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# Evaluation of pollution potential of wastewaters from some hair dressing salons in Makurdi metropolis

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## Abstract

*The study was carried out to evaluate the pollution potential of hair dressing salons in Makurdi metropolis. Physicochemical parameters (BOD, COD, pH, phenols, TPH, oil and grease) were analyzed using standard methods while heavy metals (Cd, Cr, Pb, Ni) were analyzed with AAS and the average values were recorded. The results obtained were compared with the FEPA, USEPA and WHO permissible limits for wastewater. The values of physicochemical parameters were within national and international limits for wastewater except TPH and phenols values which are above the recommended DPR limit value of 0.6ppm for groundwater and below 1000ppm for soil as well as 10 ppm limits of FEPA. The values recorded for the heavy metals were above the USEPA permissible limit. Thus, the wastewater has the potential of polluting the environment and there is need for adequate treatment before disposal into the environment.*

**Keywords:** Hairdressing; Heavy metal; Physicochemical; Pollution Wastewater.

## Introduction

Water pollution is the modification or change in the chemical, physical or biological properties of water that can cause any harmful consequences on living things and the environment. Its often caused by human activities such as; indiscriminate dumping of refuse, activities of mechanic workshop, agricultural practices, effluent discharge, and combustion of fuel, atmospheric metallic burden, and spillage), affecting all living species and the complete functioning of the entire ecosystem (Maitera *et al*., 2011; Imasuen and Omorogieva 2013; Asuen *et al*., 2015).

Pollution from wastewaters; comprises of liquid waste discharged by domestic residences, commercial properties, small scale industries and institution (Pamelle, 1995) is presently the greatest risk to the sustainable use of ground and surface water. Discharged wastewater may contain toxic substance, health-compromising pathogens and/or chemical substances which may cause adverse environmental impacts such as decrease in biodiversity, changes in species composition and aquatic habitants, and impaired use of drinking and recreational waters (Environment Canada, 2001).

Hairdressing salons generate waste in the range of various alkalis, relaxers, dyes, and other chemicals which can greatly influence the physiochemical properties of receiving water resources. Discharging into water bodies is a major problem due to the uncontrollable nature of some of the contaminants in the beauty salons' wastewater (Bowers *et al*., 2002). Cosmetologists, beauticians, and to some extent customers are exposed to high concentrations of several compounds that are included in the various chemical products used in the work or treatments. Many products used in the beauty industry in developing countries are unregulated and may release carcinogens and volatile organic compounds (VOCs) such as lithium hydroxide, calcium hydroxide, guanidine carbonate and ammonium thiocyanate (Nkansah *et al*., 2016). These chemical constituents could change the; odour, appearance, and taste of water sources. Occupational skin and respiratory disorders and disputable reproductive and geno-toxic effects have been linked to chemical exposure to beauty workers (Galiotte *et al*., 2008).

Various environmental pollution problems have been attributed to salon wastewater discharges. Organic matter and nutrients from salon wastewater cause an increase in aerobic algae and depletes oxygen from the water column; this causes suffocation of fish and other aquatic organisms. Salon wastewater contains oil and grease which stick to the bodies and feathers of seabirds and this make them unable to fly. Oils do not dissolve in water and form a thick layer on the water surface and this causes suffocation of fish and other aquatic organisms. Salon wastewater may also contain heavy metals such as; nickel, chromium, arsenic and mercury which are poisonous to most of the aquatic life and may eventually result to death. Water from such sources is obviously unfit for consumption. These chemicals can also be washed down the soil and can change the chemistry of the soil. It may also contain some poisonous volatile organic compounds which can cause air pollution (Nkansah *et al*., 2016; Onwusah *et al*., 2015).

