African Journal of Biotechnology Vol. 10(11), pp. 2066-2069, 14 March, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.1601
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

The bacterial and physico-chemical properties of hair salon wastewater and contaminated soil in Benin metropolis

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Accepted 4 February, 2011

The bacterial and physico-chemical properties of hair salon wastewater and contaminated soil in Benin metropolis were investigated. Investigations were carried out on five hair salons from different locations in Benin City. The physico chemical analysis showed that Ugbowo samples had the highest chemical oxygen demand of 208.00 mg/l, while Ekenwan had the highest biological oxygen demand of 180.00 mg/l with a constant temperature of 28.3°C for all samples. It was observed that the wastewater samples from the five different locations were not highly contaminated as the mean bacterial count of 2.48 x 10^3 to 4.88 x 10^3cfu/ml was observed. Mean bacterial count for contaminated soil samples ranged from 3.52 x 10^3 to 6.86 x 10^3 cfu/gm. Microorganisms isolated include *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli*, *Bacillus* sp. and *Klebsiella* sp. with *S. aureus* occurring most.

Key words: Hair salon, wastewater, soil sample, bacterial counts, Benin metropolis.

INTRODUCTION

Benin metropolis is made up of three Local Government Areas which are Oredo, Egor and Ikpoba Okha and it is the capital of Edo State. Benin City lies between latitudes 6°20 North and 6° 31 North and between Longitudes 5°35 East and 5° East of the Greenwich meridian. By its tropical location, it has a temperature of about 27°C and an annual rainfall of over 2000 nm. Benin City battles with waste management, its efficient treatment as well as discharge. This is a major problem as Nigeria is counted among the developing countries which do not channel much attention towards efficient waste water management.

Wastewater refers to any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, small scale industries and institutions. In general, waste water is characterized based on its bulk or organic contents, physical characterristics and specific contaminants (Damelle, 1995). Efforts have been made towards curbing the menace of pollution around the world, particularly by the United Nations Environmental Programme. There have been many international conferences to this effect, such as the Rio de Janeiro conference of 1992 (Oyesola, 1998).

In many parts of the world, human activities still have negative impact on the environment. Some of the consequences of manmade pollution are transmission of disease by water-borne pathogens, eutrophication of natural water bodies, accumulation of topic or recalcitrant chemicals in the soil, destabilization of the ecological balance and negative effect on human health (Chikere and Okpokwasili, 2004).

The continuous trend toward the formulation of new beauty tips and manufacture of novel hair products to satisfy the demands of the growing populace could lead to some pollution problems. Today's salons offer a wide range of services from hair styling and skin treatments to tanning, manicure and make up application. In providing these services, waste is generated. In most cases, this waste goes into the sanitary sewer system, where it can

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Abbreviations: BOD, Biochemical oxygen demand; **SAT,** soil aquifer treatment; **TDS,** total dissolved solids; **G.R.A,** government residential area; **COD,** chemical oxygen demand; **DO,** dissolved oxygen.

have a negative impact on the environment (Bowers et al., 2002). A typical example of what happens, is logging of contaminated water in the soil. In this situation, oxygen becomes less available as electron acceptor, results in the reduction of available nitrate into gaseous nitrogen which has negative effects. Leaching into ground water is a major concern, because of the recalcitrant nature of some contaminants (Lapygina et al., 2002; Toetora et al., 1997).

Different methods of waste treatment have been developed for reasons of public health and conservation which results in the destruction of pathogens and the mineralization of the organic components of sewage prior to discharge. Anaerobic wastewater treatment using granular sludge reactor is one of such methods (Boadi and Kuitunene, 2003). However, in Nigeria like in many developing countries, the discharge of untreated waste into the environment is still a problem, despite the establishment of Federal Environment Protection Agency (FEPA) since 1998. Other considerations for treatment can be the removal of toxic organic pollutants and heavy metal altering the physical conditions of the water (e.g. pH, electrical conductivity, etc), removing sediment loads or biochemical oxygen demand (BOD).

