, 1958).

According to United States Environmental Protection Agency, effluent is defined as “wastewater – treated or untreated that flows out of a treatment plant, sewer or industrial outfall. Generally, refers to wastes discharged into surface waters” (Arcievala, 1981).

Effluent in the artificial sense is, in general, considered to be water pollution, such as the outflow from a sewage treatment facility or the waste water discharge from industrial facilities. Industrial wastes are highly variable in both quantity and quality depending on the product produced. Since very little water is consumed in industrial processing, large volume of the water is often returned as waste (Babbit, 1958). Nearly every industry has its own particular waste disposal problem; the volume and strength of these effluents vary from industry to industry. All wastes can generally be divided into two classes (Durant, 1981), which include:

i. Those containing physiological poisons e.g. cyanide and phenol from the carbonization of coal, petroleum refining, and manufacture of synthetic resins, water gas production and hardening processes.

ii. Those containing compounds which exerts a high oxygen demand during degradation, e.g. carbohydrates, alcohols, etc which arise from the starch reduction of flour milling, brewing, distillers, diaries and milk processing factories.

Treatment of industrial waste water or effluent is similar to the process for the treatment of domestic sewage, in that they usually contain varying amounts of toxic compounds in relatively high concentrations. These compounds may be purely inorganic or predominantly organic (Durant, 1981).

Table 1. Different Types of Effluent and their Industrial Sources.

S/N	Effluent	Industrial source
1	Cadmium, chromium and molybdenum	Textile manufacturing industry
2	Blood, and gut contents	Slaughtering industry
3	Acids, alkali, salt and organic matter	Food industry
4	Suspended solid, organic matter and nutrients	Pulp and paper industry
5	Plasticizers and aerated lagoons	Plastic industry
6	Selenium and ammoniacal nitrogen	Diary processing industry
7	Nitrate as N, selenium and zinc	Breweries and distilleries industry
8	Salt, surfactants, cationic materials, hydrogen peroxide, urea, biocides.	Colouration industry

The characteristics of effluent generated depend upon the processing stages. In general, the waste water from a typical cotton textile industry is characterized by high value of biochemical oxygen demand (BOD), chemical oxygen demand (COD), colour and pH, because of high BOD in colouration industry waste water. It causes rapid depletion of dissolved oxygen if it is directly discharge into the surface of water sources. Effluents with high level of COD are toxic to biological life (ISPCH, 1995). High alkalinity and traces of chromium (employed in dyes) adversely affect the aquatic life and also interfere with the biological treatment process. High colour refers the water unfit for use at the downstream of the disposal point. The effluent waste from colouration industry is composed mainly of water but also contains a number of other substances in various concentrations. These substances are either dissolved or suspended in the liquid. The characteristics of effluent are normally divided into three main categories viz; physical, chemical and biological characteristics (Ajulo, 2001).This work is aimed at highting some Nigerian effluents from colouration industry, their hazard and treatment techniques.

Different types of effluent are classified base on the nature of

outflow or outpouring of effluent from a different type of a human-made structure such as colouration industry.

2. Overview of Effluents in Colouration Industry

Different types of colouration industry are classified base on their nature, colour of the products and outflow or outpouring of effluent they discharged viz: Textile, Leather, Paper/pulp, Pharmaceutical, Dye and Dye Intermediate, tannery etc.

Textile Industry: The textile or apparel industry is primarily concerned with the production of yarn, cloth and subsequent design or manufacture of clothing and their distribution. Textile manufacturing is a major industry; it's based on the conversion of fiber into yarn, then fabric. These are than fabricated into clothes or other artefact. The nature of textile industry can be classified into three categories viz, cotton, woolen and synthetic fibers depending upon the used raw materials. The textile dyeing industry consumes large quantities of water and produces large volumes of wastewater from different steps in the dyeing and finishing processes. The wastewater (effluents) from textile industry is often rich in colour, residues of reactive dyes and chemicals e.g aerosols, high chroma, high COD, BOD concentrations and more hard degradation materials. The toxic effects of wastewater (effluents) from textile industry are causing significant environmental problems. High values of COD, BOD, Oil and grease in the effluent cause depletion of dissolved oxygen, which has an adverse effect on the aquatic ecological system. Most of effluents are dark in colour, which increases the turbidity of water body. This in turn hampers the photosynthesis process, causing alteration in the habitat (Joseph, 2007).