Predominantly, sources of water in Makurdi metropolis include; hand dug wells, boreholes, rivers, streams and rain water (during the rainy season). However, these water sources are subjected to contamination or pollution from anthropogenic activities. Such sources of water may not be suitable for its intended domestic or irrigation use and as such become a threat to aquatic life. In addition, many water borne diseases are caused by waste contaminants that end up in water bodies. It is worthy of note that aside industrial effluents discharges into water bodies, other miscellaneous sources including wastewater from laundry shops and beauty salons contribute to the overall input of toxic chemicals in water bodies and a source of micro-organisms causing water borne diseases and other related health hazards. The study was aimed at investigating the spectrum of contaminants in wastewaters from different hair dressing salons in Makurdi metropolis of Benue State and to ascertain the load of pollutants associated with these wastewaters.

## Materials and methods

### Sample collection

Samples of wastewater were collected from different hair dressing salons in Makurdi metropolis of Benue State. The sample locations were: Wadata (A & B), Modern Market (C & D), North bank (E-H), Gboko Road (I), Benue State University (BSU) (J), Wurukum Market (K) and High level (L). A total of twelve (12) samples were collected for both heavy metals evaluation and other chemical parameters. The areas were chosen due to their high number of hairdressing salons. Samples for heavy metals determination were collected in plastic containers while samples for COD, oil and grease, TPH, pH, BOD and phenols determination were collected in glass containers. The wastewater samples collected for heavy metals determination from each site was preserved by adding 10 mL of 4 % nitric acid in each 200 mL of the samples collected before taking them to the laboratory in order to keep the required species of the heavy metals in solution (Mendham *et* al., 2002; Amadi *et al*., 2012).

### Analysis of wastewater samples

In situ measurements of temperature and pH were determined intrusively with appropriate probes while four heavy metals: Cd, Cr, Pb and Ni were determined using Atomic Absorption Spectrometer (Perkin Elmer AAS-Analyst 800) after aqua ragia digestion. Other parameters were evaluated using standard methods (American Public Health Association (APHA), 1992;

USEPA, 1996; FEPA, 1991). Petroleum hydrocarbons were analysed with a GC-MS instrument (Thermo Scientific Quadruple 800 GC-MS).

**Results and discussion**

Presented in table 1 below are results for physicochemical analysis of beauty salon wastewaters in the study area. The results indicate that the pH values of the studied wastewater samples varies from weakly acidic to alkaline (6.71-10.56). The alkaline nature of most of the samples (excluding: A, K & L) could be attributed to the presence of chemicals like; sodium hydroxide in hail relaxers and sodium phosphates and dyes used in hair conditioners (Dias, 2015). The pH values of the wastewater samples were however within the WHO and FEPA acceptable limits of 6.0-9.0 for drinking water and wastewaters discharge into the surroundings (World Health Organization, 2004; FEPA, 1991). The pH values are also in agreement with those reported by Nkansah *et al*., 2016 for wastewaters in beauty salons in Ghana but in contrast to the generally acidic values of salon wasters reported by Ajuzie and Osaghae (2011) in Benin City-Nigeria. This difference may be attributed to the variation in hydrogen ion concentration of residual ions of the precursor reagents used in hair care products. pH has a marked influence on the solubility of minerals and equilibrium carbonate concentration in water bodies (WHO, 2004). Extreme pH may depopulate fish and increase the number of undesirable planktons as well as mobilize ions (such as $Al^{3+}$) from the shore into aquatic systems (Lenntech, 2017).

The values of phenolic content of the wastewater samples ranged from 5.25-12.65 ppm. Samples A-E recorded phenols concentration above 10 ppm whereas the other samples had phenols <7.00 ppm. These values of phenols are far above the 0.001 mg/L limit of phenol concentration in potable water set by W.H.O (WHO, 1958). The foremost sources of phenolic waste are petroleum refineries, petrochemical, steel mills, coke oven plants, coal gas, synthetic resins, pharmaceuticals, paints, plywood industries and mine discharge (Shareefdeen, & Singh, 2005). Hence, the levels of phenols detected in the present study point to the petrochemicals origin of hair treatment products. Phenolic waste imparts a carbolic odour to river water and are also toxic to fish and human beings (Mukherjee, *et al*., 2007).