One of such methods of wastewater treatment and/or disposal is recharging the wastewater into ground water, either by infiltration or direct injection (Bouwer and Chaney, 1974). The process uses surface soil to remove nutrient and microbial pathogens through physical, chemical and biological process. This treatment processes is often termed soil aquifer treatment (SAT) which cleans up wastewater prior to recovery and reuse (Kanarek and Michail, 1996). The aim of this study is to examine the extent of contamination in untreated wastewater of five different hair salons in Benin City, Nigeria and the impact on soil receiving part of the wastewater, to ascertain the harm associated with hair salon wastewater from bacteria and chemical contaminant to man and ecology and to reawaken continued government agencies and other stakeholder of the danger associated with discharge of hair salon wastewater

MATERIALS AND METHODS

Sample collection

Samples of salon wastewater and contaminated soils where the wastewater is disposed off, respectively, were collected directly from five selected shops in Benin metropolis including Owina, Ekanwan, Ugbowo, Ehaekpen and Government reservation areas (GRA) in Benin City. Sterile 250 ml bottles with stoppers were used to collect the effluent samples and packed in cooler containing ice bags and transported to the laboratory for further analysis. Soil samples were collected in sterile polyethylene bags at a depth of 0 to 15 cm. The effluents samples for dissolved oxygen and BOD were fixed on site by adding 1.00 ml each of Wrinkler's solution and taken to laboratory for other physicochemical analysis.

Physicochemical analysis

The following parameters were determined for the hair salon effluent samples: pH, temperature (°C), conductivity (µ(s/cm), total dissolved oxygen (mg/L), biochemical oxygen demand (mg/L) chemical oxygen demand (mg/L), total dissolved solids (TDS), nitrate(mg/l), potassium, turbidity(mg/l) and dissolved oxygen, carbon, nitrogen, phosphorus, carbon and organic matter. Effluent analysis was in accordance with standard methods for the examination of water and wastewater. pH was read using Jenway 2030 pH meter for about 30 min before use. Conductivity was determined using a conductivity meter after meter had been calibrated and stabilized at 0.0 $\mu.scm^{-1}$. Total suspended solid was determined by the difference in weight between filter paper containing residue and filter paper alone. Biochemical oxygen demand was determined by the open reflux method of APHA (1998). Nitrate level was determined using phenol-disulphoric acid method and absorbance was read at 4.15 nm. Dissolved oxygen was measured using the probe and meter method, and potassium values in effluent samples was determined with corning flame photometer IV using lithium as a reference filter (APHA, 1998).

Enumeration, isolation, characterization and identification of bacteria in hair salon effluent and contaminated soil

The total heterotrophic bacterial counts of hair salon effluent and contaminated soil was performed in triplicates by plating out 0.1 ml of the samples on nutrient agar plates containing fusin (anti-fungal). Plates were enumerated after 48 h of incubation at 37°C. Pure stock cultures were identified and characterized using the criteria of Krieg and Holt (1994).

RESULTS AND DISCUSSION

Notably is the low bacterial counts level observed in samples from Government Residential Area (G.R.A) when compared to the four zones of which Ekenwan area recorded the highest bacterial count (Table 1). This could be due to the general degree of hygiene of that particular zone and also attempts of some sanitation practices by the hair dressers. Table 2 which had counts from contaminated soils showed that the bacteria counts were higher than that obtained from the effluent samples. Literatures have reported and proposed extensive microbial diversity including species richness and evenness with population estimated between approximately 4 x 10^3 to 10^4 species per gram of uncontaminated soil (Borneman et al., 1996). It is known that abundance and activities of micro flora in soil are controlled by water availability, nutrients, pH, metal ions and so on (Nazina et al., 2002). While a variety of nutrients are required for microbial growth, the two nutrients required in the largest stoichiometric ratio and relative to the contaminant are nitrogen and phosphorus (macronutrients). Trace nutrients (micronutrients) such as potassium and magnesium are also required for microbial growth. The most commonly used electron acceptor is molecular oxygen, although nitrate, sulphate and other compounds have been used (Bouwer and Chaney, 1974).

Tables 3 and 4 show the isolated organisms from hair salon wastewater and contaminated soil, respectively. The reoccurring of *Pseudomonas aeruginosa* which was isolated from all but two of the tested samples was not

Table 1. Bacterial counts from hair salon wastewater.

Sample area	Bacterial count (cfu/ml)				
	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}
Owina	67	50	37	23	17
Ekenwan	89	61	49	26	19
Ugbowo	63	49	35	23	15
Ehaekpen	70	52	37	24	18
G.R.A	42	31	28	14	9

Table 2. Bacterial counts from hair salon contaminated soils.