Leather Industry: Leather industry plays an important role in the economic development of our country and the wastewater from this industry is a major source of pollution among all industrial sectors considering both volume and composition of effluent, During leather processing, a number of size reduction, levelling and purification operations are carried out which results in generation of untanned and tanned proteinaceous waste materials which pose as a major environmental problem if not managed effectively. The effluent characteristics of leather industry it contains a lot of NaCl, Chromium, soluble proteins, organic matter, suspended solid, alkali, sulphides and high BOD. The toxic effect of leather industry effluent make the water unsuitable for irrigation, the present of chromium affects the fish and aquatic life. The treatment options for leather industry effluent are: - primary treatment which includes screening to remove hairs, fleshing etc. then sedimentation. The secondary treatment includes processes such as chemical coagulation and biological treatment. Removal of chromium followed by activated sludge process gives an effluent of better quality. Oxidation pond and anaerobic lagoon are recommended for small and isolated tanneries (Rao and Amal, 1987).

Paper/Pulp Industry: The effluent from the paper and pulp industry is generally high in suspended solids and biochemical oxygen demand. The nature of paper and pulp industry is characterized by having dark brown colour, characteristic odour, high content of suspended and dissolved solid. The toxic effect of wastewater from paper and pulp industry are coursing environmental effect due to the dark colour of effluent which is not easily biodegradable and hence inhibits photosynthesis and depletion of oxygen which effects to the aquatic life. Stand alone, paper mills using important pulp may only require simple primary treatment, such as sedimentation or dissolved air floatation. Increased BOD or COD loadings, as well as organic pollutants, may require biological treatment such as activated sludge or up flow anaerobic sludge blanket reactors. For mills with high inorganic loadings like salt, tertiary treatments may be required either general membrane treatments like ultra filtration or reverse osmosis or treatment to remove specific contaminants, such as nutrients (Ashoka, 2006).

Pharmaceutical Industry: Pharmaceutical and bulk drug industries emanate effluents with high COD. Some industries have developed a system to treat such effluents, through evaporation, drying technology and by removing the solvent from high COD stream, using stripper column. With the help of this technology, effluents concentrate is dried to a bag gable powder with 6 – 8% moisture content, which can be reused as a land filling/disposed. Finally, the whole of the effluent is converted into solid/sludge form so that it can be disposed using various ways like land filling (Wesburger, 2002).

Dye and Dye Intermediates Industry: Dye intermediate is petroleum downstream products, which are further processing for any application. On processing they are transformed to finishing dyes and pigments. The dye intermediates serve many industries like textiles, plastics, paints, printing inks and paper (Duarte and Hullman, 1990). It serves as important raw materials for the acid, reactive and direct dyes. A major application of dye intermediates are found in hair dyes, example 1 – Amino – 4 – Naphthalene sulfuric acid sodium used in the synthesis of azo dyes. The responsible dye manufacturers have almost eliminated the prohibitive colours from their range of products (Dayama, 1987).

Tanning Industry: The tanning industry is considered to be a major source of effluent and tannery wastewater in particular,

is a potential environmental concern. Tanning industry wastes poses serious environmental impact on water with its high oxygen demand, discolouration and toxic chemicals constituents (FEPA, 1991). Tannery waste characteristically, contains a complex mixture of both organic and inorganic pollutants. For example, chlorinated phenols and chromium were found to be closely associated with the tannery waste, chromium as inorganic pollutant is a transition metal and exists in several oxidation states, with trivalent Cr^{3+} and hexavalent Cr^{6+} species being the most common forms. Other effluents of concern within the tanning industry include Azo-dyes, cadmium compounds, cobalt, copper, arsenic, polychlorinated biphyenyl (PCB), nickel, formaldehyde resins and pesticides residues(ISPCH, 1995).