Very little amounts of oil and grease (as low as 0.3-0.4 ppm) were recorded in the present study. These levels are far below the FEPA, (1991b) limit of 10 mg/L and thus the effluents do not pose a threat for oil and grease pollution. The presence of oil and grease in water bodies leads to the formation of oil layer, which causes significant pollution problem such as reduction of light penetration and photosynthesis. It further hinders oxygen transfer from atmosphere to water medium and this leads to decreased amount of dissolved oxygen at the bottom of the water and this adversely affects survival of aquatic life in water. In addition, it may cause odour and taste problems in water bodies as well as a significant reduction of soil ability to transmit water (Jameel, *et al*., 2011).

A spectrum of petroleum hydrocarbons was found in the salon wastewater samples with carbon chains ranging from $C_8$ (octane) to $C_{34}$ (tetratriacontane) as illustrated in fig.1 below. It is noteworthy that while petroleum hydrocarbons were not detected (ND) in many of the effluents, concentrations as high as >56 ppm were found in some samples.

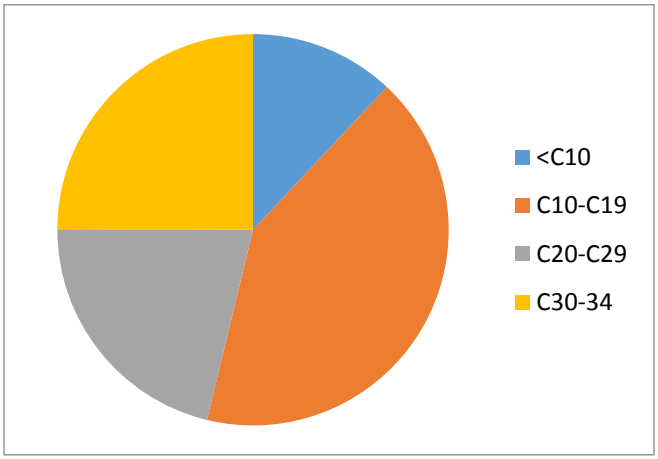


Fig.1. Range of carbon chains of petroleum hydrocarbons in wastewater samples

Carbon chains of $C_{10}$ to $C_{19}$ were the predominant fractions of petroleum hydrocarbons. A summation of petroleum hydrocarbons in the samples revealed total petroleum hydrocarbons (TPH) in the range of 81.12 ppm to 266.25 ppm which are far above the recommended 10.00 mg/L by FEPA for effluent limitation. The major feedstock of hair care products is sourced from petrochemicals which could be responsible for these levels of TPH in the salons' wastewater. The toxicity of Petroleum hydrocarbons to aquatic life is well known. The accumulation of lipophilic hydrocarbons in the membrane lipid bilayers of microorganisms have been reported to interfere with their structural and functional properties (Sikkema, *et al*., 1995).

Table 1. Physicochemical analysis for hairdressing salon wastewaters (ppm)

| Sample | pH | Oil & grease | COD | BOD | Phenols | TPH |
|---|---|---|---|---|---|---|
| A | 6.82 | 0.03 | 8.85 | 5.45 | 10.35 | 211.009 |
| B | 10.56 | 0.03 | 8.73 | 5.31 | 12.11 | 266.245 |
| C | 9.16 | 0.03 | 8.53 | 5.23 | 15.11 | 81.123 |
| D | 8.17 | 0.03 | 8.89 | 5.49 | 12.65 | 227.102 |
| E | 7.67 | 0.03 | 5.43 | 12.65 | 7.67 | 252.727 |
| F | 7.02 | 0.04 | 6.43 | 5.11 | 5.36 | 192.090 |
| G | 10.15 | 0.04 | 6.45 | 5.14 | 5.25 | 150.040 |
| H | 8.36 | 0.04 | 5.41 | 6.00 | 8.36 | 90.612 |
| I | 7.15 | 0.04 | 8.07 | 4.82 | 5.62 | 159.214 |
| J | 7.70 | 0.04 | 8.45 | 5.13 | 6.35 | 204.410 |
| K | 6.85 | 0.04 | 8.32 | 5.08 | 6.89 | 215.115 |
| L | 6.71 | 0.04 | 8.63 | 5.37 | 6.89 | 195.011 |
| **FEPA 1991** | **6-9** | **10** | **40** | **10** | **0.50** | **10** |
| **WHO 2004** | **6-9** | **-** | **250** | **30** | **-** | **-** |