Sample area	Bacterial count (cfu/ml)				
	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}
Owina	76	52	44	32	26
Ekenwan	96	84	71	56	36
Ugbowo	70	50	41	30	27
Ehaekpen	84	61	51	40	30
G.R.A	59	45	36	28	16

Table 3. Identification of bacterial isolates from hair salon wastewater.

Sample area	Bacterial isolated
Owina	*Staphylococcus aureus, Escherichia coli, Bacillus* sp.
Ekenwan	*Staphylococcus aureus, Pseudomonas aeruginosa, Bacilus* sp.
Ugbowo	*Staphylococcus aureus, Klebsiella* sp.
Ehaekpen	*Staphylococcus aureus, Bacillus* sp.
G.R.A	*Staphylococcus aureus*

surprising as *P. aeruginosa* is an extremely adaptable organism found in a variety of habitats and even in distilled water (Paul and Clark, 1989). However, it is also known to be opportunistic in persons with impaired host defenses.

Escherichia coli and *Klebsiella* sp. which are members of the family Enterobacterceae as well as indicator organisms were found to occur sparsely. Inference can therefore be made that there was little or no fecal contamination of the water and soil. Their low occurrence could also be due to the chlorine content of the waste water observed during physico chemical analysis as chlorination is bactericidal to enteric bacteria. Species of *Klebsiella* known to exist in the environment include *Klebsiella terrigena* which has been isolated from the environment alone and *Klebsiella planticola* which has been isolated from both the environment and urinary tract (Gemmer et al., 2002).

Table 5 shows some physicochemical properties of hair salon wastewater and contaminated soil from the five selected areas. The physicochemical analysis of the wastewater samples revealed that all the samples had constant temperatures. Samples from Ugbowo area had the highest chemical oxygen demand (COD). A high COD value suggests more waste products or pollutants presence in the effluent such as sodium, dimethyl-phthalates and bis(2 ethylhexyl) phthalate and ammonium nitrogen. Since COD indirectly measures the amount of organic compound present in water, it therefore means that the water was heavily polluted. The area with the high COD is highly populated because of the location of a university and as such, students would always make use of hair salons, thereby resulting to large quantities of wastewater from salons. Of striking note was the value of dissolved oxygen (DO) obtained in all the samples. All the samples recorded zero dissolved oxygen value and this was as a result of high turbidity of the samples analyzed. The high turbidity was as a result of different particles in the suspension.

Conclusion

The study indicates that hair salon wastewater can be characterized as only slightly more of industrial strength than typical domestic and house wastewater. However,

Table 4. Identification of bacterial isolates from hair salon contaminated soil.

Sample area	Bacterial isolated
Owina	*Staphylococcus aureus, Klebsiella* sp, *Pseudomonas aeruginosa*
Ekenwan	*Staphylococcus aureus, Pseudomonas aeruginosa*
Ugbowo	*Staphylococcu aureus, Klebsiella* sp.
Ehaekpen	*Pseudomonas aeruginosa*
G.R.A	*Pseudomonas aeruginosa*

Table 5. Physicochemical properties of hair salon wastewater from the five selected areas.

Parameter	Owina	Ekenwan	Ugbowo	Ehaekpen	G.R.A	FEPA effluent limitation guideline (1991) (mg/l)
pH	6.12	5.83	6.19	5.57	5.59	6 - 9
Conductivity (µs/cm)	540.00	710.00	80.00	267.00	30.00	-
Temperature (°C)	28.30	28.30	28.30	28.30	28.30	30.00
BOD (mg/L)	30.80	2.70	5.70	9.70	4.80	10.00
COD (mg/L)	112.00	160.00	208.00	104.00	84.00	40.00
Potassium (mg/l)	8.040	21.69	25.10	22.66	13.65	20.00
Nitrate (mg/L)	1.04	1.51	1.06	1.69	1.07	20.00
Dissolved oxygen (DO) (mg/l)	0.00	0.00	0.00	0.00	0.00	20.00
Total dissolved Solids (TDS) (mg/L)	208.30	369.21	437.60	117.84	15.60	2000
Turbidity(mg/L)	14.84	12.19	20.75	18.38	13.57	-

product industries should start producing products that are not considered hazardous. Attempts should be made to treat salon effluents before disposal as it would help reduce organic and inorganic substances present.

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