Food and Beverages Industry: The Food and Beverages processing industries consume large quantities of water. The food industrial effluents in general are characterized by high Biological Oxygen Demand and Chemical Oxygen Demand along with fats, oil–grease and many other recoverable nutrients like Nitrogen, Phosphorous and Potassium. In the present investigation thorough treatment studies were carried out on diary, sweet-snacks and ice-cream industrial effluents using alum, electro-coagulation and powdered activated charcoal as adsorbent. Characterization of the effluents was also carried out to check the pollution potential of these effluents. More emphasis was given on the representative water parameters mainly pH, Electrical Conductivity, Total Dissolved Solids, Chemical Oxygen Demand, Turbidity and Hardness. The electro-coagulation was performed with aluminum electrodes at different time intervals in order to check the variations in effluent parameters. Present studies revealed that electro-coagulation and adsorption have better ability to reduce the water parameters. The treated wastewater consists of refractory materials and high organic content of hydrolyzed peptone residues from pharmaceutical factory. The combination of electro-coagulation (EC) followed by heterogeneous photocatalysis (TiO_2) conditions was maximized (Ghafoor *et al.,* 1994).

Plastic Industry: This is the type of industry which characterize by high BOD, high suspended solids, characteristic odour and variable PH. The source of effluents is coagulation of rubber and latex, washings etc. The toxic effects of wastewater (effluents) from textile industry are causing significant environmental problems. High values of COD, BOD, Oil and grease in the effluent cause depletion of dissolved oxygen, which has an adverse effect on the aquatic ecological system. The treatment methods are aeration, activated carbon adsorption treatment or chlorination to remove odour and phenolic substances, trickling filtration or activated sludge process (Ghafoor *et al.,* 1994).

3. Hazard of the Industry Wastewater

Colouration Industries represent an important environmental problems or issues due to their high water consumption, even though effluents are produced in an effort to improve human living standard and fashion but indirectly, their unplanned invasion and lack of proper management into the environment can reverse the same standard of living by impacting negatively on the environment water contaminated with metallic effluent can cause several health issues, lead for instance, can interfere with enzyme activities and formation of red blood cells. It can affect nerves and brain at low concentration.

Any change in pH of water bodies as a result of influx of effluent can cause serious change in chemistry of water, which can affect the resources e.g. vegetables play important role in meeting the food requirements of people worldwide, because they are important source of various essential components i.e. minerals dietary fibers and vitamins (Ajulo, 2001).

Many researchers predicted that at high concentration of numerous effluents such as textile, paper, marble, diary and brewery along with high osmotic pressure, result in decreased germination (Rao and Amal, 1987). It was noticed that kidney beans and lady finger had reduced germination percentage in the presence of Industrial effluent. However, there was no hazardous effect in the presence of treated waste effluent.

The effect of textile mill effluent on germination and growth of black gram vinga mungo L. and found that under low concentration of effluent the germination and seedling growth was higher than the control but in higher concentration there is a gradual decrease in both germination and growth.

Best germination and seedling growth was observed in 25% concentration so they concluded that textile effluents can be safely used for irrigation after proper treatment and dilution at 25%.

Many researchers documented that under different concentrations of textile and paper effluents, there is improved seedling lengths of various crops (Daniel, 2006). But it has been stated that high amounts of heavy metals in soils hinder plant growth, physiological, metabolic processes and nutrient uptake (Kharker *et al*, 1972). In higher plants like ferns, club mosses, horsetails, flowering plants, conifers and other gymnosperms toxic metal comes into contact with roots. As a root tip is a site of injury when it comes to contact with toxic metals results in inhibition of root growth, reduced yield due to less uptake of water and nutrients and a stunted

root system.

Land polluted with heavy metals is becoming a matter of health, planning, economic and environmental concern in the world nowadays (Deborah, 1996).

Table 2. Classification of Effluent Treatment Techniques.