**A-L: are as defined in the previous section

While BOD measures the concentration of biodegradable substances in wastewaters, COD on the other hand is a measure of the amount of oxygen required to break down both inorganic and organic particles in water system. The concentration of BOD ranged between 4.82 ppm and 12.65 ppm in the samples. These values are below the FEPA and WHO recommended limit of 10 mg/L and 30 mg/L with exception of the value obtained in effluent samples at sample E, which exceeded the FEPA limits. Hence the levels of biodegradable species in the wastewater samples were indeed at barest minimum. COD levels were recorded in the range of 6.43 (sample F) to 8.85 ppm (sample A). These values are far below the permissible limits by the WHO and FEPA. The low levels of BOD and COD in the salon wastewater samples is an indication of the low pollution index of these samples. The BOD/COD ratios in the studied samples ranged from 0.60 to 0.80 (Fig.2) with highest ratio occurring in sample G.

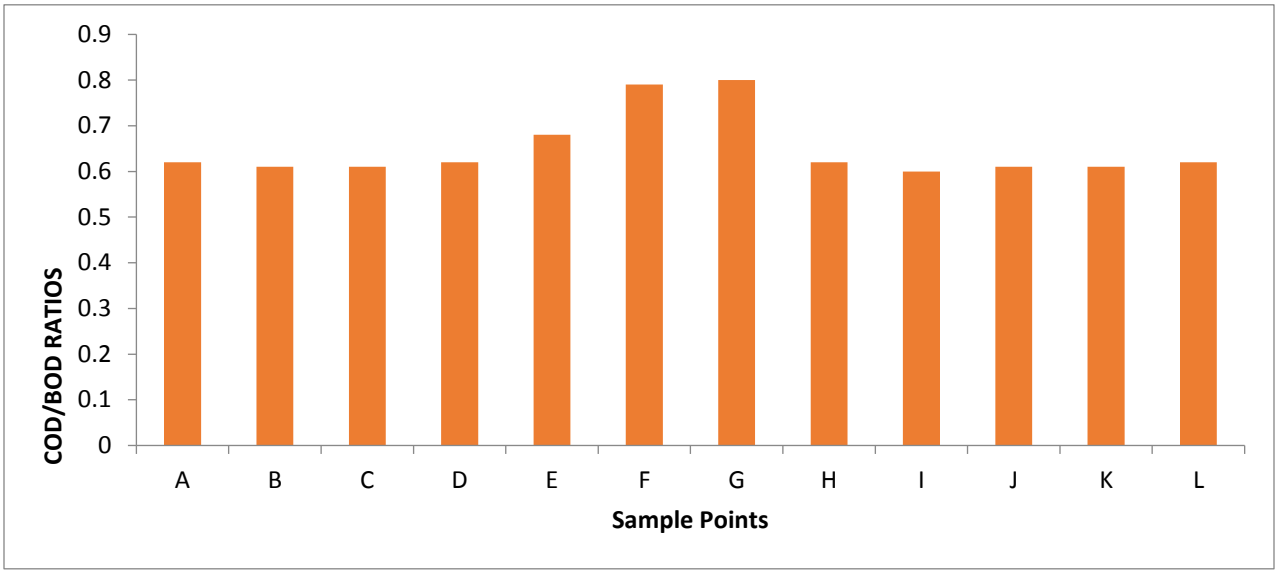


Fig 2: COD/BOD ratios of wastewater samples

It has been reported that BOD/COD ratio <0.5 depicts the presence of non-biodegradable matter in wastewater samples (Ntuli *et al.*, 2009). Although the ratios recorded in the present study are low, there is a reflection of biodegrability in the wastewaters.

Table 2. Mean heavy metals levels of the wastewater samples

| Sample | Cd | Cr | Ni | Pb |
|---|---|---|---|---|
| A | 0.628±0.001 | 1.929±0.001 | 0.430±0.000 | ND |
| B | 0.633±0.005 | 1.929±0.001 | 0.436±0.001 | 0.098±0.001 |
| C | 0.637±0.001 | 1.929±0.001 | 0.072±0.000 | 0.012±0.001 |
| D | 0.616±0.009 | 1.929±0.001 | 0.116±0.000 | 0.011±0.001 |
| E | 0.599±0.001 | 1.895±0.001 | 0.066±0.001 | 0.012±0.001 |
| F | 0.606±0.001 | 1.912±0.001 | 0.105±0.001 | ND |
| G | 0.599±0.001 | 1.895±0.001 | 0.081±0.001 | 0.055±0.001 |
| H | 0.619±0.000 | 1.915±0.001 | 0.129±0.000 | 0.011±0.001 |
| I | 0.620±0.001 | 1.915±0.001 | 0.088±0.001 | 0.011±0.001 |
| J | 0.593±0.001 | 1.889±0.001 | 0.088±0.001 | ND |
| K | 0.613±0.001 | 1.912±0.001 | 0.052±0.001 | 0.088±0.001 |
| L | 0.619±0.001 | 1.915±0.001 | 0.377±0.001 | 0.065±0.001 |
| **FEPA,1991** | **0.01** | **0.05** | **<1** | **0.05** |
| **USEPA,** | **0.2** | **0.37** | **0.55** | **-** |

**A-L: are as defined in the previous section *ND: Not detected

The results of mean heavy metal concentration in the samples in Table 2 above indicates that cadmium concentration ranged from 0.593 mg/L (sample J) to 0.637 mg/L (sample C). These levels of cadmium exceed the recommended limits of 0.01 mg/L and 0.2 mg/L of FEPA and USEPA for industrial effluents, hence the need for proper treatment before discharge into any environmental media (FEPA, 1991; USEPA, 2004). The concentration of chromium (Cr) recorded in this study ranges from 1.889 mg/L to 1.929 mg/L. These levels are higher than the 0.079 mg/L and (0.005-0.095) mg/L reported by Oguzie & Okhagbuzo (2010) and Tyohemba (2010) for effluents in Benin City and industrial effluents in Ibadan. Similarly, the recorded Cr concentration exceeds the FEPA and USEPA limits of 0.05 and 0.37 mg/L for industrial effluents. Nickel in effluents may arise due to leaching of nickel chromium plated taps as well as stainless

steel pipes and fittings (W.HO. 2004). The FEPA and USEPA limits for Ni in effluents is <1 mg/L and 0.55 mg/L. The ranges of Ni concentration (0.052-0.436) mg/L are in compliance with the recommended standards. Lead (Pb) content of the solon wastewaters was present in the range of 0.011 to 0.098 mg/L although it was not detectable in samples A, F and J. The Pb content in the effluent is below the FEPA recommended limits of 0.05 mg/L except in four samples; B, G, K & L. The solubility of lead increase markedly as the pH <8 because of substantial decrease in the equilibrium carbonate concentration (W.H.O., 2004). Thus, with the reported pH values above, Pb could be present in highly mobile form for uptake by organisms when such effluents are discharged into the environment.

**Conclusion**

The results indicate that the salon wastewater samples in the study area contains some of the studied physicochemical parameters below the local and international regulatory limits. Their phenolic and total petroleum hydrocarbon content however fall short of the acceptable regulatory limits. Furthermore, these effluents are said to contain levels of the studied heavy metals above the permissible limits and this pose toxicity to receiving environmental media. Although there is non-existent information regarding monitoring the quality of effluent discharges by beauty salons in the study area, it is imperative to ensure the treatment of effluent discharges from these miscellaneous sources as they may contribute to the overall pollution burden of receiving environmental media.l

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