S/N	Treatment	Operational Activities
1	Preliminary	• Mixing and balancing (equalization) • Removal of large solids • Sedimentation • Screening • Sedimentation
2	Primary	• Equalization • Neutralization • Dilution • Mechanical flocculation and chemical coagulation
3	Secondary	• Aerated lagoon • Adsorption Process • Activated sludge process • Trickling filtration • Oxidation ditch and pond • Anaerobic digestion
4	Tertiary	• Oxidation technique • Electrolytic precipitation and foam fractionation • Membrane technologies • Electrochemical processes • Ion exchange method • Photo-catalytic degradation • Absorption (activated carbon) • Thermal evaporation

Colouration industry processes produce wastewater (effluent) that contains heavy metal contaminants. There is an increase in the heavy metal contents when soil irrigated with wastewater (Kefas, 2006). If these effluents are continuously used for irrigation for long periods of time then it may result in toxic levels for plant and animal health. Heavy metals persist in soil which then leaches down into the groundwater and may induces enhanced antioxidant enzymatic activities in plants or become absorbed with solid soil particles. Humans are exposed to toxic heavy metals either by the ingestion of contaminated food or by drinking water bioaccumulation of metal contaminants in the food chain leads to disastrous effects on human health (Glazer, 1997).

4. Treatment Processes

Technology is now available to treat effluent to the extent that it will meet drinking water quality standards. However, direct reuse of treated effluent is practicable only on an emergency basis. Many natural bodies of water that are used for municipal water supply are also used for effluent disposal which is done to supplement the natural water resources by reusing the effluent many times before it finally flows to the sea (ISPCH, 1995).

The coloured effluent may be treated alone or in admixture with other sewages or done by various methods, which include: Physicochemical methods, Biological methods, Mechanical methods and Thermal methods.

Depending on pollution load, other methods are flame method, photochemical oxidation method, ultrasonic technology high energy physical processes. The treatment processes may be categorized into preliminary, primary, secondary and tertiary treatment processes (ISPCH, 1995), as shown in table 2.

The colouration industry consumes large quantities of water and produces large volumes of waste in three different forms viz solid waste, wastewater (effluent) and atmospheric emissions from different steps in the colouration and finishing processes which have rigorous detrimental effects on the environment.

The wastewater from colouration industries is often rich in colour, countermining residues of reactive dyes and chemicals. The effect of dyestuffs and other organic compounds, as well as acidic and alkaline contaminants are widely noted. At present, the dyes are mainly aromatic and heterocyclic compounds with colour displaying groups and polar groups. The structure is more complicated and stable resulting in greater difficulty to degrade the printing and dyeing wastewater (effluent). The colouration industry wastewater (effluent) has a large amount of complex components with high concentrations of organic, high-colour and greatly changing characteristics. Owing to their high biochemical oxygen demand (BOD) and chemical oxygen demand (COD), their colouration and salty load,as aquatic organisms need light or minute in order to develop, any deficit in this respect caused by coloured wastewater lead to an imbalance of the ecosystem. Moreover, the water of river that are used for dyeing must not be coloured, as otherwise the treatment costs will be increased. Many techniques have been developed to find an economic and efficient way to treat the colouration industry wastewater (effluent) including physicochemical, biochemical, combined treatment processes and other technologies (Aslam et al., 2004).

5. Conclusion

In conclusion, most of the effluents obtained from temperature, potential hydrogen and suspended solids pose no danger to the aquatic ecosystem while that obtained from chemical oxygen demand (COD) and biological oxygen demand (BOD) and biological oxygen demand pose danger to the aquatic ecosystem. The present review is aimed at assessing the effluent treatment status by Nigerian colouration industry with a view to highlight the necessary strategist that will guide the authorities concerned and also the Nigerian colouration industries to effectively discharge their social responsibilities to the concerned community.

Technology is now available to treat effluents to the extent that it will meet drinking water quality standards. However, direct reuse of treated effluent or wastewater is practicable only on an emergency basis but prevention and treatment of dyeing wastewater pollution are complementary. We can both use preventive measures as well as a variety of methods to control the waste and make use of treated water in order to achieve sustainable development of our society. In general, it should be noted that no commercial or industrial product is as important as the environment. Moreover, it is now possible to convert industrial wastes into profitable products and every effort should be made to make profitable use of industrial wastes in order to save environment.

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